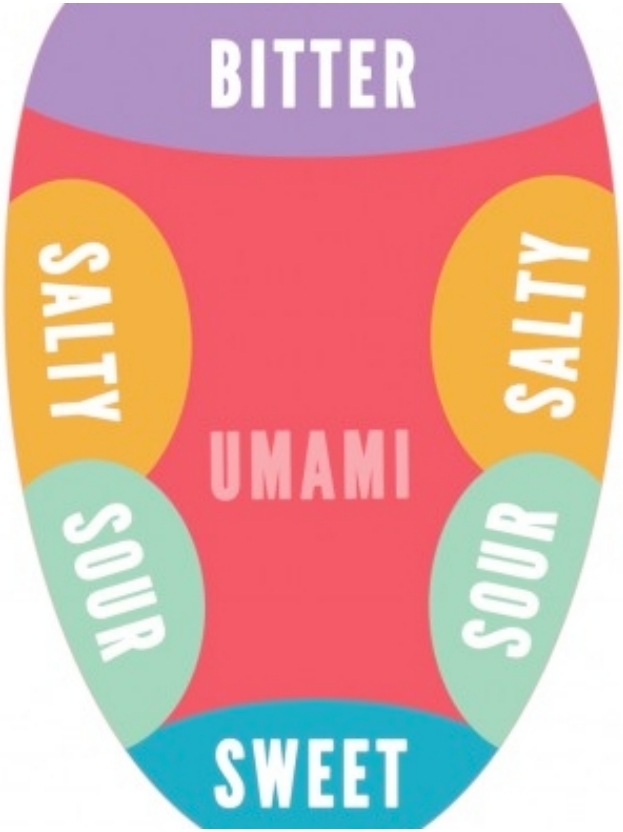
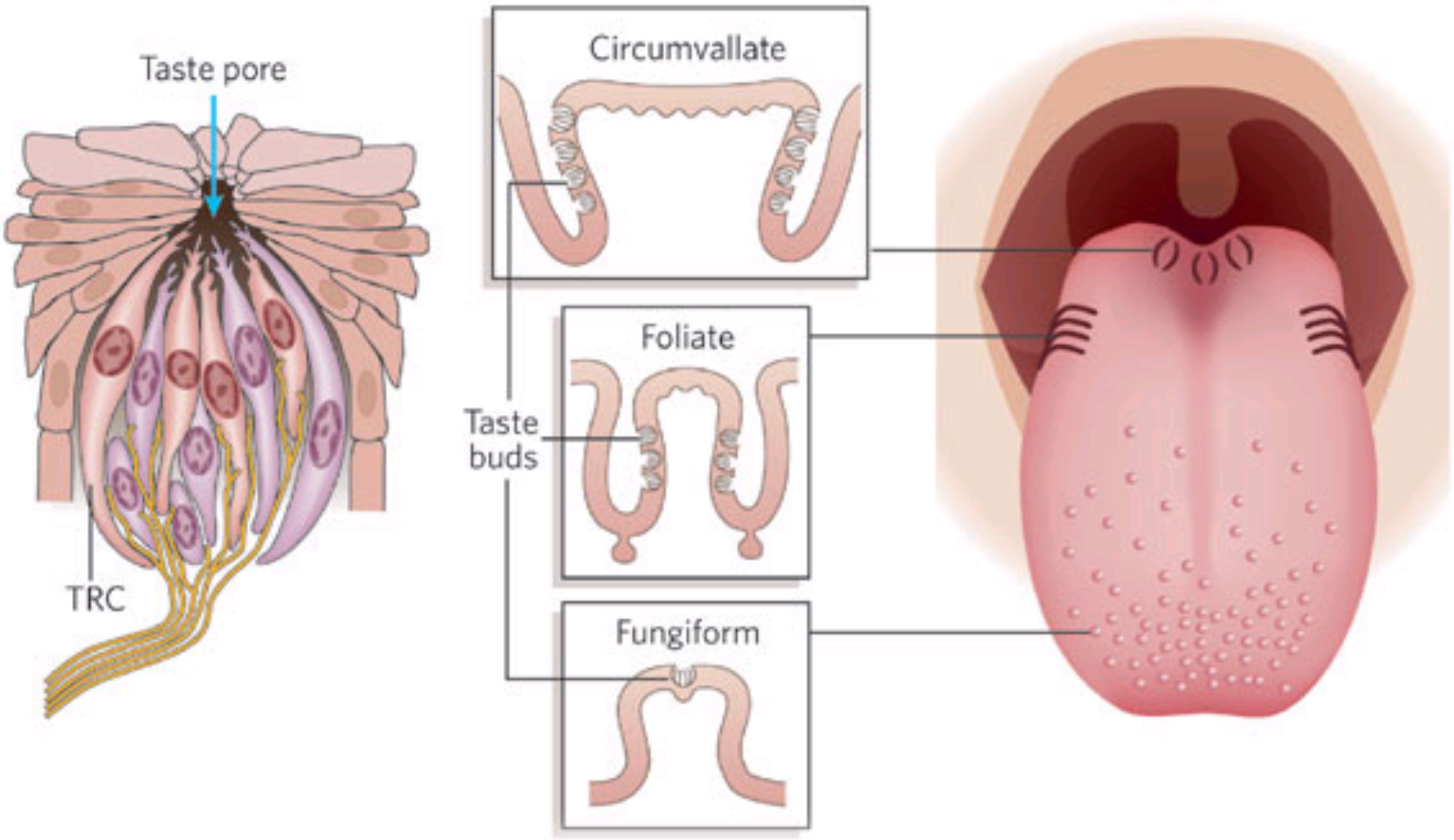
La percezione gustativa



- VALUTAZIONE DEL CONTENUTO NUTRITIZIO DEI CIBI
- PREVENZIONE DI INGESTIONE DI SOSTANZE TOSSICHE

Le cellule recettoriali sono contenute nelle papille gustative



Microvilli: sono in contatto con la cavità orale

Trasduzione del segnale

Sinapsi: punto di contatto con le vie afferenti

Codifica del segnale

acetilcolina (?) e noradrenalina(?)

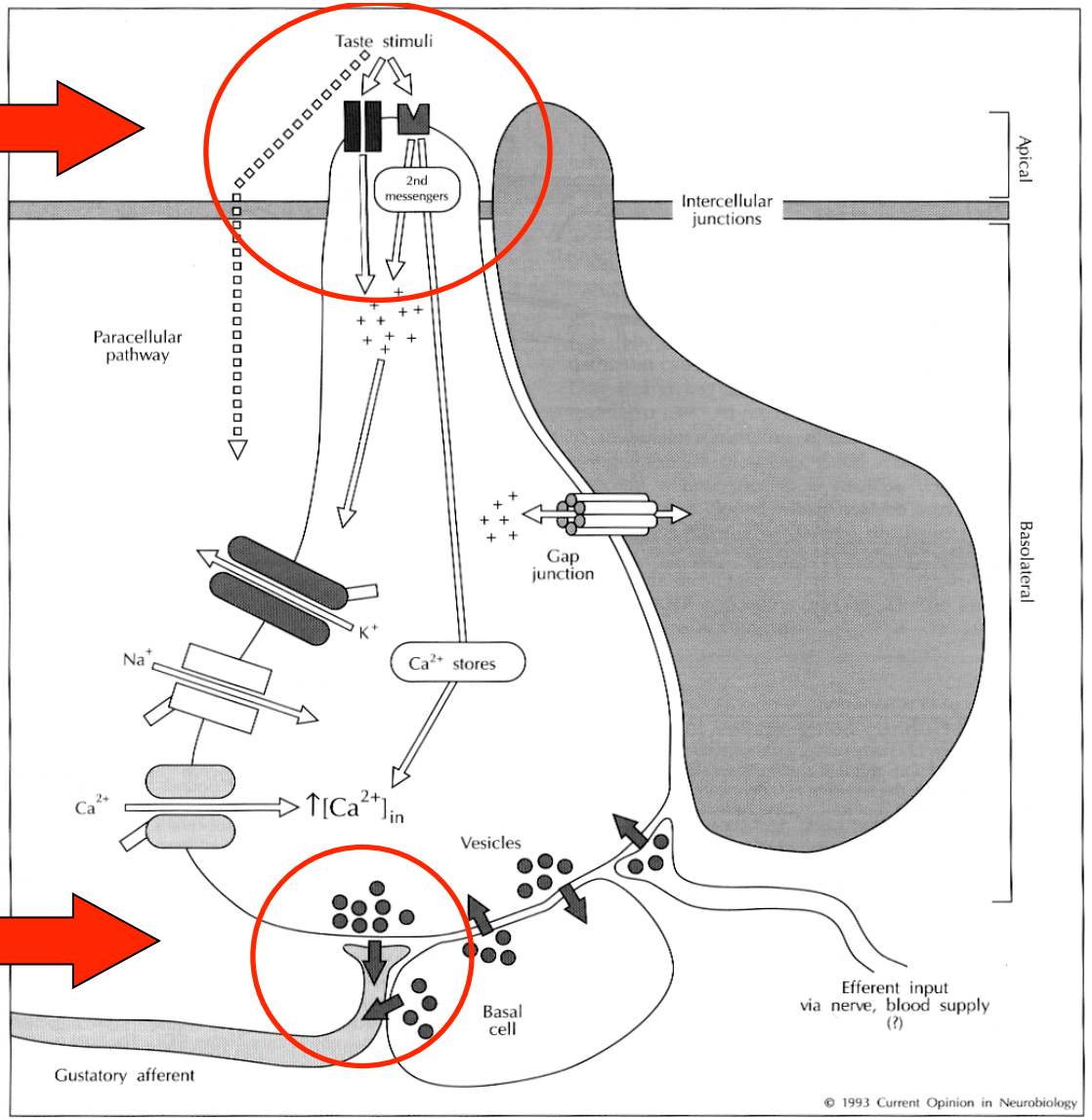


Fig. 1. Summary of taste receptor cell function. Taste stimuli interact directly with ion channels or receptors present in the apical membranes of taste cells. Typically, these interactions produce a depolarization of the cell, either directly or through the action of second-messengers (see Fig. 2). This depolarization, or receptor potential, activates voltage-dependent Na^+ and K^+ channels to produce action potential(s) within the cell. The differential permeability of intercellular junctions (e.g. paracellular pathways) may affect the development of receptor potentials. Voltage-dependent Ca^{2+} channels, in turn, are activated, allowing an influx of Ca^{2+} into the cell. A direct release of intracellular Ca^{2+} from internal stores without the associated voltage-dependent phenomena has also been reported. Increases in intracellular free Ca^{2+} concentrations facilitate fusion of synaptic vesicles with the basolateral membrane causing a release of the taste-cell neurotransmitter onto the gustatory afferent nerve. The presence of gap junctions between taste cells in some species indicates that the gustatory signal may spread to adjacent cells. In addition, in lower vertebrates, bidirectional synapses between basal cells and receptor cells and synapses between basal cells and the gustatory afferent have been observed, suggesting that significant processing of the taste signal may occur. Finally, taste cell function may be under efferent control by means of direct nerve input or by factors, such as hormones and bioactive peptides, present in the bloodstream.

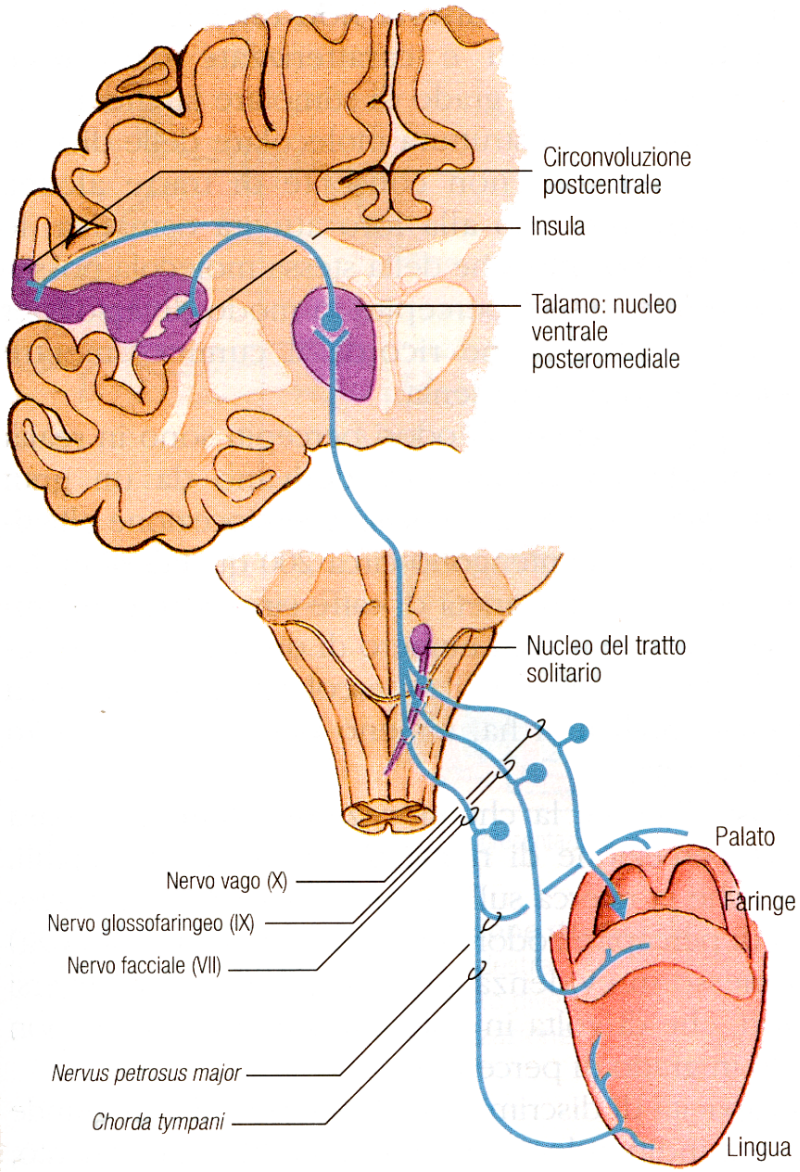


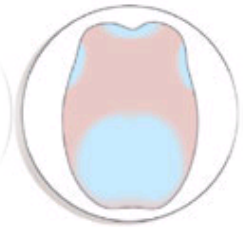
Figura 24.5 Localizzazione e destinazione delle vie gustative nel sistema nervoso centrale (secondo ➠8).

Attività riflesse dell'apparato digerente

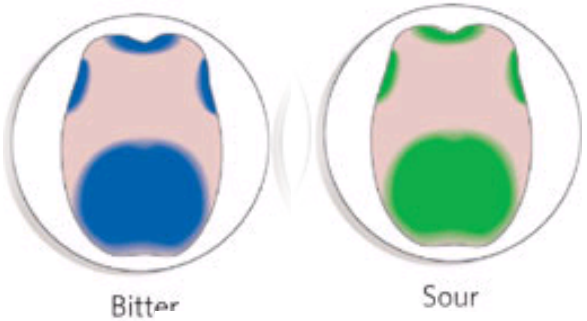
Percezione gustativa consapevole

Percezione gustativa consapevole

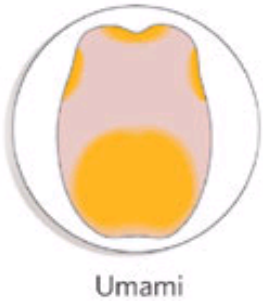
Componente emozionale della percezione gustativa



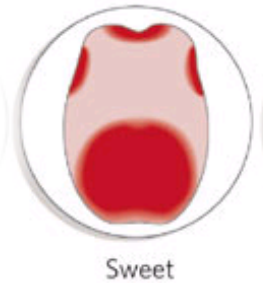
Bilancio elettrolitico



Protezione ingestione eventuali sostanze tossiche/velenose



Riconoscimento amminoacidi



Riconoscimento di sostanze altamente energetiche

Tabella 24.1 **Valori di soglia assoluta (soglia di percezione) relativi ad alcune sostanze attive sulla chemiocezione gustativa; i valori sono stati rilevati in seguito alla stimolazione complessiva del cavo orale**

Qualità (gusto fondamentale)	Sostanza percepibile	Concentrazione (espressa in mol/l)
Dolce	Glucosio	10^{-1}
	Saccarosio	10^{-2}
	Saccarina	10^{-5}
Acido	HCl e altri acidi	10^{-3}
Salato	NaCl e altri sali	10^{-2}
Amaro	Caffeina	10^{-3}
	Chinino	10^{-5}
	Stricnina	10^{-6}

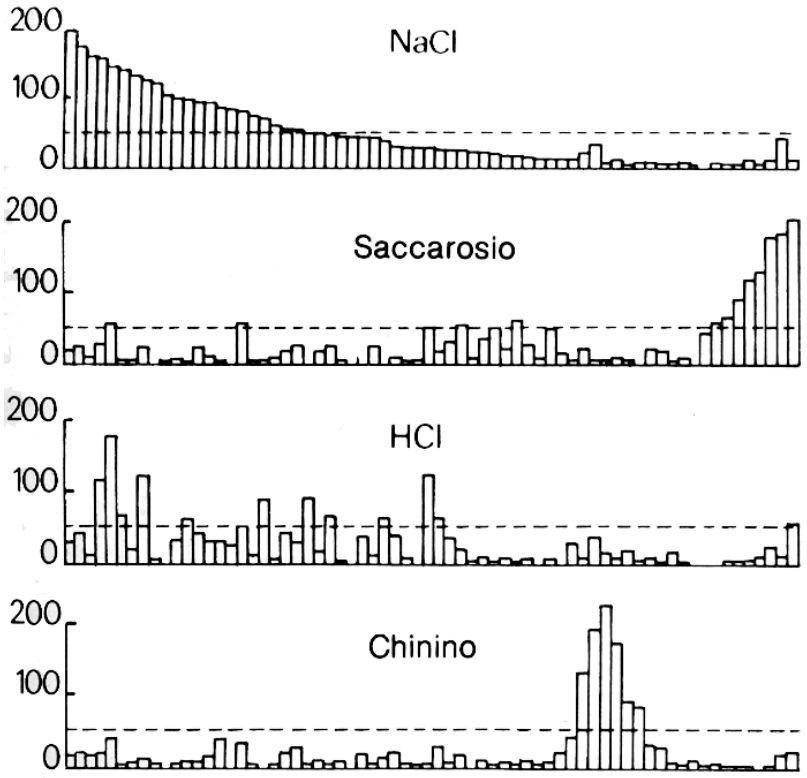
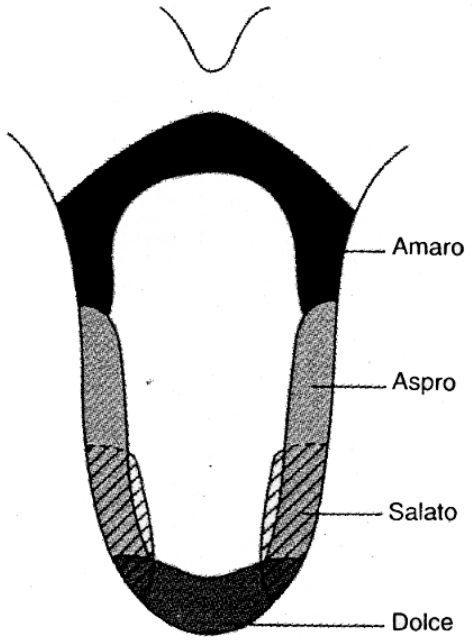
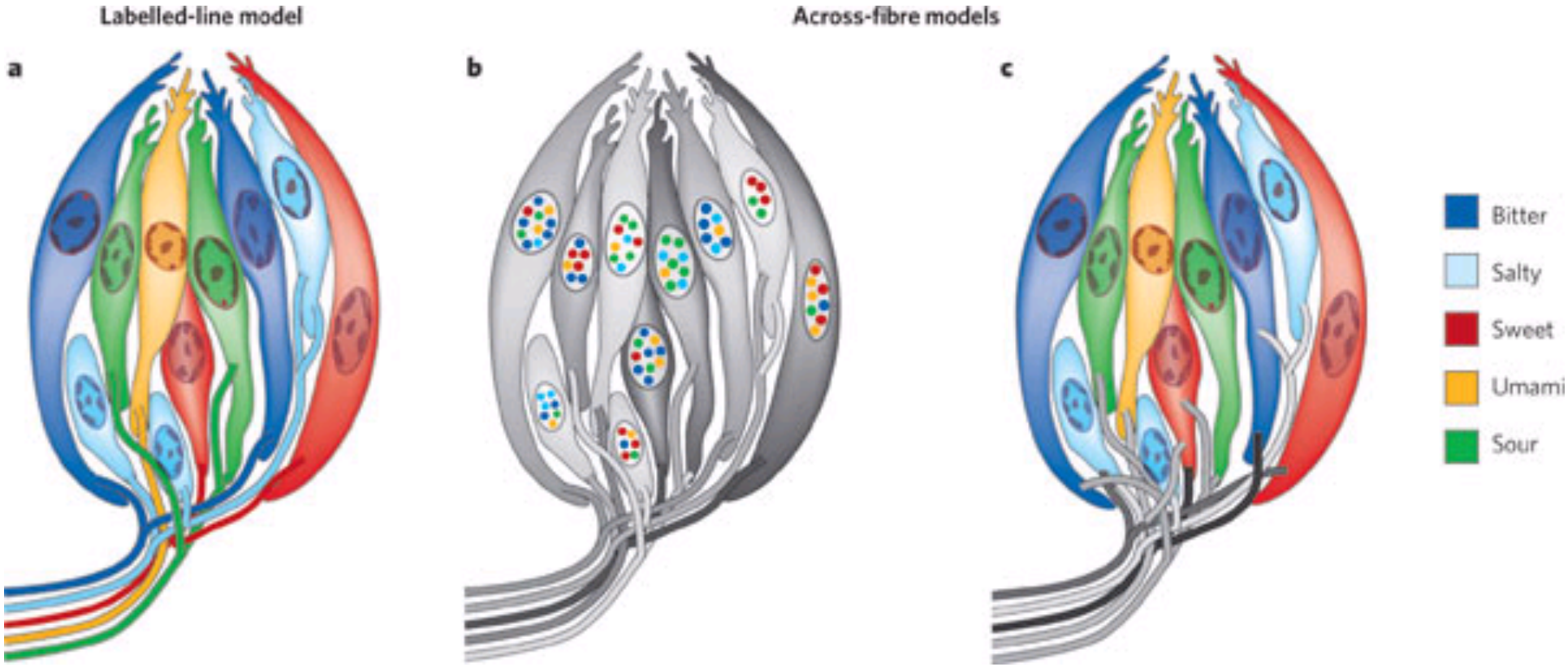


Fig. 31. *Profili di risposta di 67 fibre isolate della chorda timpani di scimmia a quattro stimoli rappresentativi dei sapori fondamentali*
(da Sato, Ogawa e Yamashita, 1975).
Nelle ordinate, gli impulsi (5 s).

Regioni della lingua umana dove è minore la soglia per il dolce, il salato, l'aspro e l'amaro.





There are two opposing views of how taste qualities are encoded in the periphery. a, In the labelled-line model, receptor cells are tuned to respond to single taste modalities — sweet, bitter, sour, salty or umami — and are innervated by individually tuned nerve fibres. In this case, each taste quality is specified by the activity of non-overlapping cells and fibres. b,c, Two contrasting models of what is known as the 'across-fibre pattern'. This states that either individual TRCs are tuned to multiple taste qualities (indicated by various tones of grey and multicoloured stippled nuclei), and consequently the same afferent fibre carries information for more than one taste modality (b), or that TRCs are still tuned to single taste qualities but the same afferent fibre carries information for more than one taste modality (c). In these two models, the specification of any one taste quality is embedded in a complex pattern of activity across various lines. Recent molecular and functional studies in mice have demonstrated that different TRCs define the different taste modalities, and that activation of a single type of TRC is sufficient to encode taste quality, strongly supporting the labelled-line model.

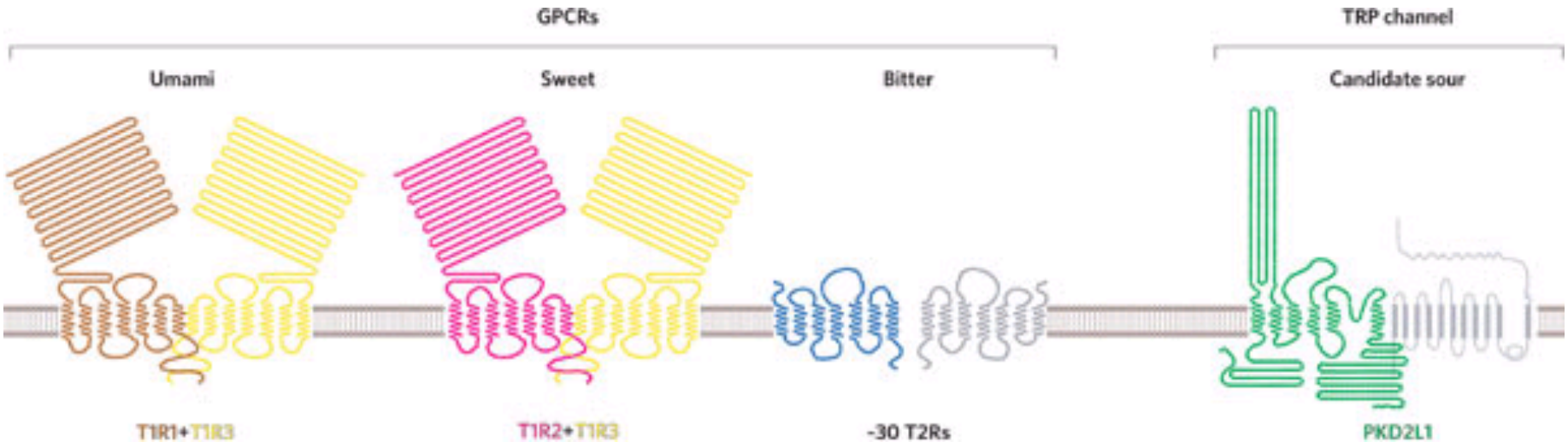
- **ogni papilla gustativa contiene 50-100 cellule recettrici**

- **le cellule recettrici hanno una vita media di 10 giorni**: ogni cellula nervosa deve essere pronta a generare nuove sinapsi con cellule recettrici "simili"

- **cellule recettrici con diversa sensibilità coesistono nelle stessa papilla gustativa**

Transient receptor potential or **TRP** channels: family of loosely related ion channel that are non-selectively permeable to cation, including calcium and magnesium

GPCRs:G-protein-coupled receptors



Dolce

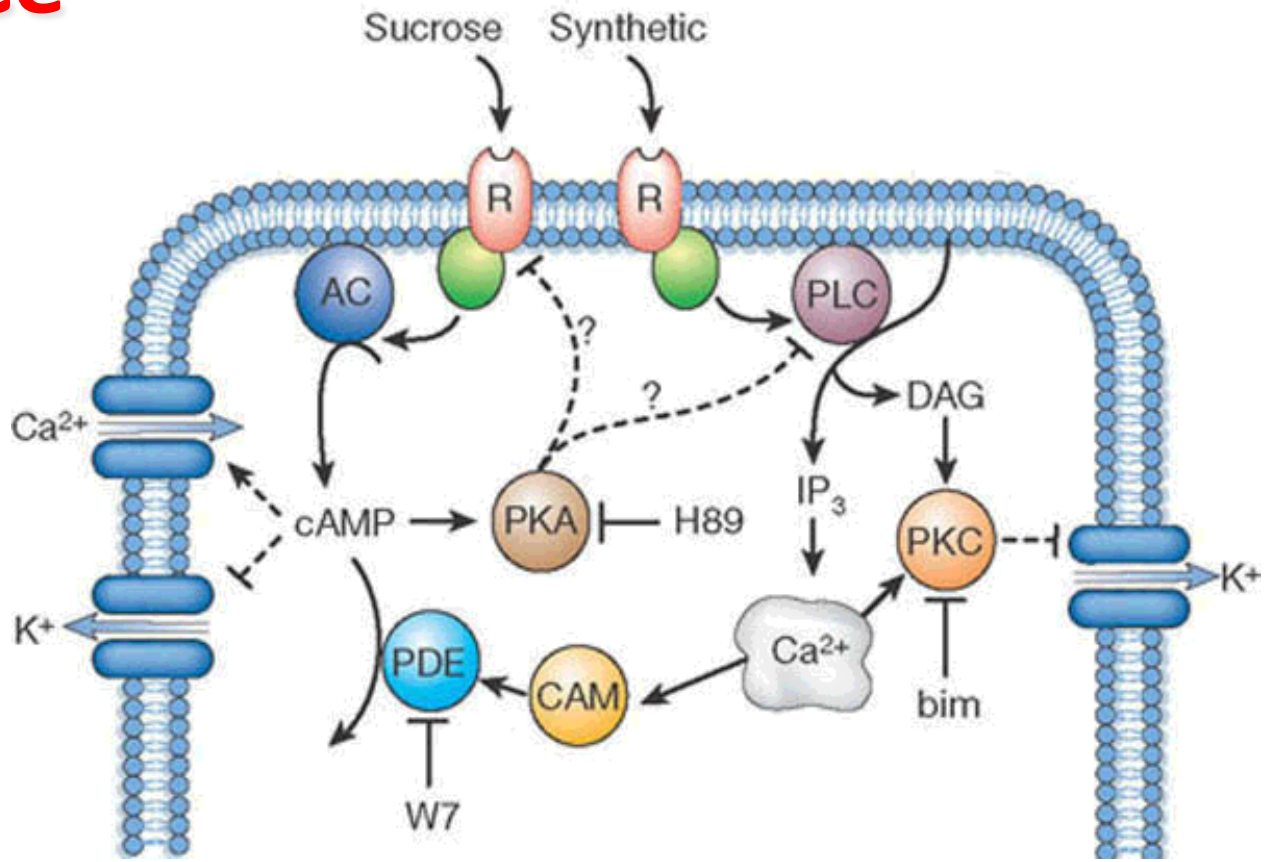


Figure 4 Molecules involved in the transduction of sweet taste. Two separate sweet receptors are shown, but the possibility that one receptor activates both of the transduction pathways[100] is not excluded at this stage. R, candidate receptor(s)[72-75]; AC, adenylate cyclase[81, 82, 87]; cAMP, cyclic adenosine monophosphate[21]; PDE, phosphodiesterase, inhibitor W7 (ref. 89); CAM, calmodulin[89]; PKA, protein kinase A, inhibitor H89 (ref. 89); PLC, phospholipase C[89]; DAG, diacylglycerol; Ins(1,4,5)P_3, inositol-1,4,5-trisphosphate[21]; PKC, protein kinase C, inhibitor bim (bisindolylmaleimide)[89]. For crosstalk between pathways and effects of inhibitors (H89, bim and W7), see ref. 89.

Amaro

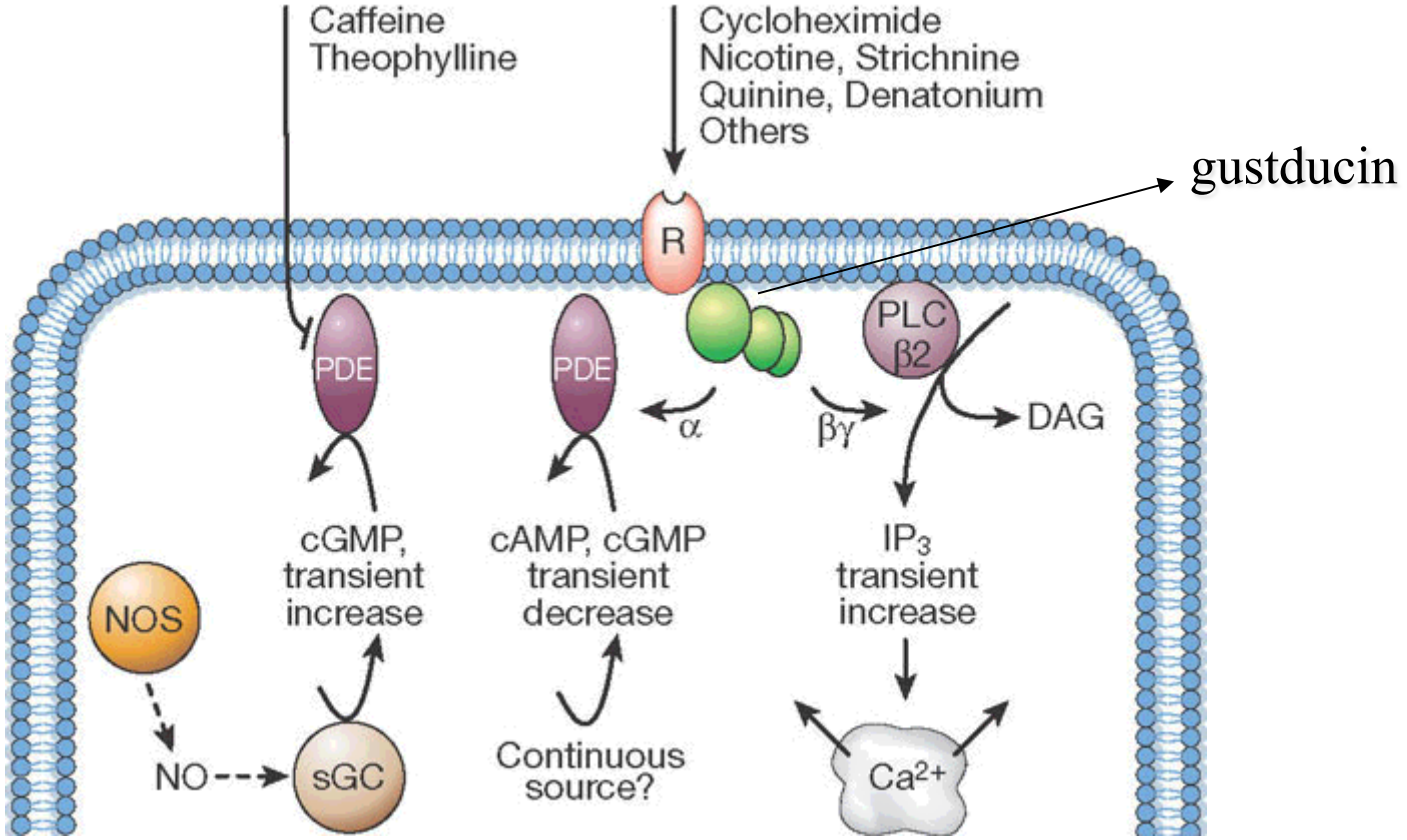
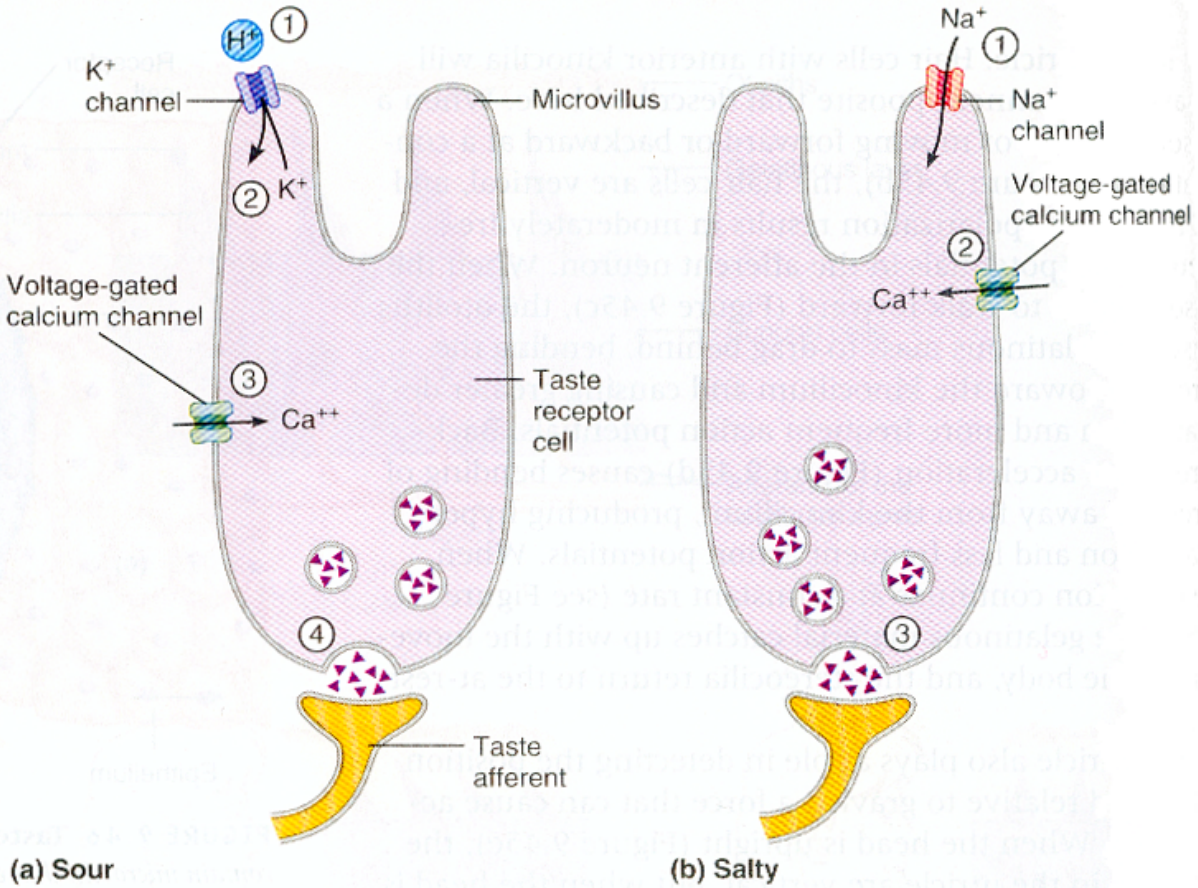


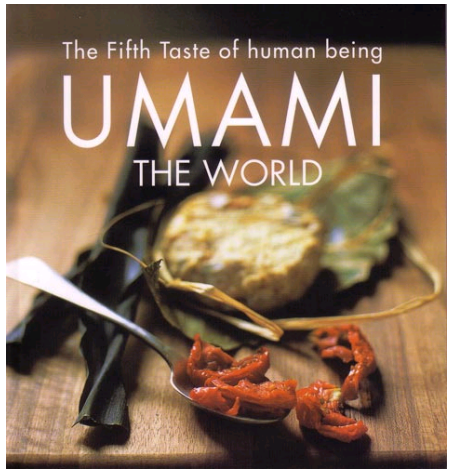
Figure 3 Transduction of bitter taste as elicited by a variety of ligands. Rs, multiple GPCRs of the T2R family, coupled to the G protein gustducin[47-49]; , -subunit of gustducin[6, 57]; , G-protein subunits 3 and 13 (refs 60–62); PLC2, phospholipase C subtype[61]; Ins(1,4,5)P_3, inositol-1,4,5-trisphosphate[59]; PDE, taste-specific phosphodiesterase[58]; cAMP, cyclic adenosine monophosphate[59]; cGMP, cyclic guanosine monophosphate[59]; sGC, soluble guanylate cyclase[55]; NO, nitric oxide[55]; NOS, NO synthase[56]. For second-messenger kinetics, see refs 55,59,63,64.

Acido Salato

FIGURE 9.47 Taste transduction mechanisms for the four primary tastes. **(a)** *Sour is produced by the presence of hydrogen ions.* **(b)** *Salty is produced by the presence of sodium ions.* **(c)** *Sweet is produced by molecules that can bind to a receptor on the plasma membrane of receptor cells.* **(d)** *Bitter taste can be produced by two different mechanisms shown here.*



Sweet, Sour, Salty, Bitter and Umami

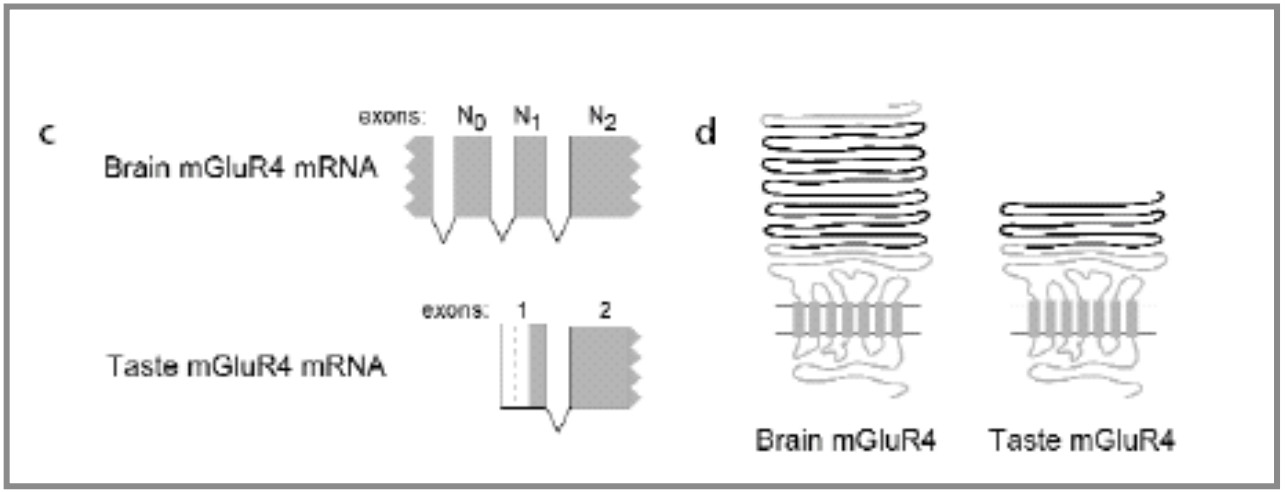


At the beginning of the twentieth century, Professor Kikunae Ikeda of Tokyo Imperial University was thinking about the taste of food:

"There is a taste which is common to asparagus, tomatoes, cheese and meat but which is not one of the four well-known tastes of sweet, sour, bitter and salty."

It was in 1907 that Professor Ikeda started his experiments to identify what the source of this distinctive taste was. He knew that it was present in the "broth" made from kombu (a type of seaweed) found in traditional Japanese cuisine. Starting with a tremendous quantity of kombu broth, he succeeded in extracting crystals of glutamic acid (or glutamate). Glutamate is an amino acid, and is a building block of protein. Professor Ikeda found that glutamate had a distinctive taste, different from sweet, sour, bitter and salty, and he named it "umami". 100 grams of dried kombu contain about 1 gram of glutamate.

Professor Kikunae Ikeda

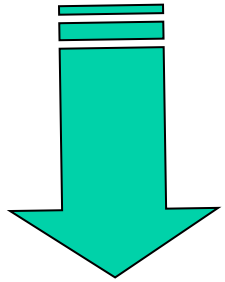


Sesto gusto?

Il recettore per il GRASSO

- E' stato recentemente identificato un recettore che riconosce gli acidi grassi
- l'espressione di questo recettore è correlata alla maggior tendenza a scegliere cibi ricchi di grassi
- ci sono evidenze sperimentali che associano la percezione del *grasso* con un meccanismo di trasduzione associato all'attivazione di conduttanze al K+ (Gilbertson et al 1997)

trigliceridi —*lipasi **→ acidi grassi → ATTIVAZIONE RECETTORE



AUMENTO ASSORBIMENTO GRASSI

* Il blocco farmacologico della lipasi riduce l'assorbimento dei grassi

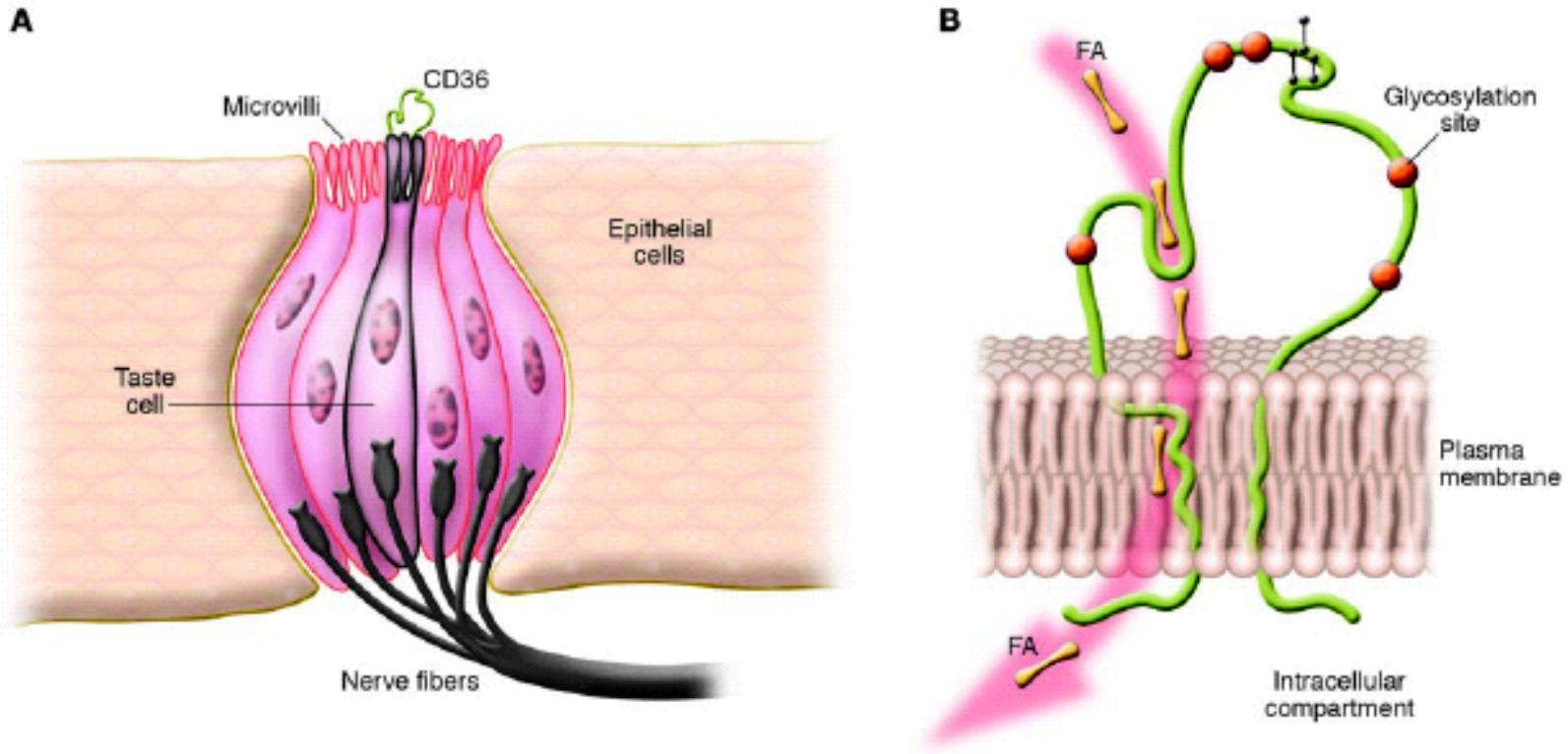
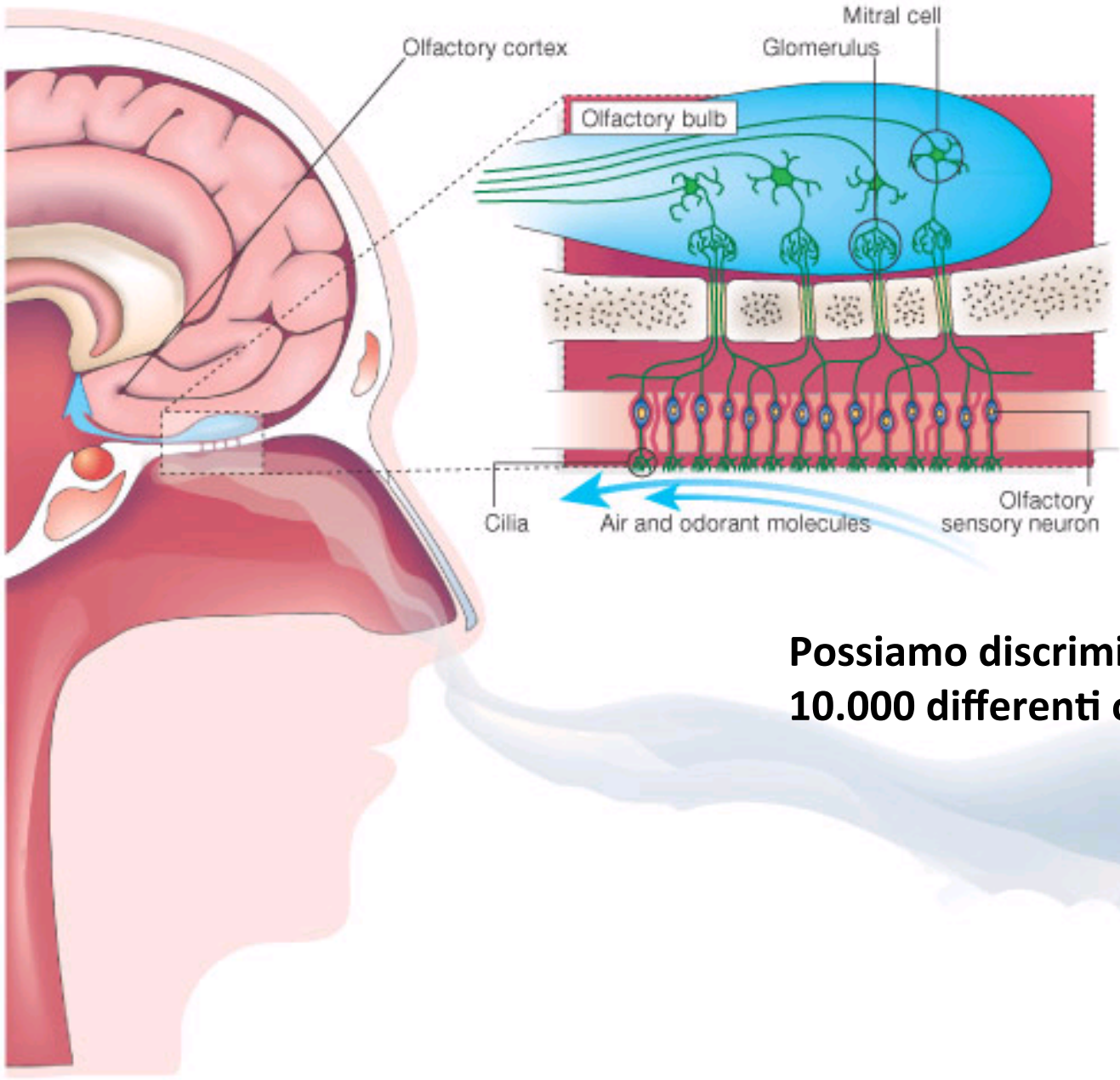


Figure 1

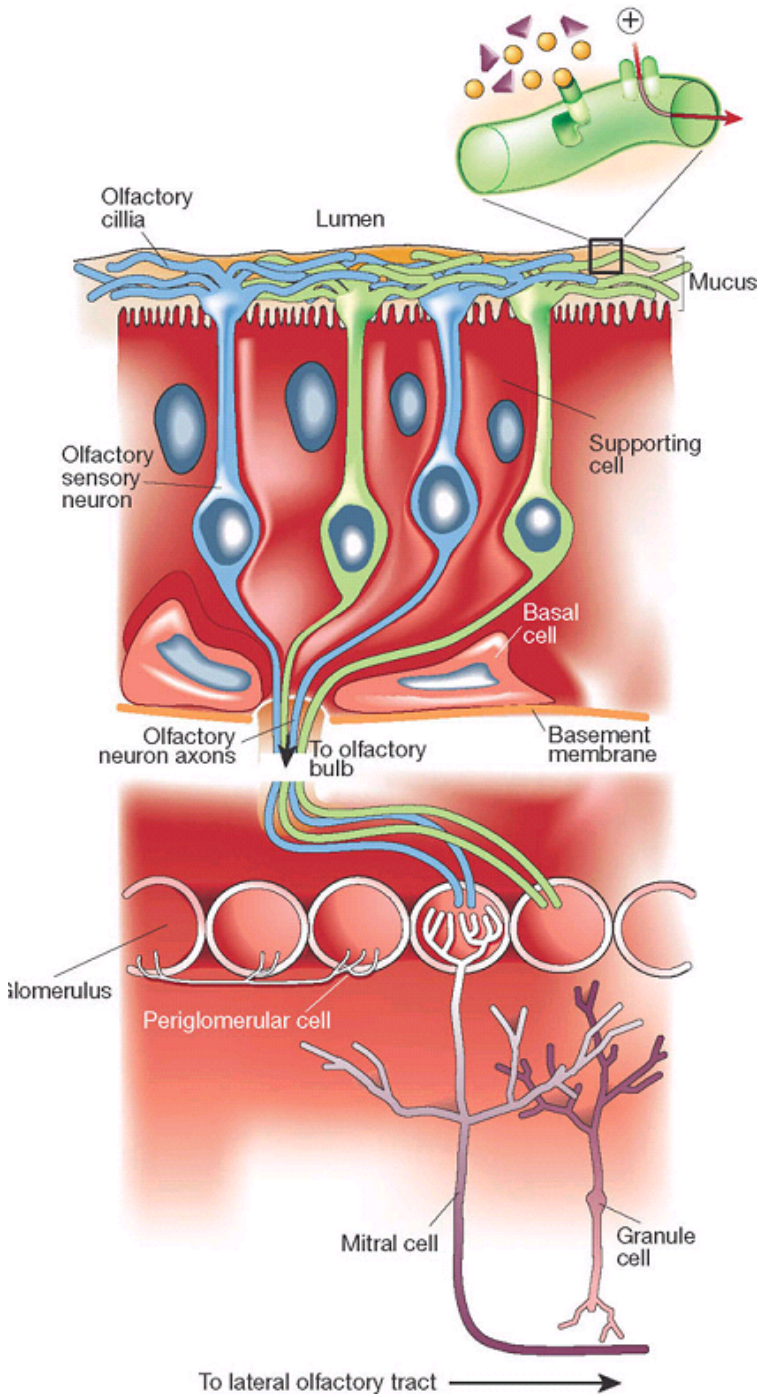
The taste bud and the predicted structure of the taste receptor for fat, CD36, expressed on the apical surface of taste cells. (A) Schematic structure of a taste bud, which contains 50–100 taste cells. One such taste cell is highlighted, showing CD36 expression on its apical surface. Following interaction of CD36 with FAs derived from hydrolysis of triglycerides by lingual lipase, a signal is transduced to nerve fibers, which leads to taste perception and release of bile acid, preparing the digestive system for fat absorption. (B) The predicted structure of membrane CD36, which is proposed to function as a taste receptor recognizing long-chain FAs (10). CD36 is heavily glycosylated (orange circles) and also N-myristoylated and palmitoylated at multiple sites adjacent to both the N and C termini (not shown). CD36 binds FAs with high affinity, presumably in its extracellular domain, and facilitates their transfer into the cell, a process that may involve interaction with other proteins. In taste bud cells, interaction of the FA with CD36 may be sufficient to initiate signaling events without internalization. Alternatively, internalization and generation of intracellular FA derivatives may be required for signal transduction.

La percezione olfattiva



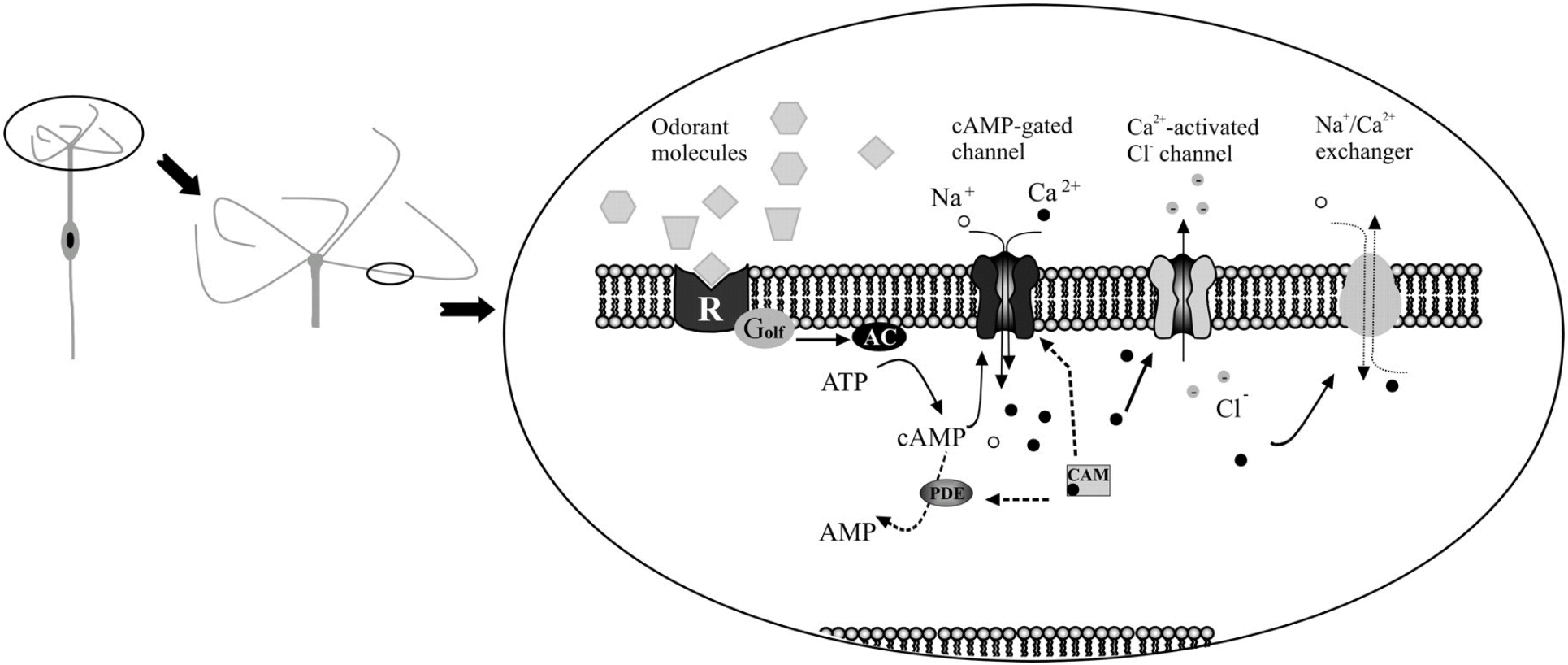
Possiamo discriminare circa 10.000 differenti odori!!

C. Dennis Nature 428, 362 -364 (2004)



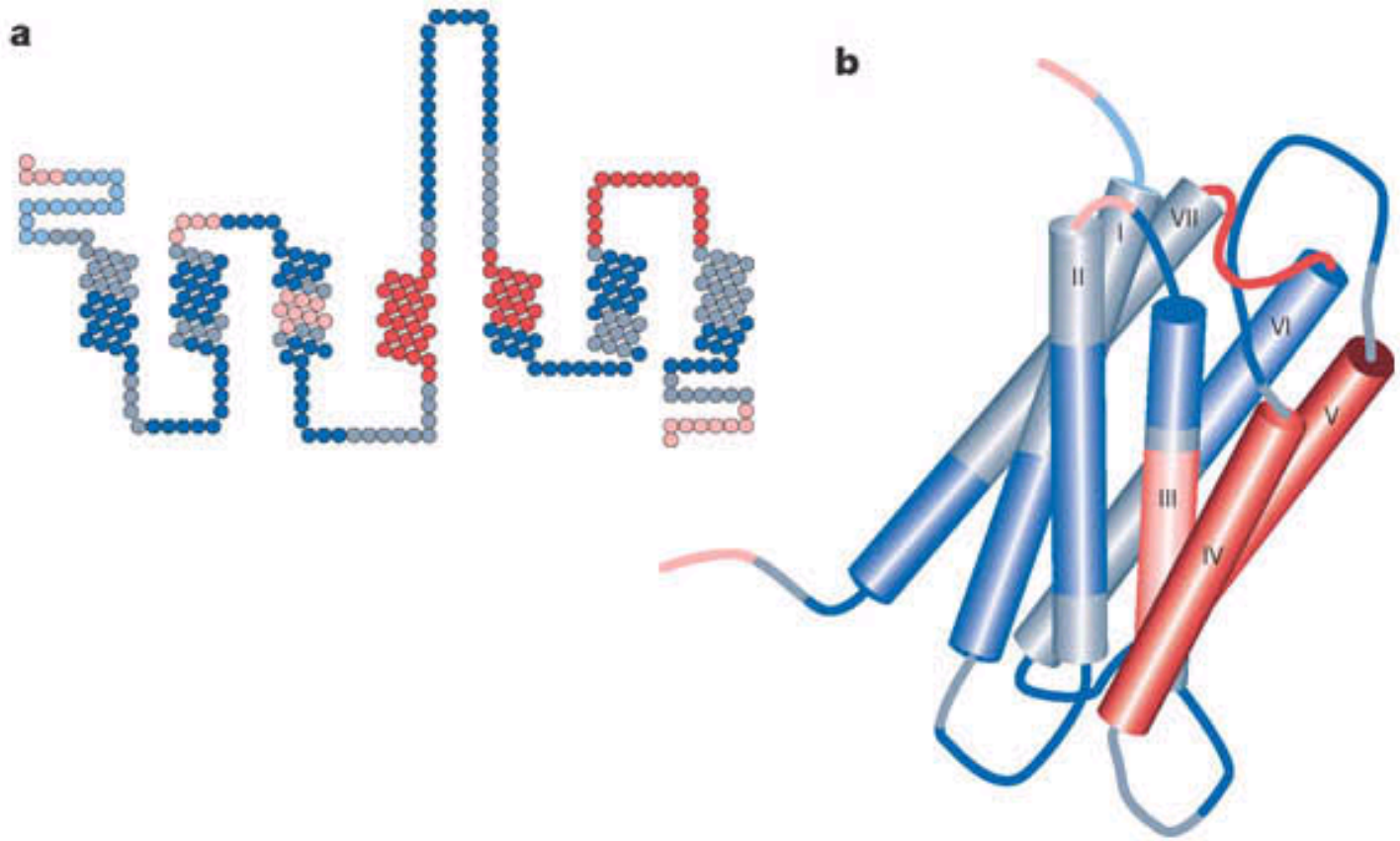
The olfactory neuroepithelium is a relatively simple tissue consisting of only three cell types: olfactory sensory neurons (OSNs; the only neuronal cell type), supporting or sustentacular cells (a kind of glial cell, which possess microvilli on their apical surface), and a stem-cell population, known as basal cells, from which new OSNs are generated.

Wiring of the early olfactory system. Each OSN expresses only one of the **1,000 OR genes** and the axons from all cells expressing that particular receptor converge onto one or a few 'glomeruli' in the OB. The nearly **2,000 glomeruli** in the rat OB are spherical knots of neuropil, about 50–100 m in diameter, which contain the incoming axons of OSNs and the apical dendrites of the main input-output neuron of the OB, the mitral cell. Mitral axons leaving the OB project widely to higher brain structures including the piriform cortex, hippocampus and amygdala. Lateral processing of the message occurs through two populations of interneurons: periglomerular cells and granule cells.



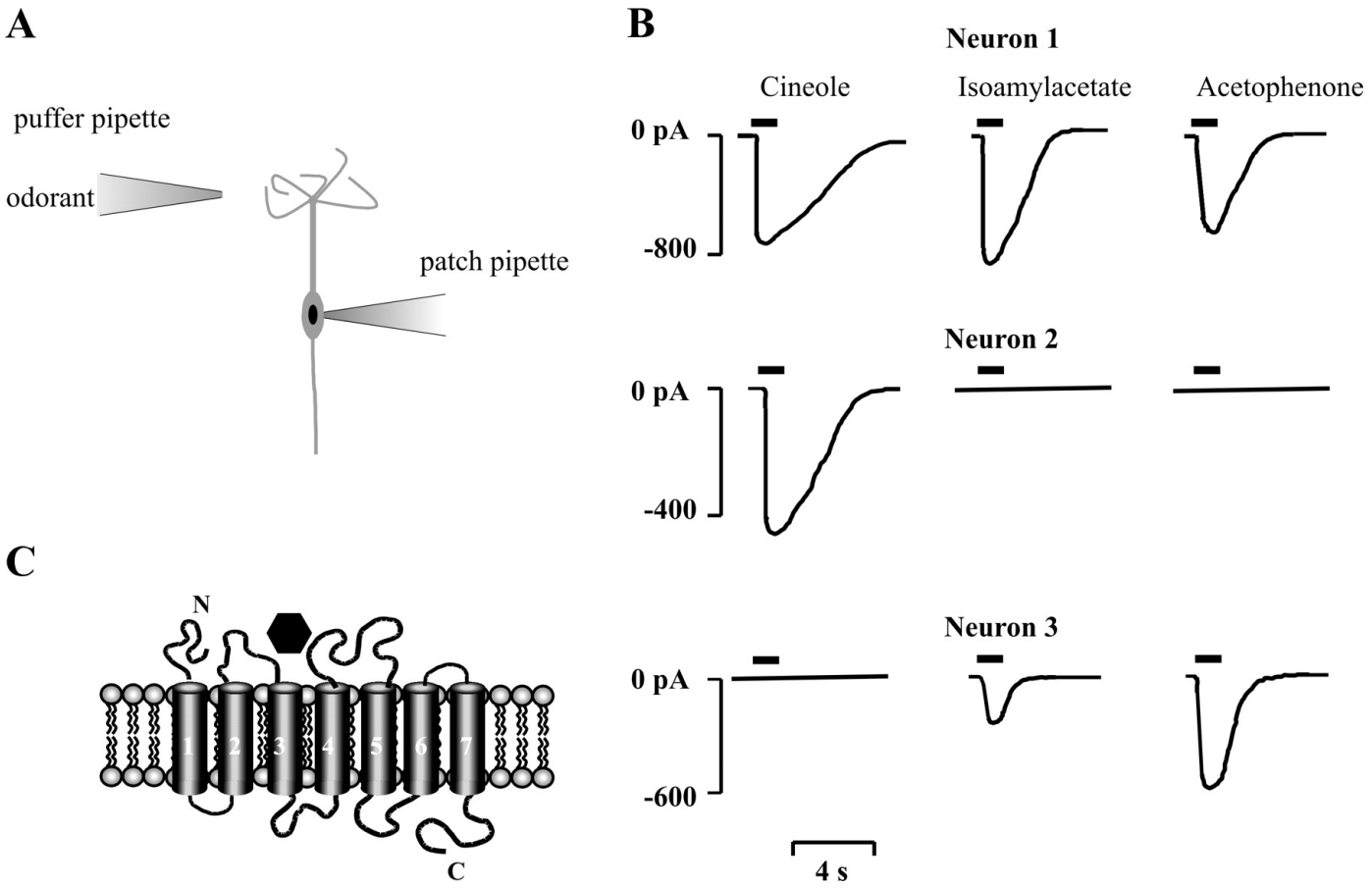
Olfactory transduction. Olfactory transduction takes place in the cilia of the olfactory sensory neurons. Odorant molecules bind to odorant receptors (R) located in the ciliary membrane, thus activating a G protein (Golf) that stimulates adenylyl cyclase (AC), producing an increase in the generation of cAMP from ATP. cAMP directly gates ion channels, causing an inward current carried by Na^+ and Ca^{2+} ions. Ca^{2+} entry amplifies the signal by activating a Cl^- current. These ion fluxes cause a depolarization. Inhibitory actions (dashed lines) are played by the complex Ca^{2+}-calmodulin (Ca^{2+}-CaM) by increasing the activity of the phosphodiesterase (PDE) that hydrolyzes cAMP and by reducing the affinity for cAMP of the cAMP-gated channel. Ca^{2+} is extruded by the Na^+/Ca^{2+} exchanger.

Menini, A. et al. News Physiol Sci 19: 101-104 2004;



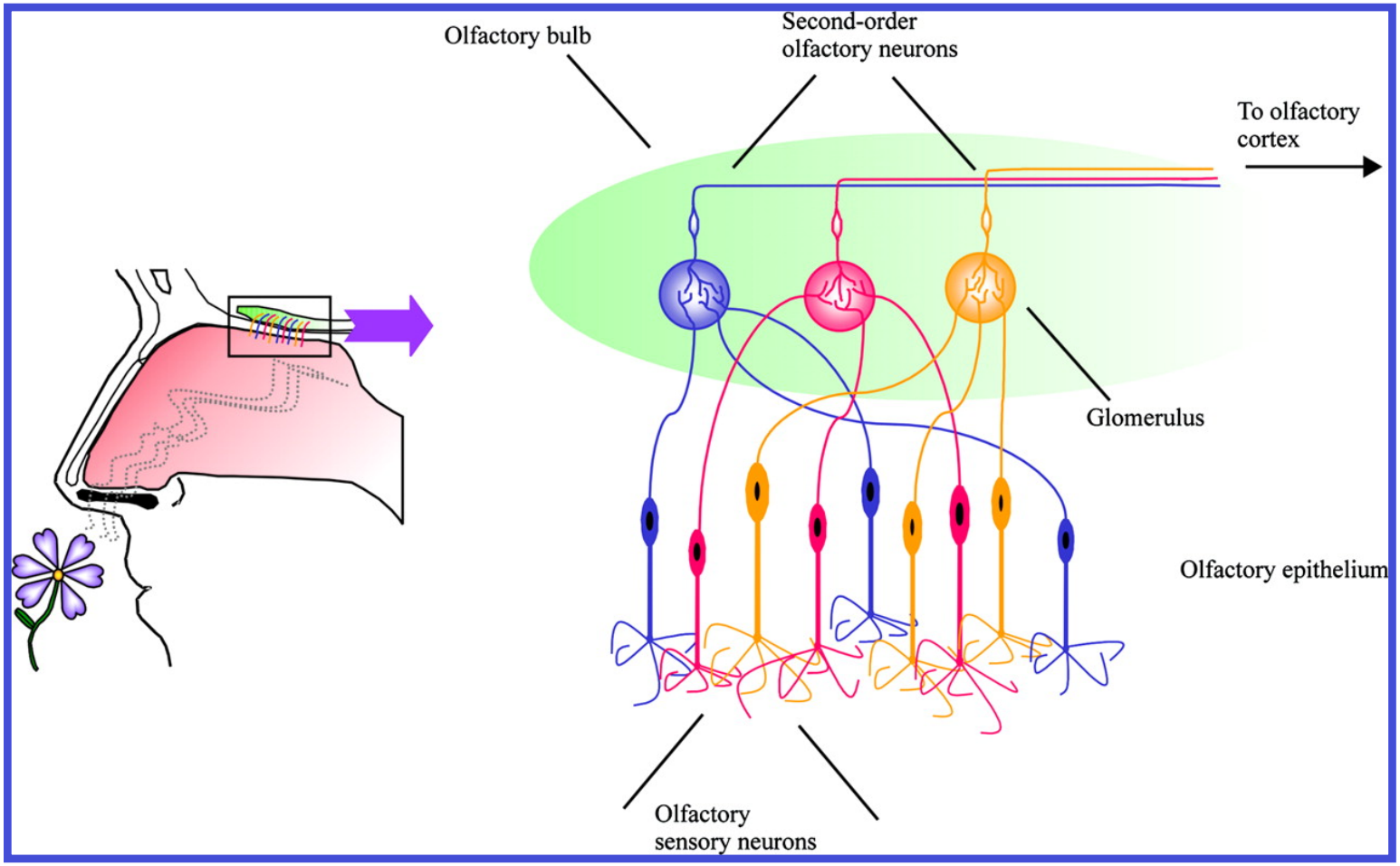
The odorant receptors comprise the largest family of GPCRs. In mammals, odour receptors are represented by as many as 1,000 genes and may account for as much as 2% of the genome. Sequence comparison across the receptors has revealed many regions of conservation and variability that may be related to function. a, In a 'snake' diagram showing the amino acids for a particular receptor (M71), those residues that are most highly conserved are shown in shades of blue and those that are most variable are shown in shades of red. The seven -helical regions (boxed) are connected by intracellular and extracellular loops. b, A schematic view of the proposed three-dimensional structure of the receptor based on the recently solved structure of rhodopsin. Each of the transmembrane regions is numbered according to that model. **The conserved (blue) and variable (red) regions are sketched onto this qualitative view and suggest that a ligand-binding region may be at least partially formed by the variable regions of the receptor.**

Responses of individual olfactory sensory neurons to different odorants



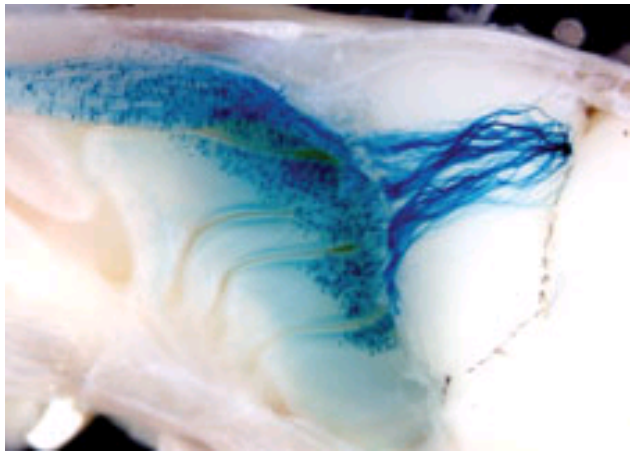
Menini, A. et al. News Physiol Sci 19: 101-104 2004;

Organizzazione del sistema olfattivo



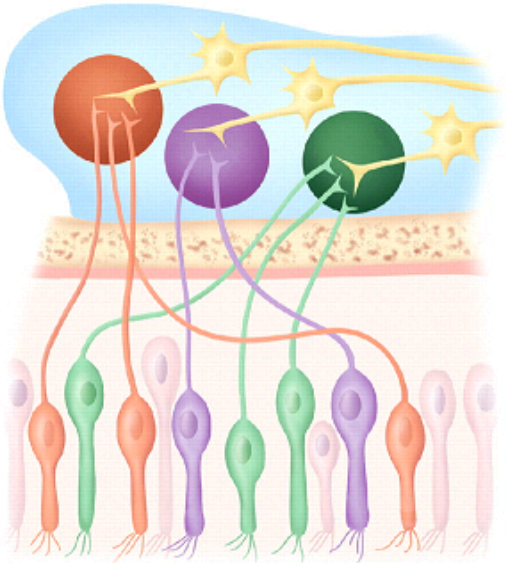
Menini, A. et al. News Physiol Sci 19: 101-104 2004

Convergenza assonale verso il glomerulo



C. Dennis Nature 428, 362 -364 (2004)

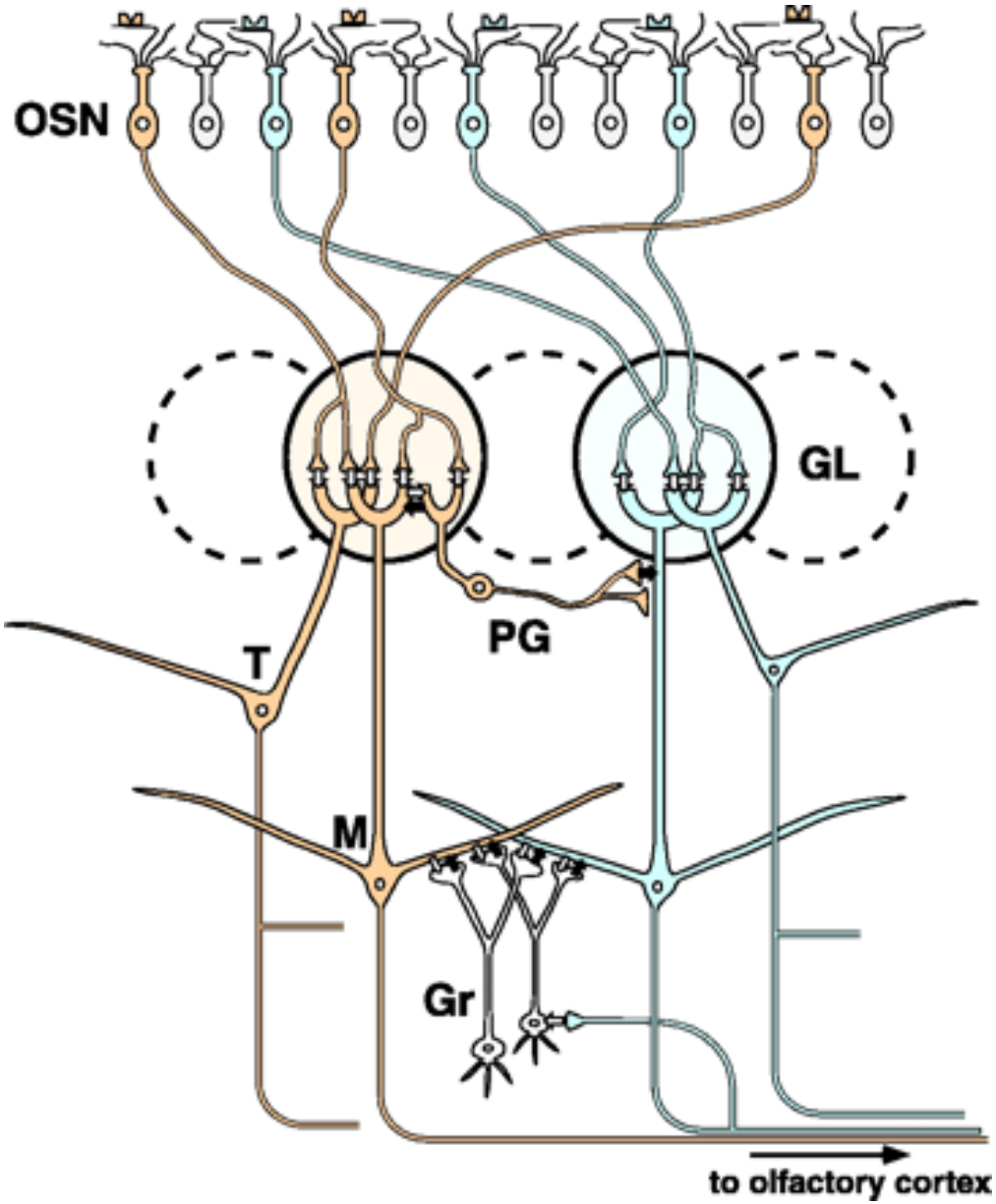
Nasal passage: smells are picked up by receptors on cilia at the end of a sensory neuron. Sensory cells bearing the same receptor (stained blue, above) then connect to the same glomerulus (top right).



P. Mombaerts Science 286, 707 -711 (1999)

Olfactory sensory neurons that express the same odorant receptor gene project their axons to either of two glomeruli in the olfactory bulb. Three populations of OSNs, each expressing a different OR, are depicted in different colors. Their axons converge on specific glomeruli, where they synapse with the dendrites of the second-order neurons (in yellow).

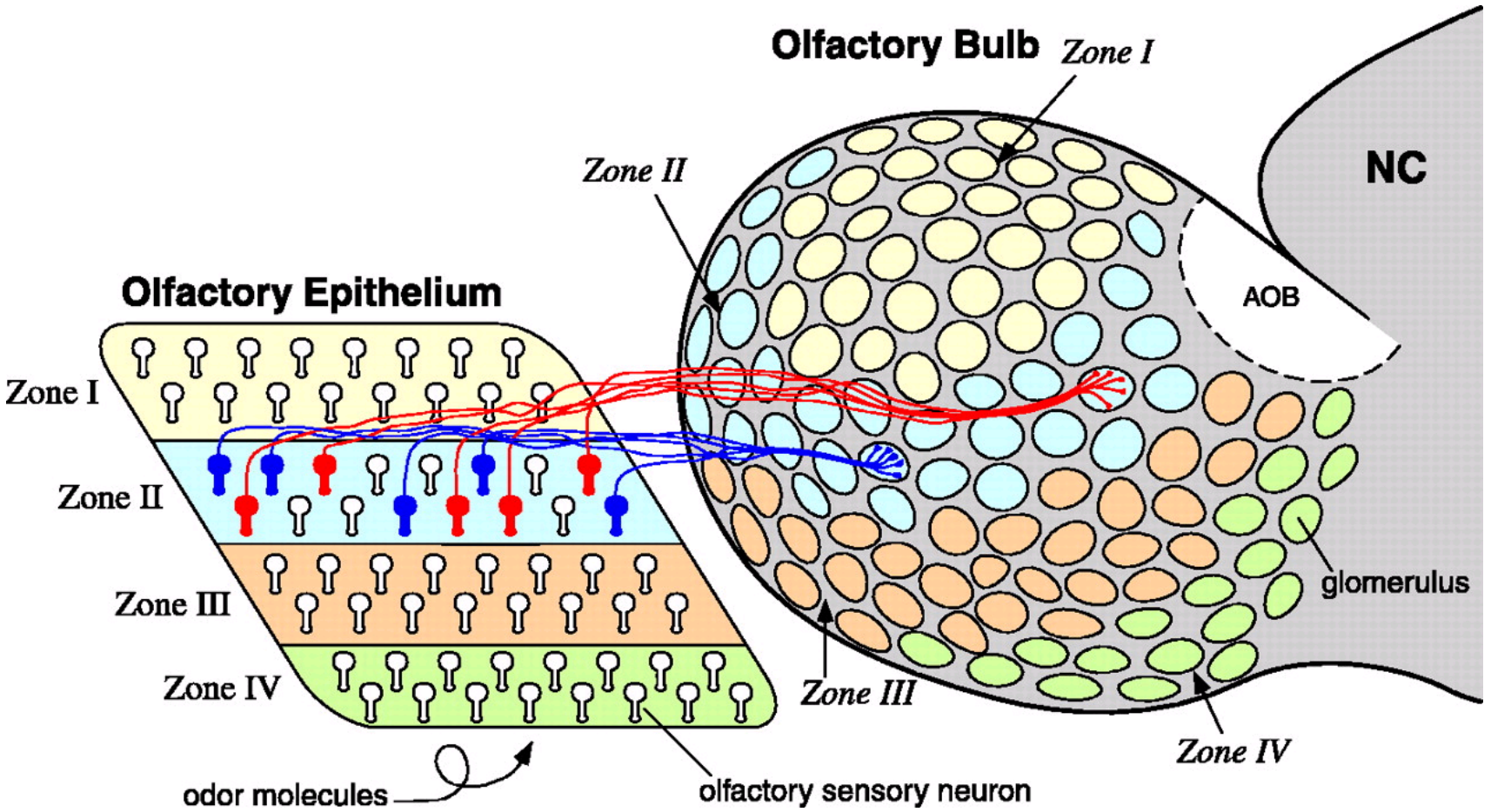
2.000.000 di neuroni olfattivi che esprimono 347 recettori
e ogni neurone esprime un solo recettore



OSN = neuroni sensoriali olfattivi

1000 glomeruli:
3 glomeruli per ogni recettore!!
Ogni glomerulo è contattato da
20.000 neuroni gemelli.

Bulbo olfattivo:
GL = glomeruli
PG = cellule periglomerulari
T = cellule T
M = cellule mitrali
Gr = cellule granulari



Schematic diagram illustrating the axonal connectivity pattern between the nose and the MOB. The OE in mice is divided into four zones (zones I through IV) that are defined by the expression of odorant receptors. Olfactory sensory neurons in a given zone of the epithelium project to glomeruli located in a corresponding zone (*zones I* through *IV*) of the MOB. Axons of sensory neurons expressing the same odorant receptor (red or dark blue) converge to only a few defined glomeruli. NC, neocortex; AOB, accessory olfactory bulb.

“un glomerulo - un recettore”

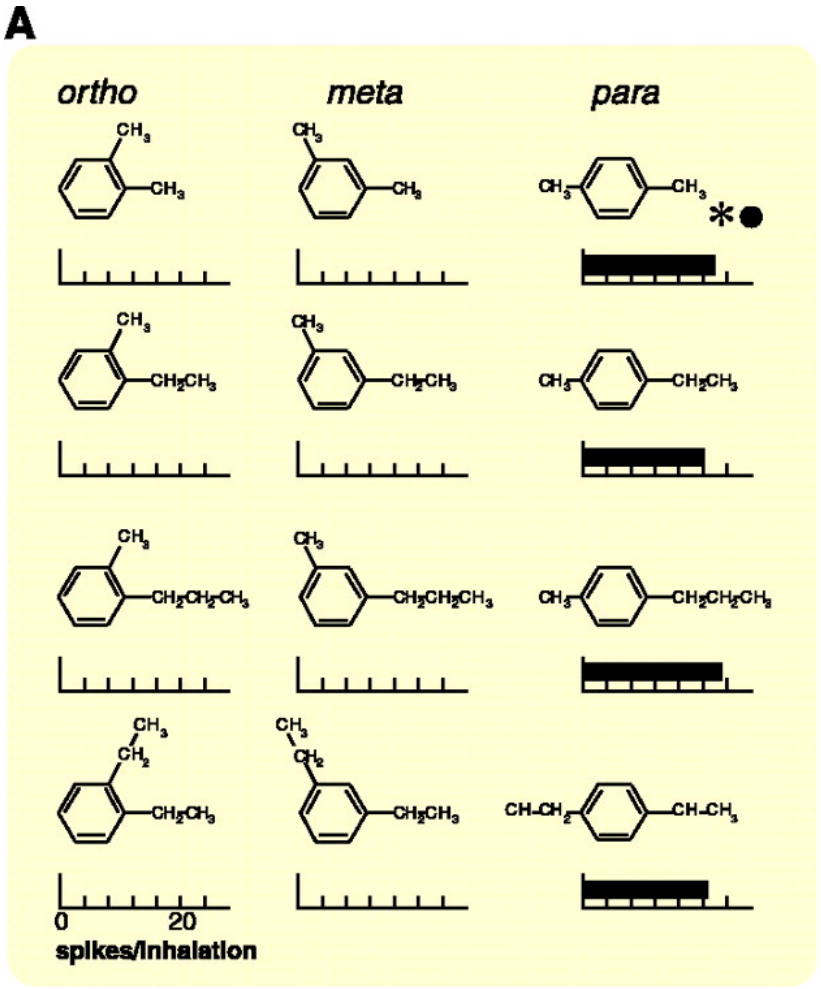


Fig. A. La cellule mitrale è sensibile ai paraisomeri del benzene.

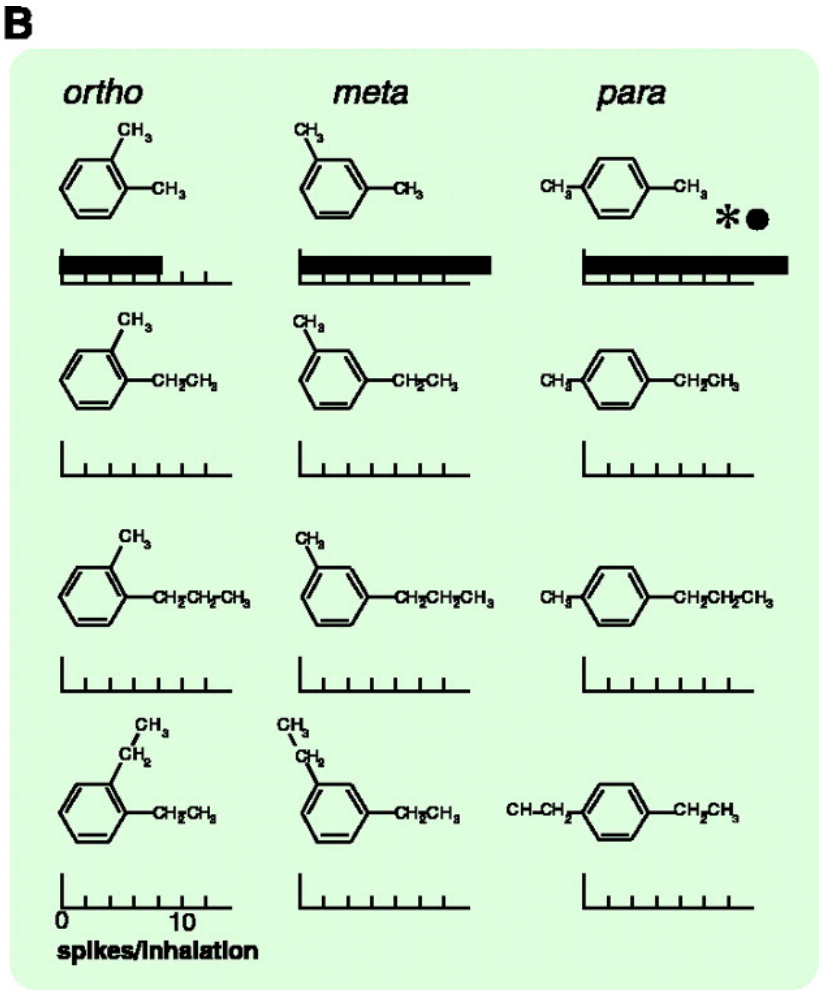
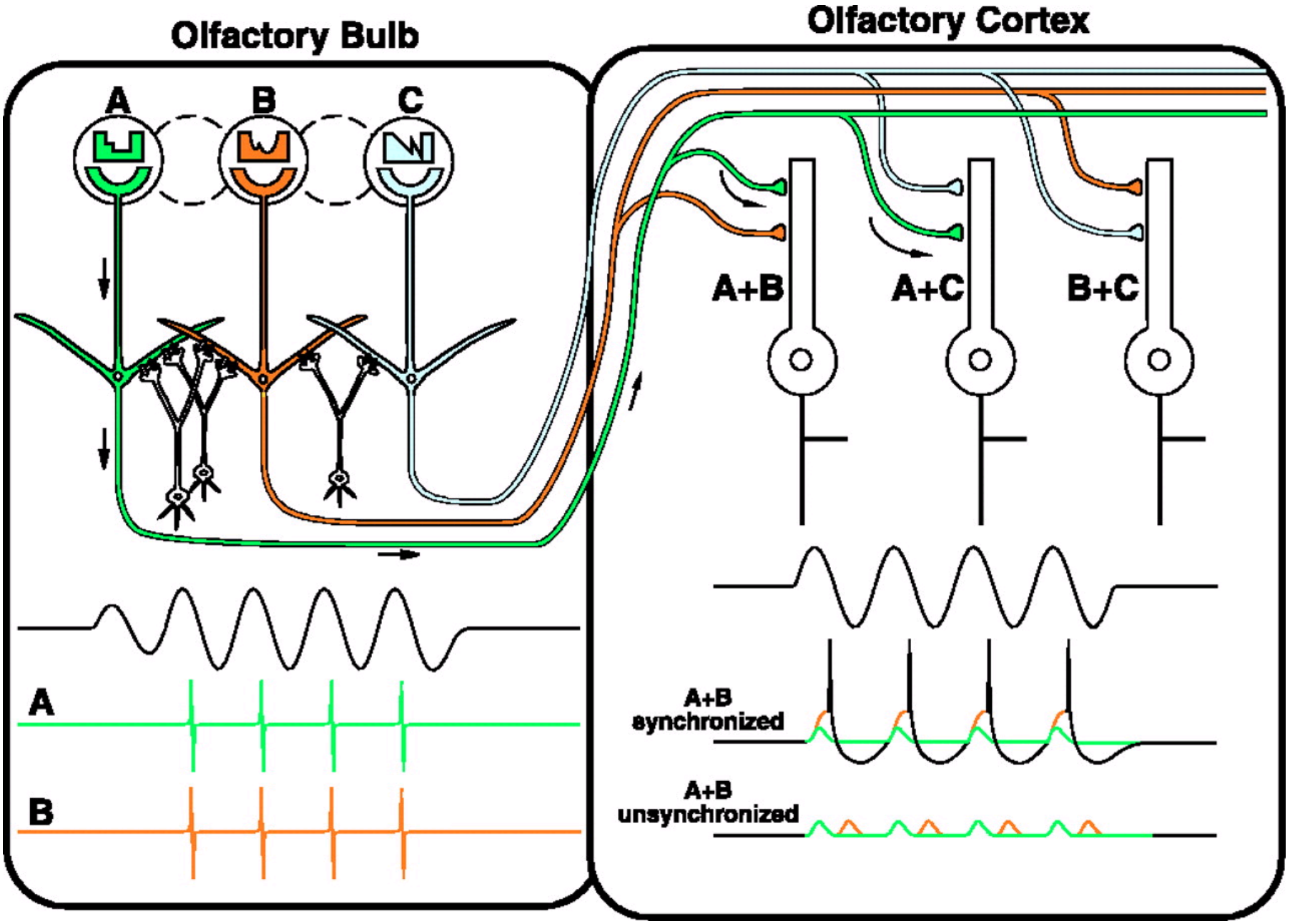
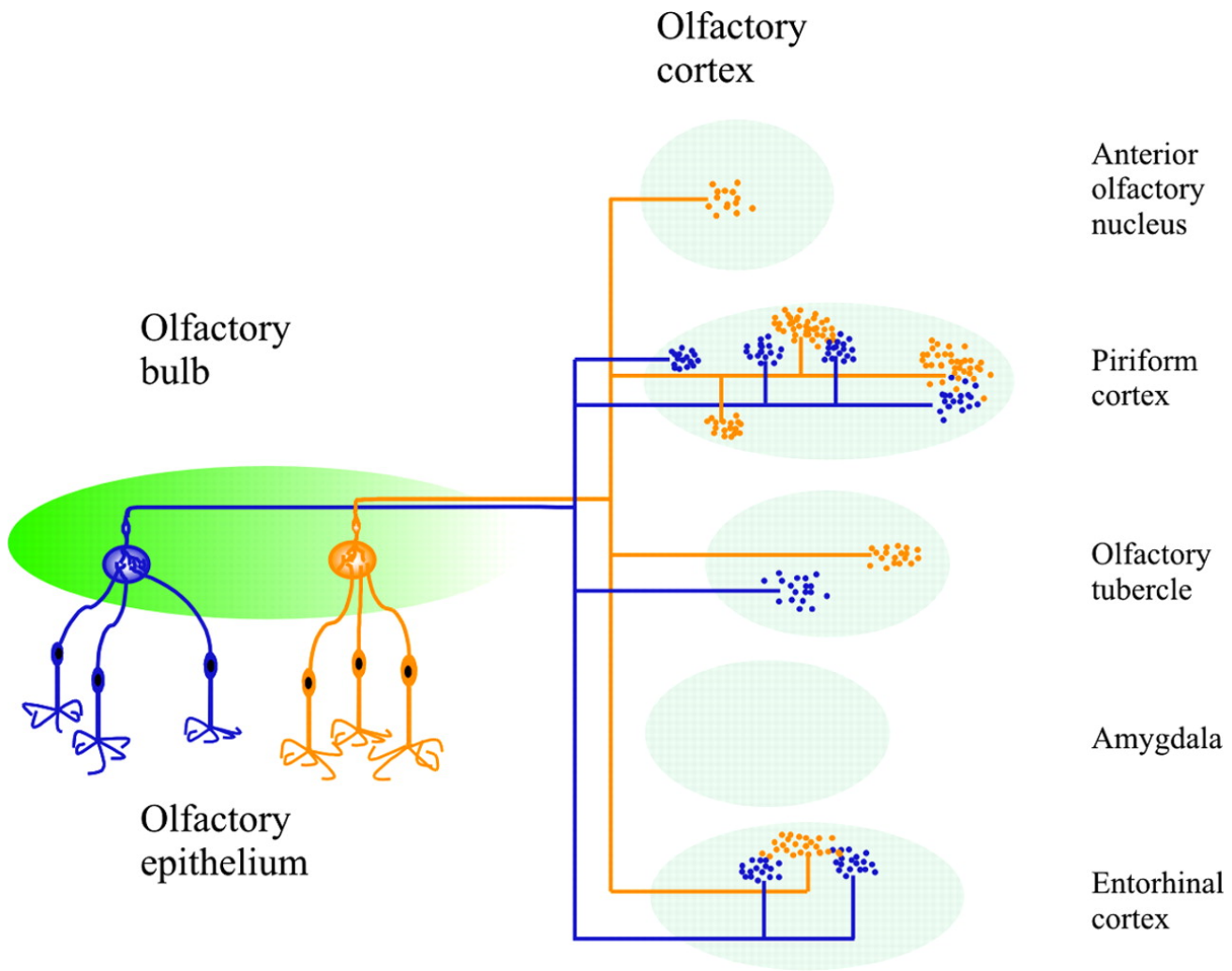


Fig. B. La cellule mitrale è sensibile al benzene legato a catene corte.

K. Mori Science 286, 711 -715 (1999)


Olfactory Bulb
Olfactory Cortex
A
B
C
A+B
A+C
B+C
A
B
A+B
synchronized
A+B
unsynchronized

Dai recettori alla corteccia olfattiva



Menini, A. et al. News Physiol Sci 19: 101-104 2004;