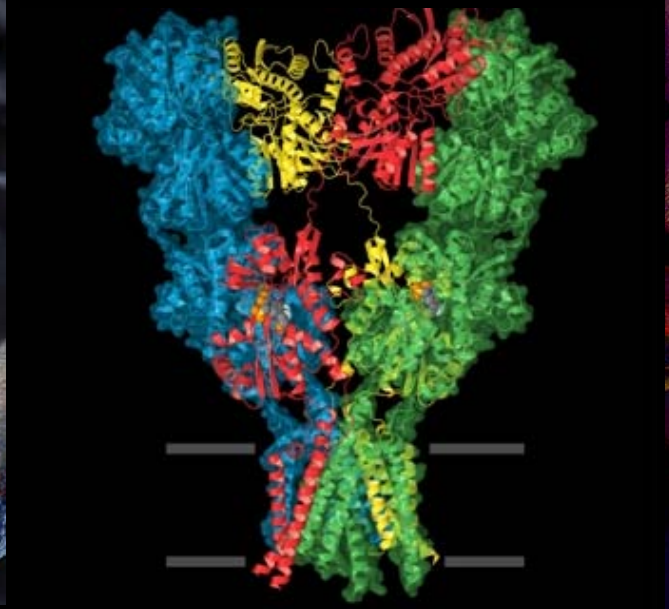
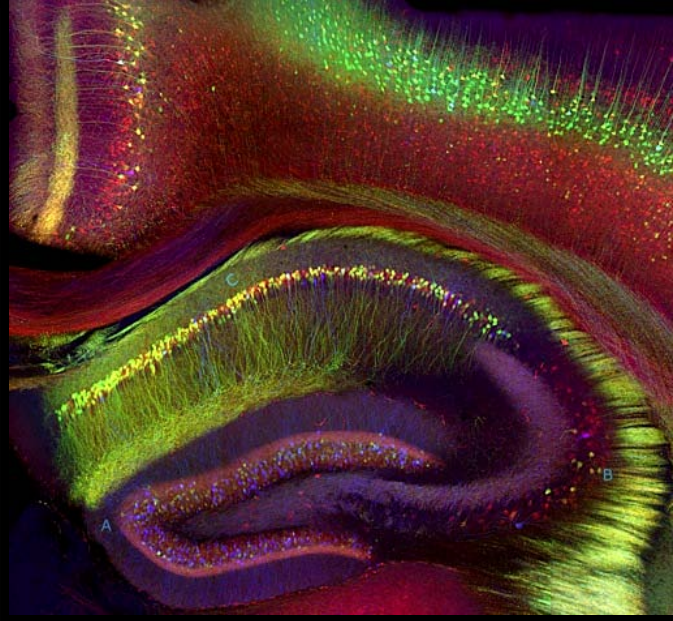
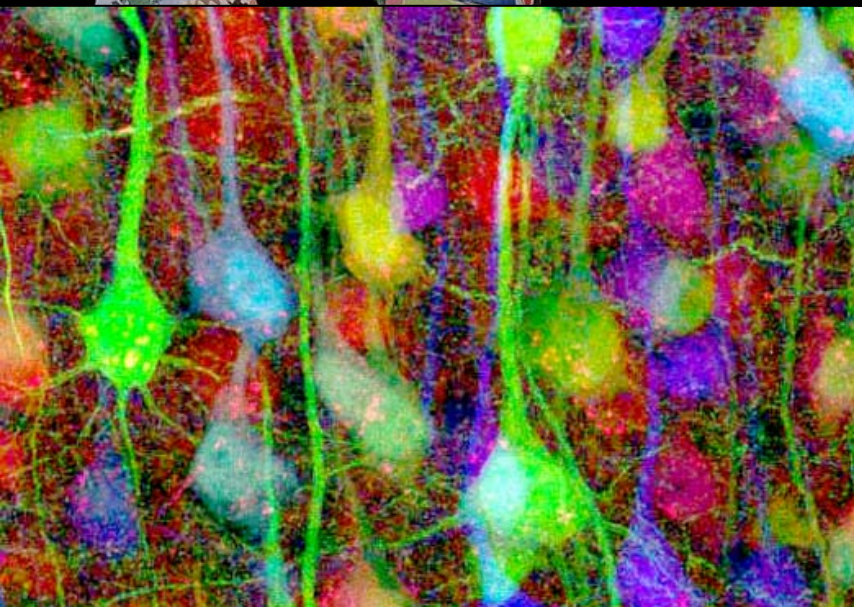


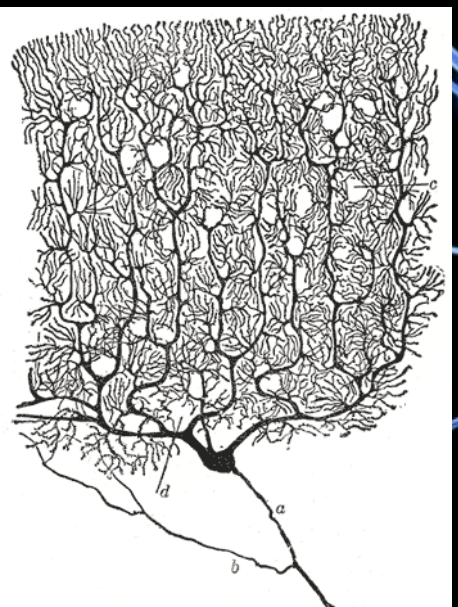


Les sens chimiques

Prof. Alan Carleton

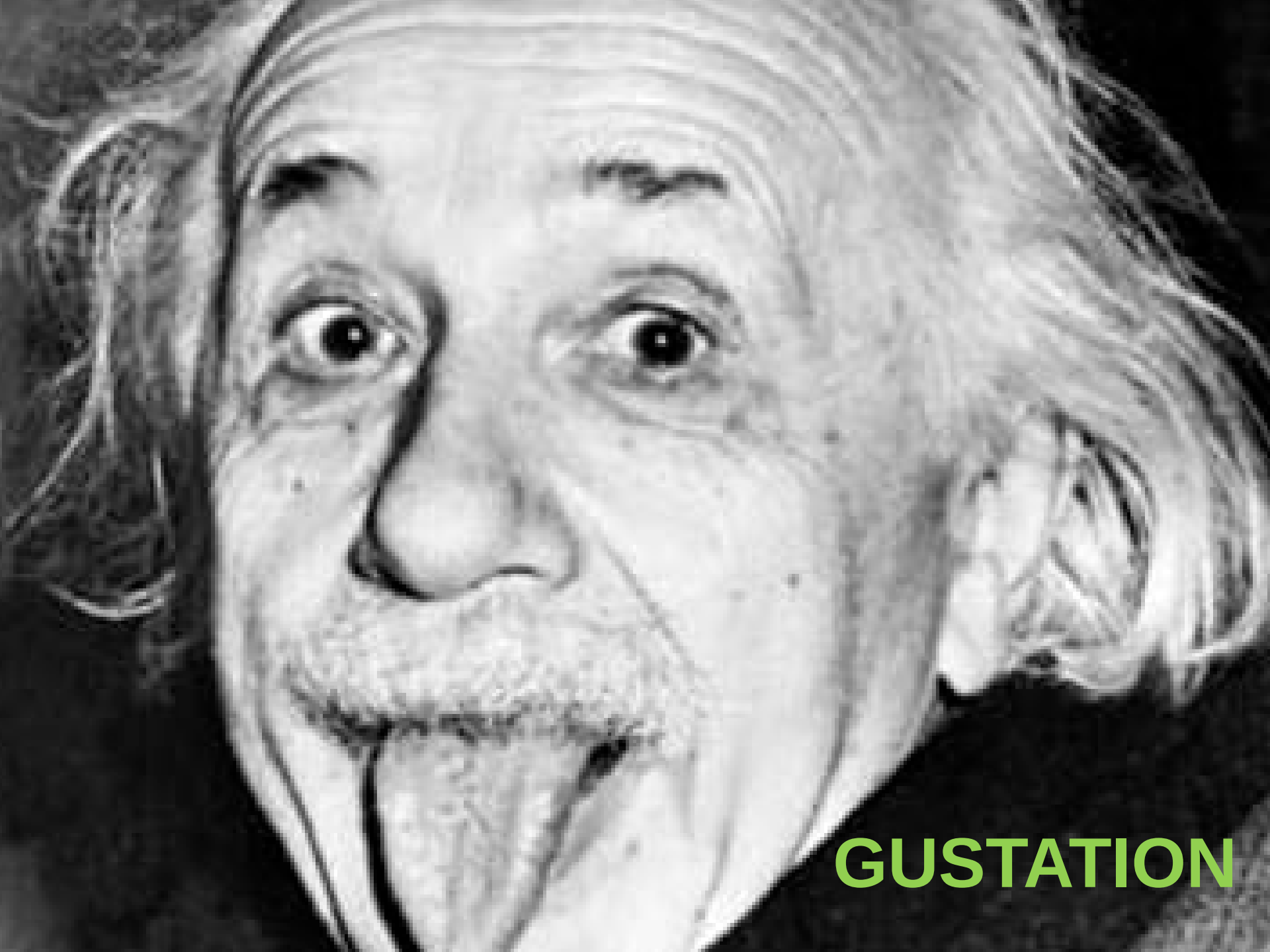
Département de Neurosciences Fondamentales



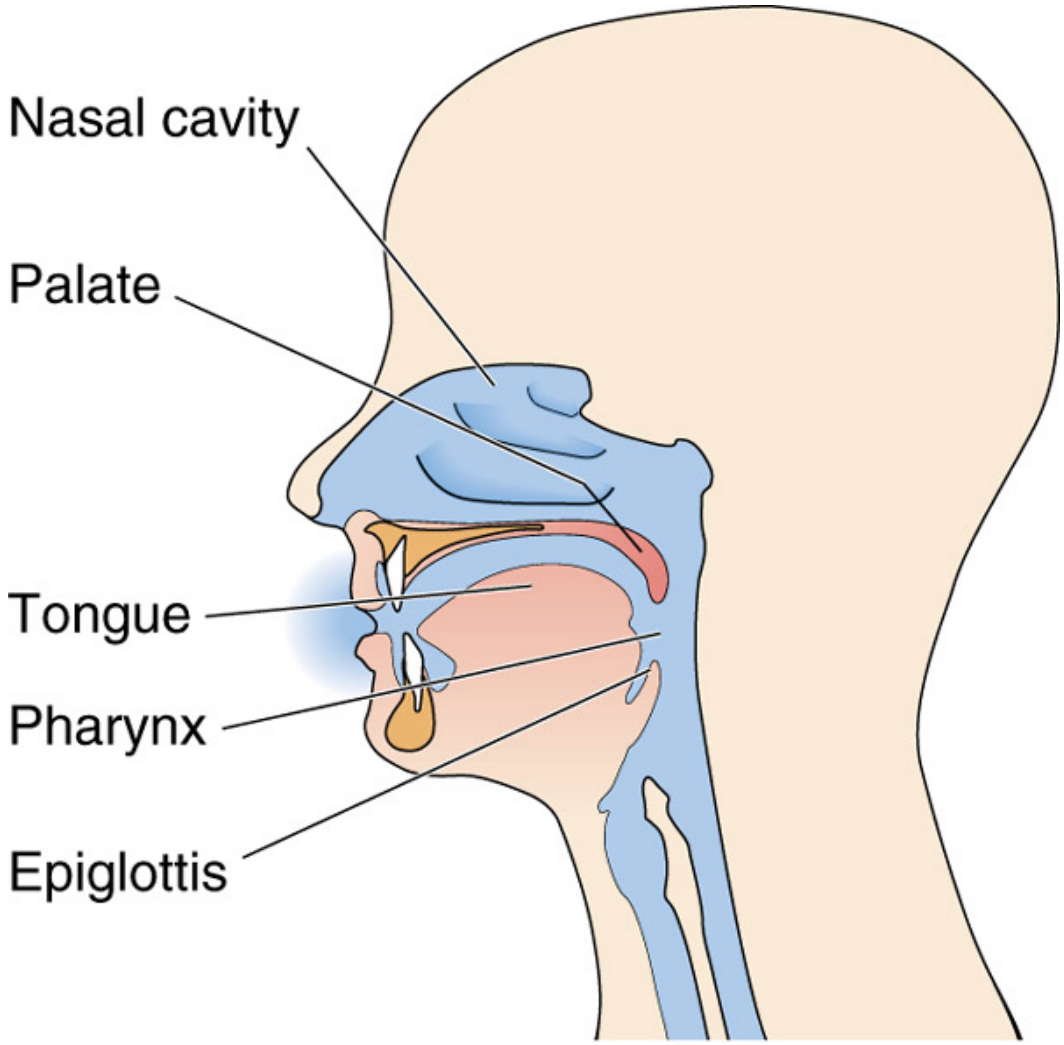


Les sens chimiques

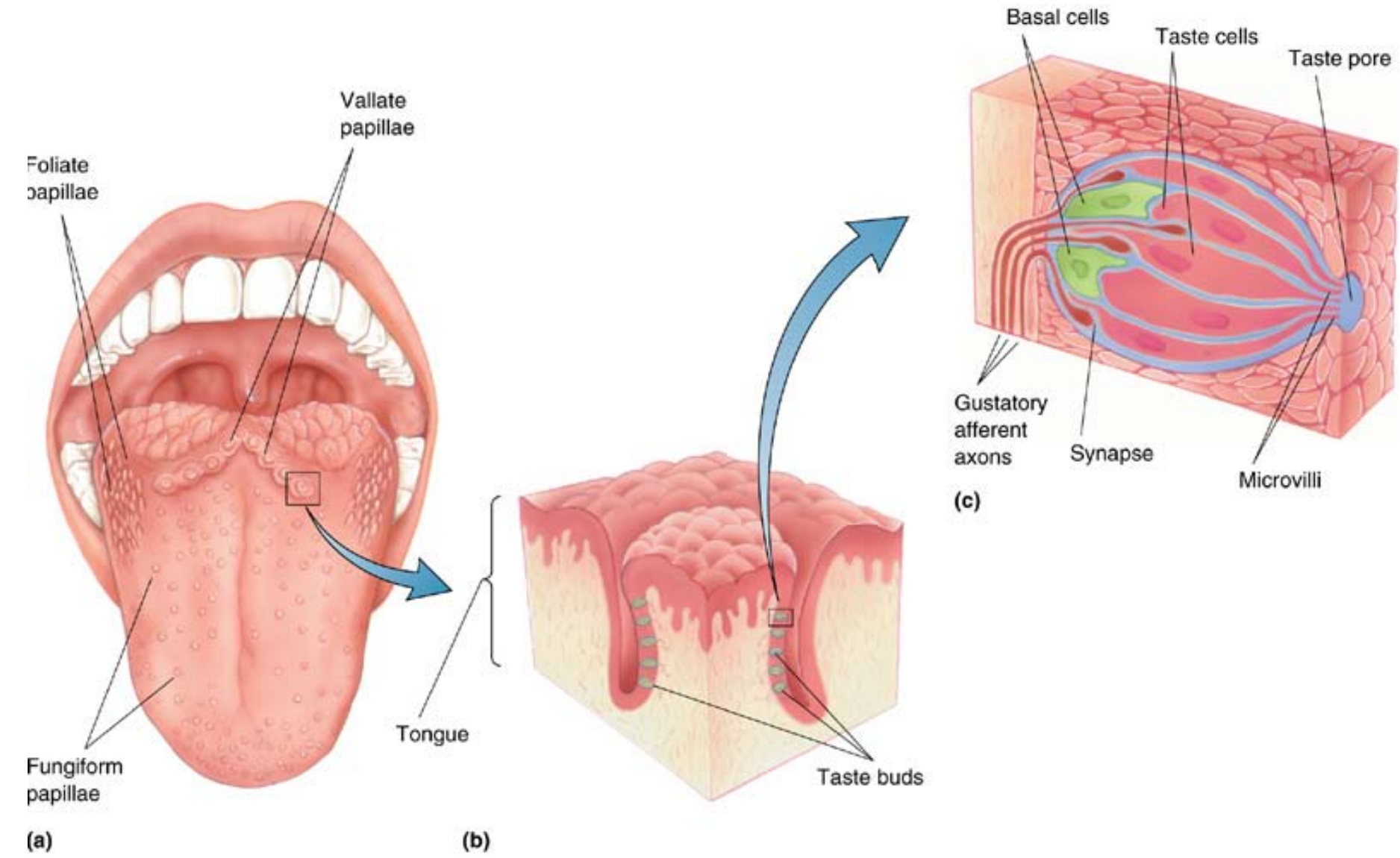
- Le système olfactif principal
- Organe voméronasal et détection des phéromones
- La perception des goûts


GUSTATION

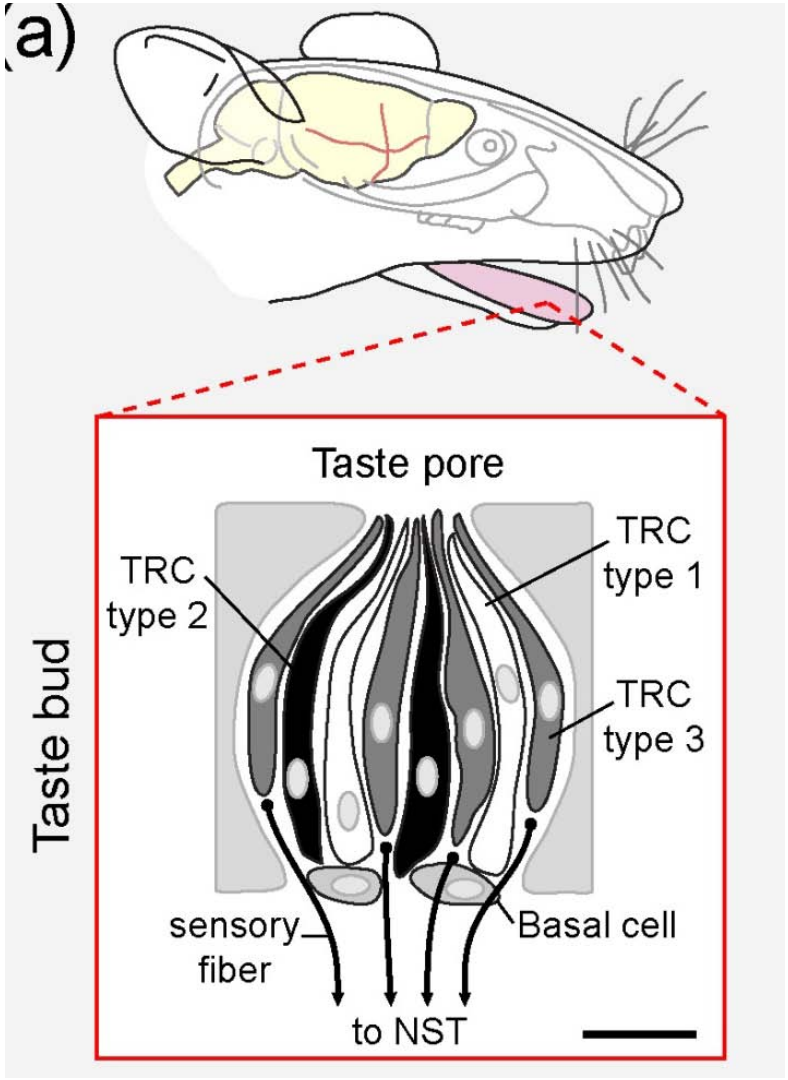
Organisation anatomique de la perception du goût



Les bourgeons du goût et papilles gustatives

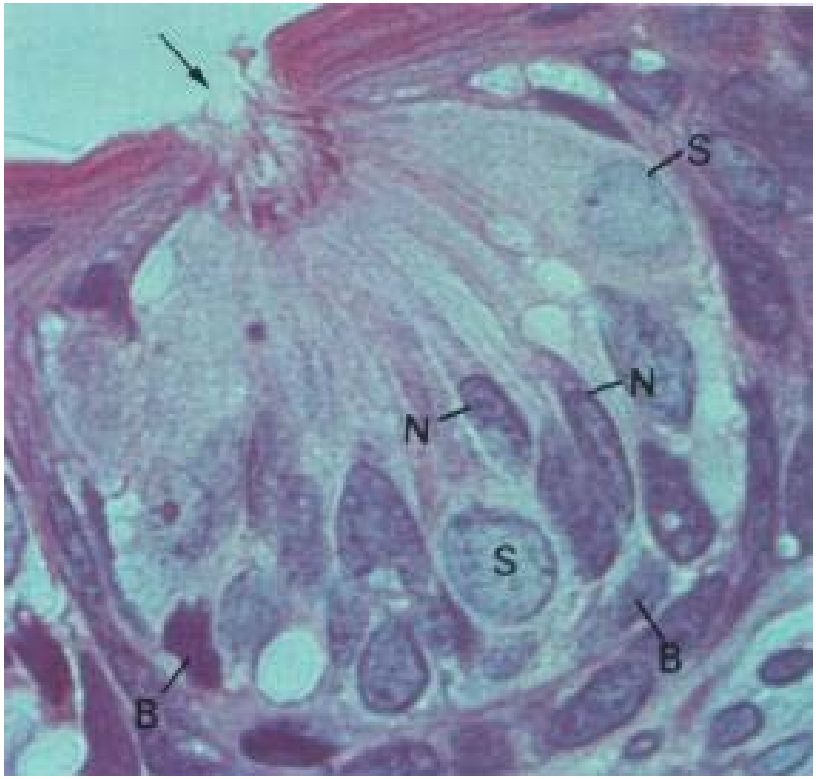


Organisation des bourgeons du goût



Bourgeons du goût:

Homme (10000)
Rat (1000)
500 CV



20 μm

Les saveurs du goût

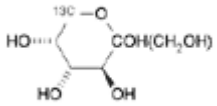
Salé

NaCl

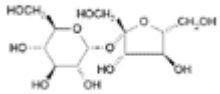
KCl

Sucré

Fructose



Sucrose



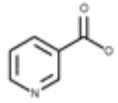
Artificial Sweeteners

Acide

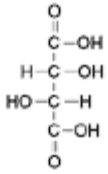
HCl

Citric Acid

Nicotinic Acid

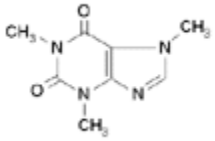


Tartaric Acid

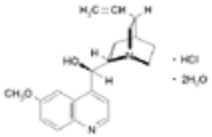


Amer

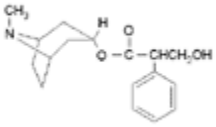
Caffeine



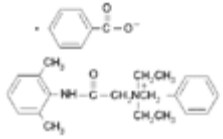
Quinine-HCl



Atropine



Denatonium

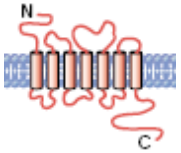


Umami

MSG

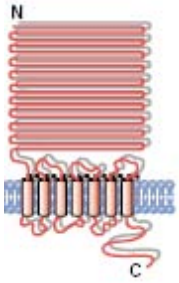
Les receptors du goût

Bitter



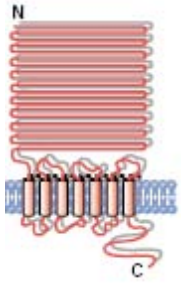
40 T2Rs

Sweet



T1R2/T1R3

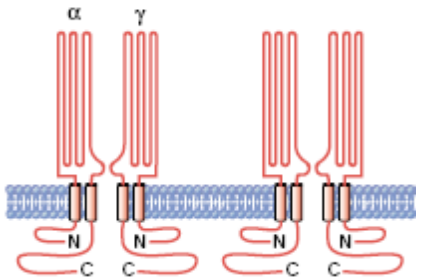
Umami



T1R1/T1R3

GPCRs

Salt **Sour**

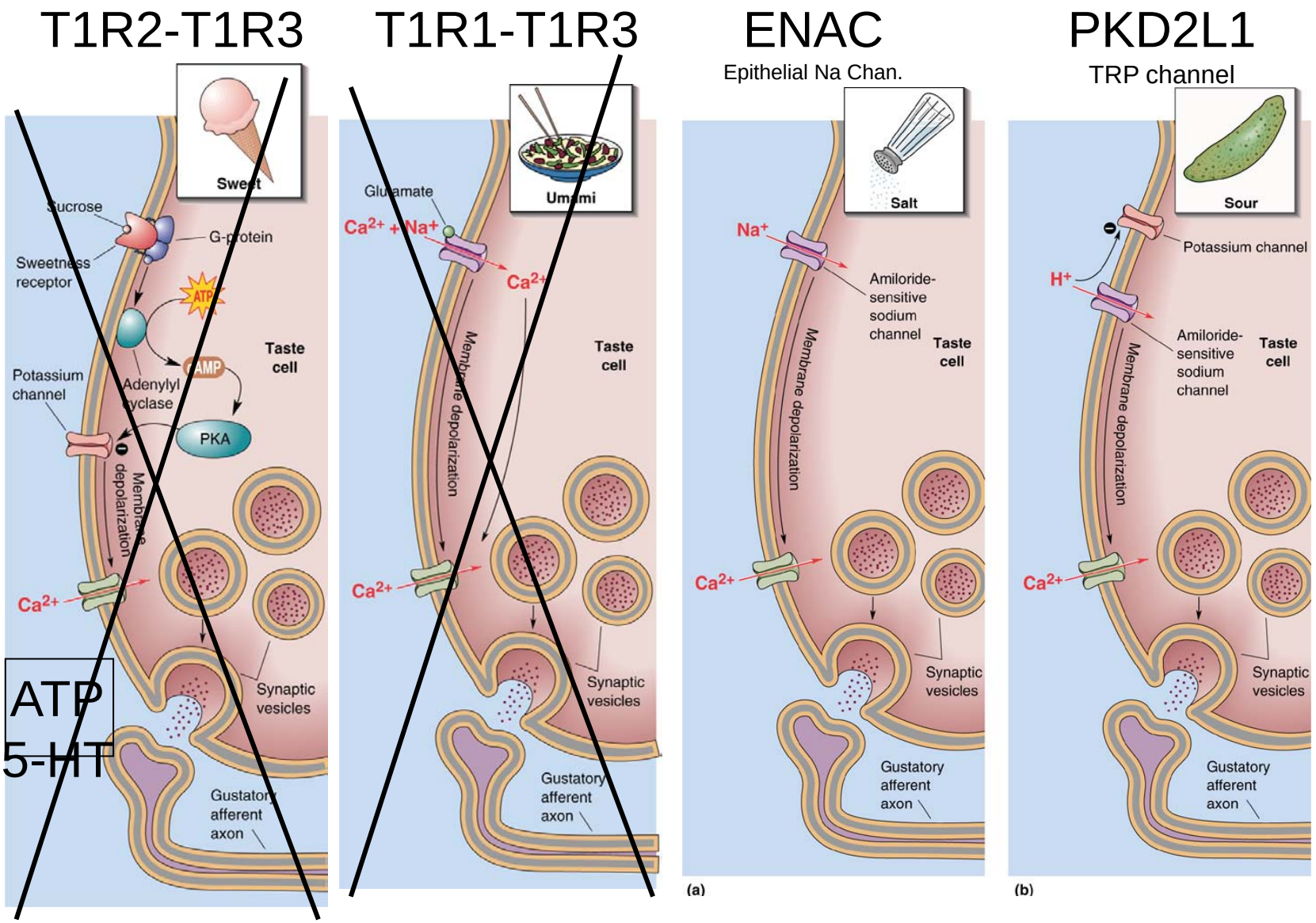


ENAC
Epithelial Na Chan.

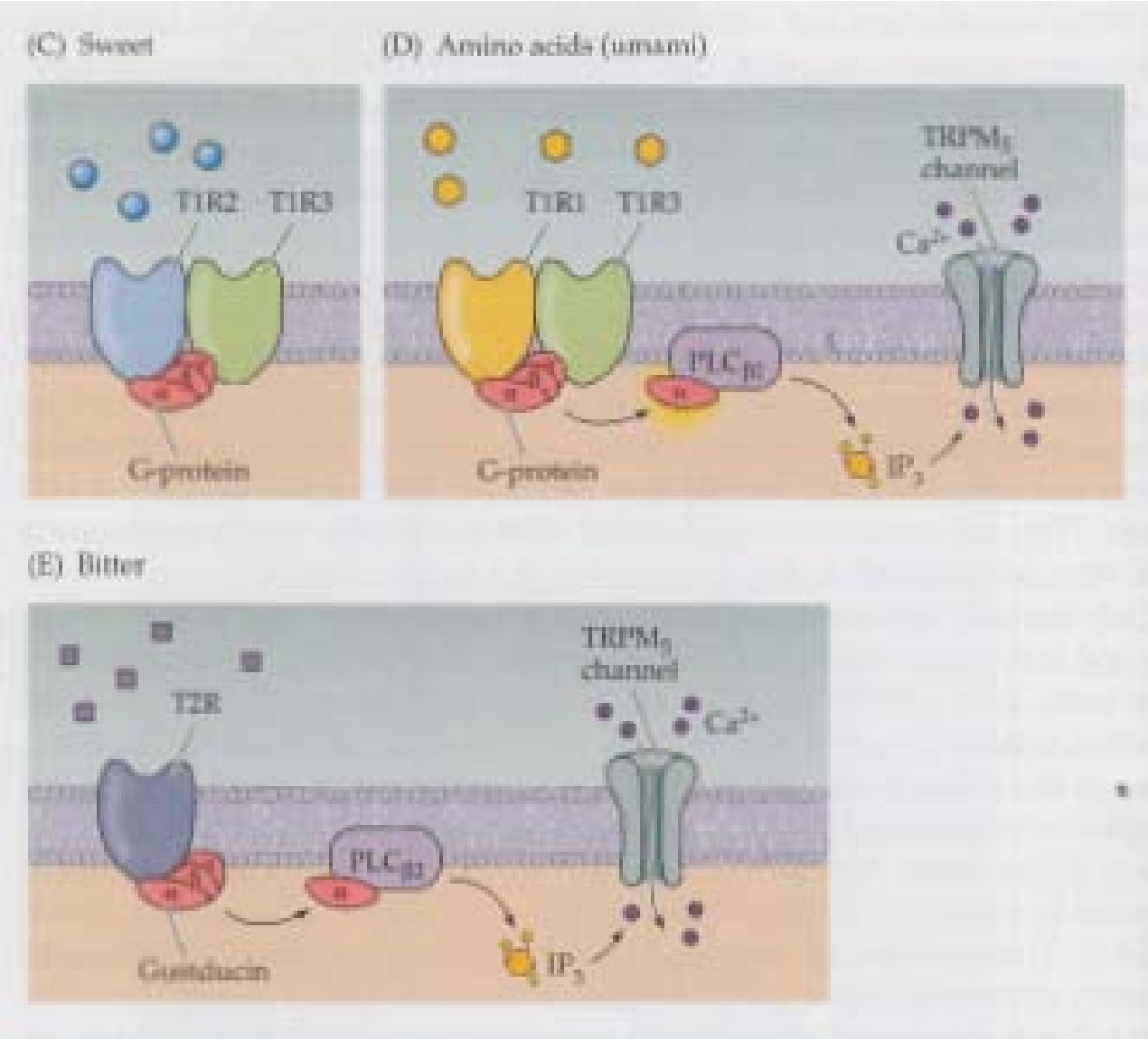
Pkd2l1

Ion channels

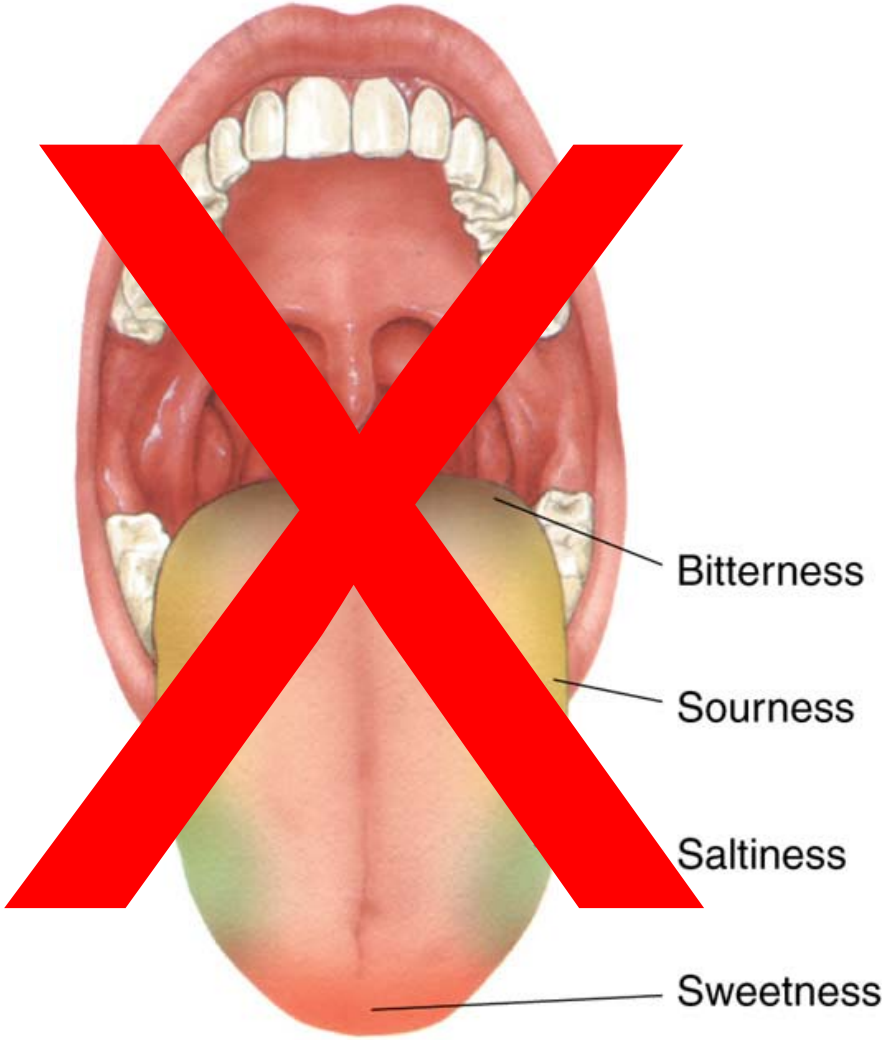
Transduction



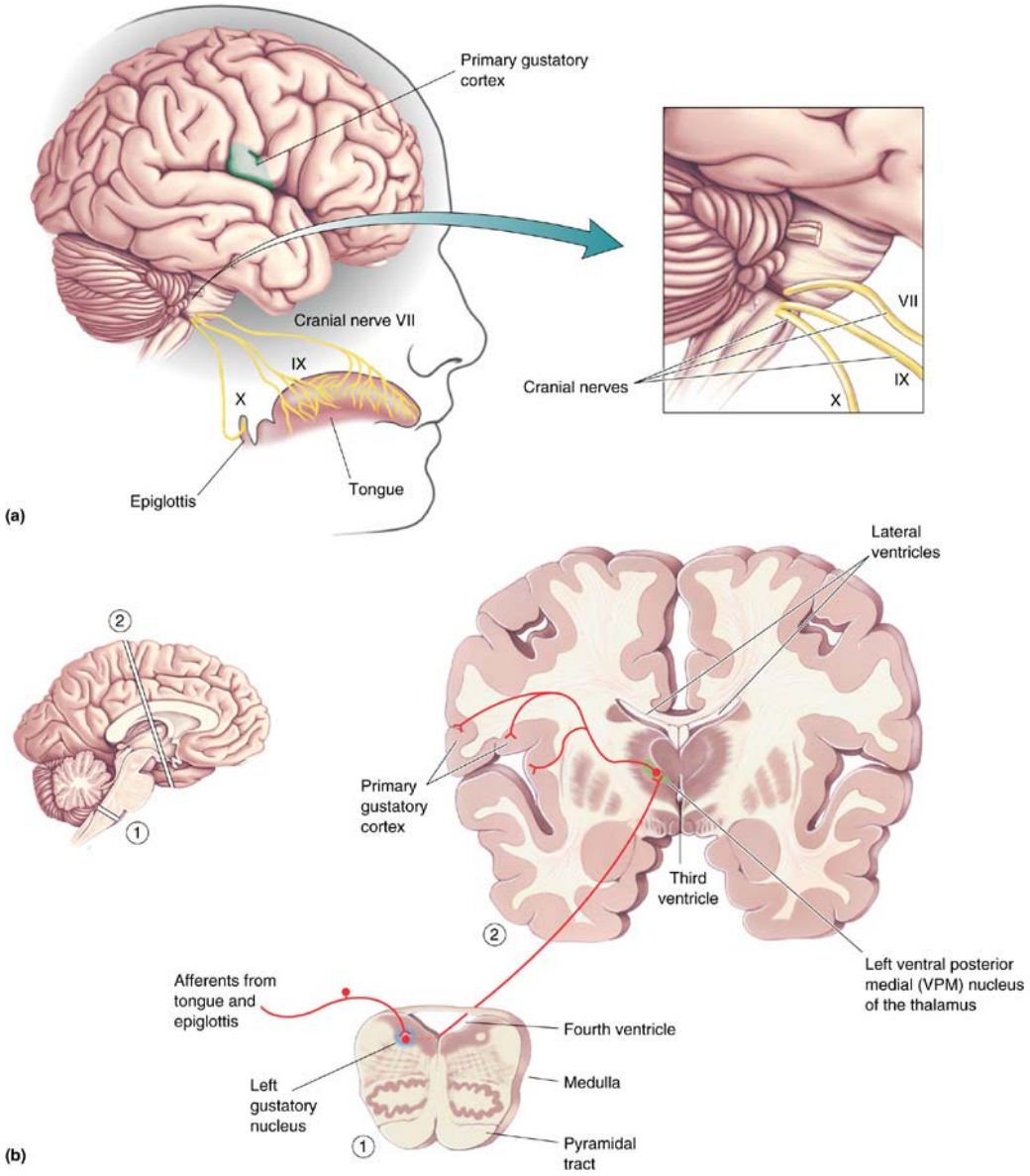
Transduction



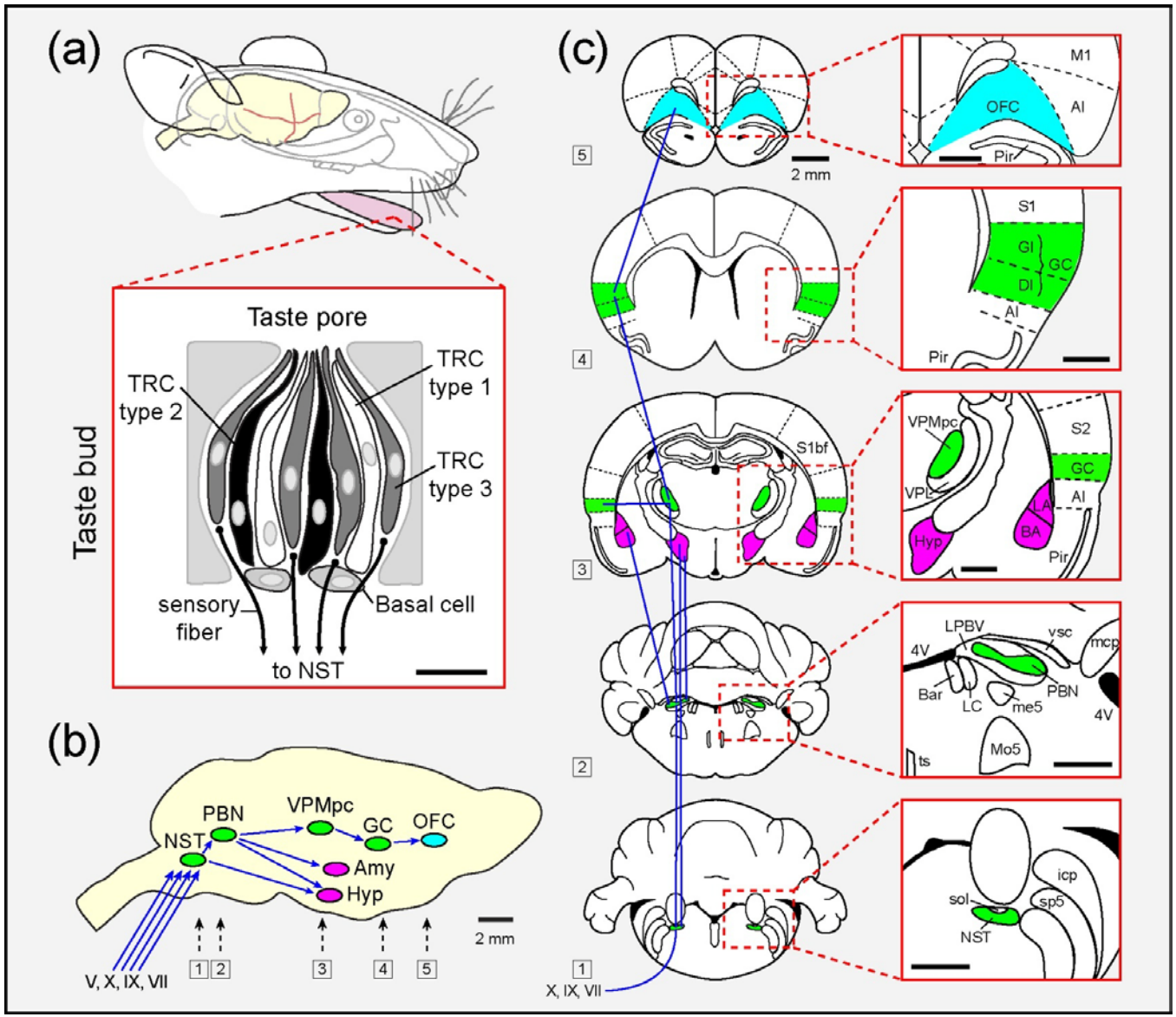
Representation sensorielle sur la langue



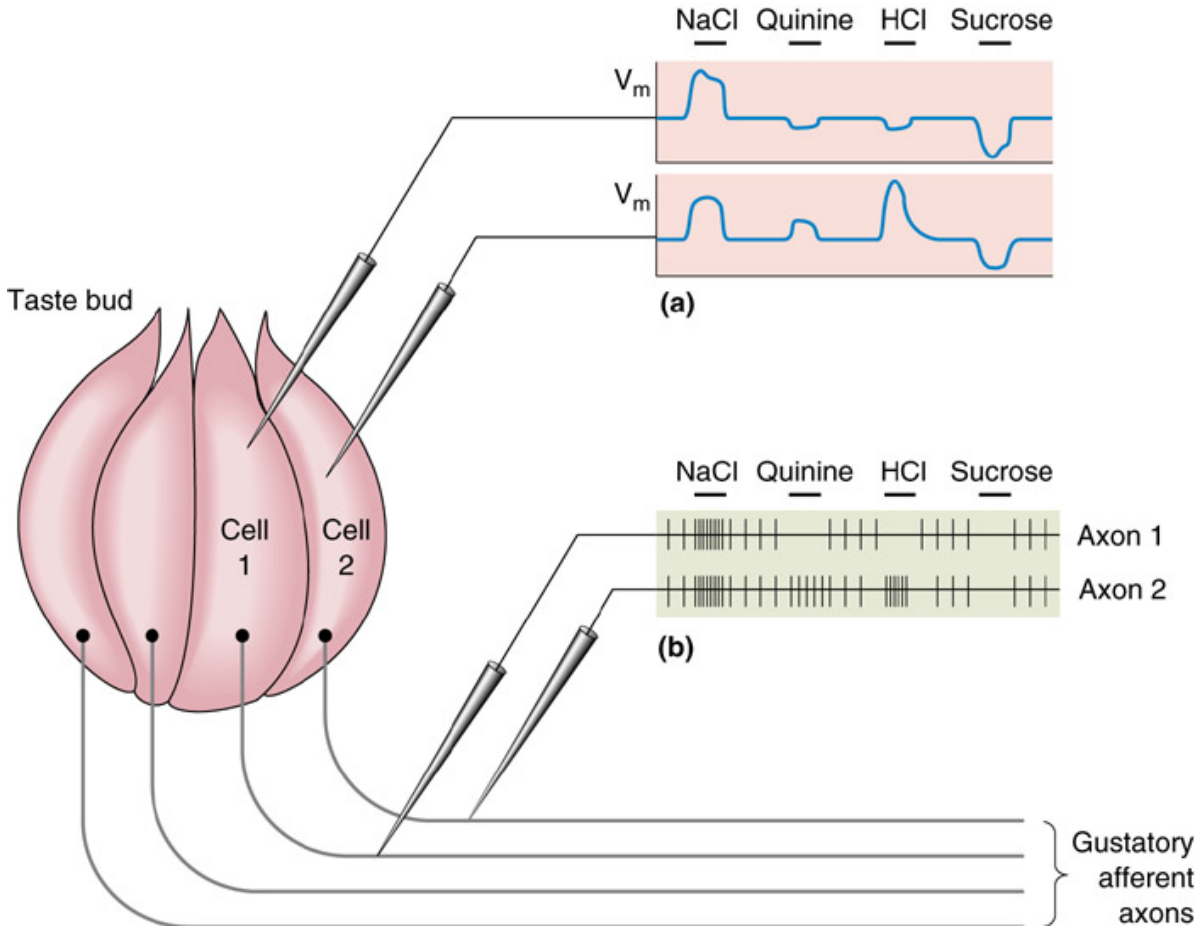
Gustatoray pathways in the human brain

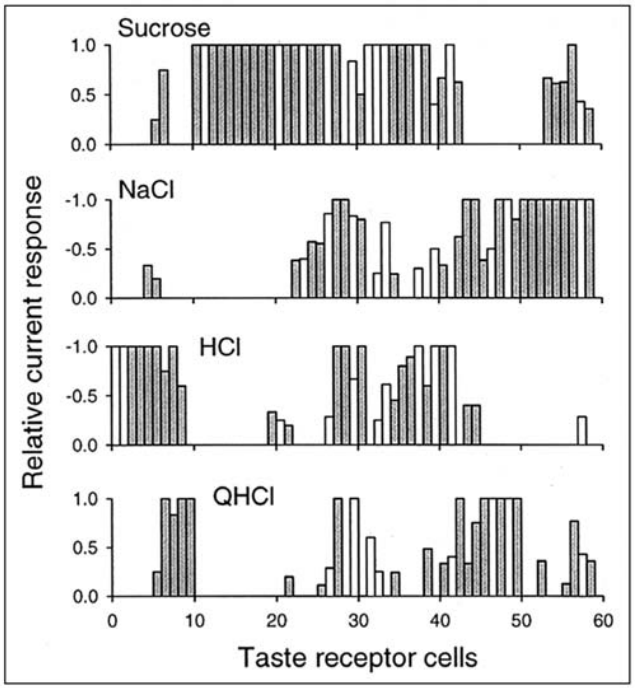


Gustatoray pathways in the rodent brain



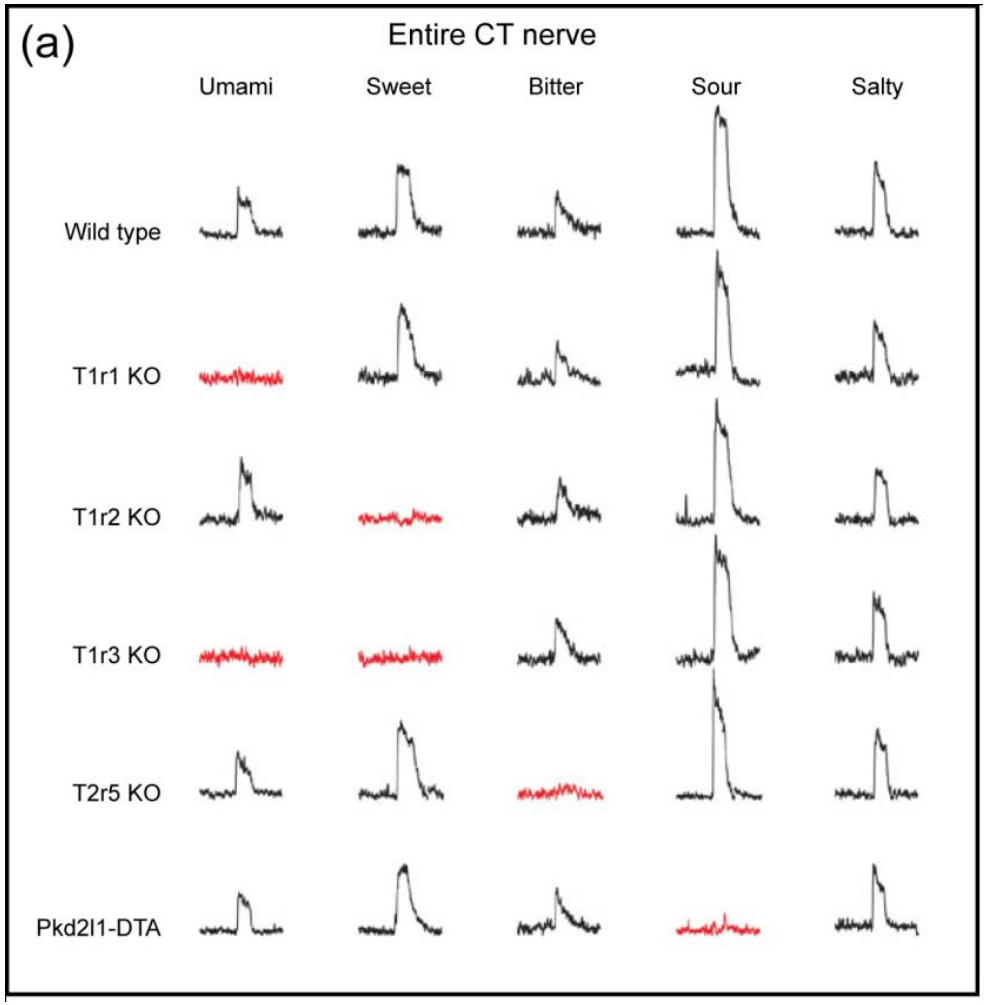
Codage de l'information sensorielle



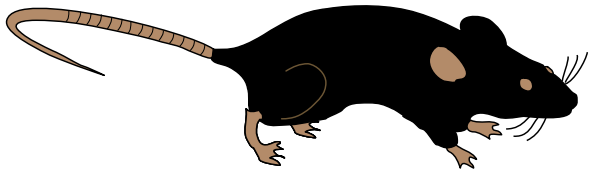


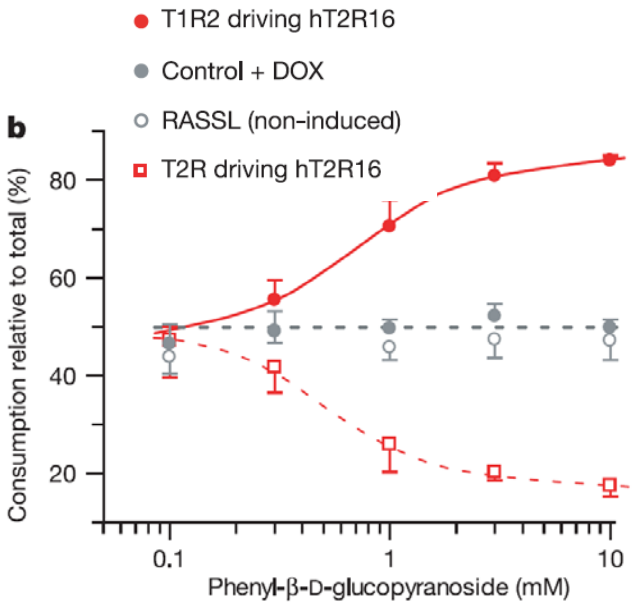
Gilbertson et al. J Neurosci (2001)

Codage de l'information sensorielle



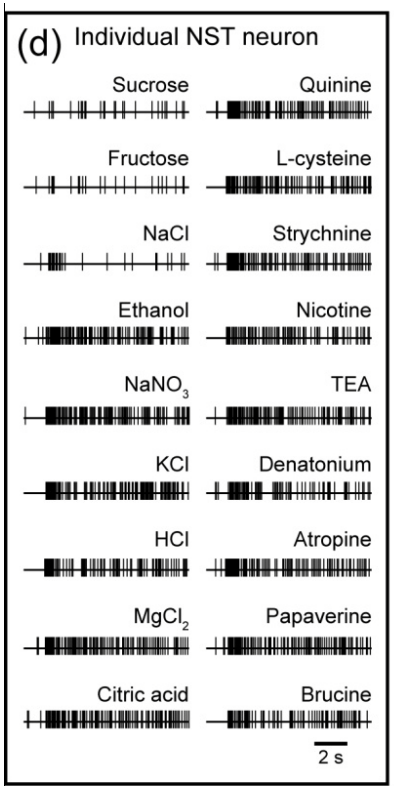
Mouse behaviour

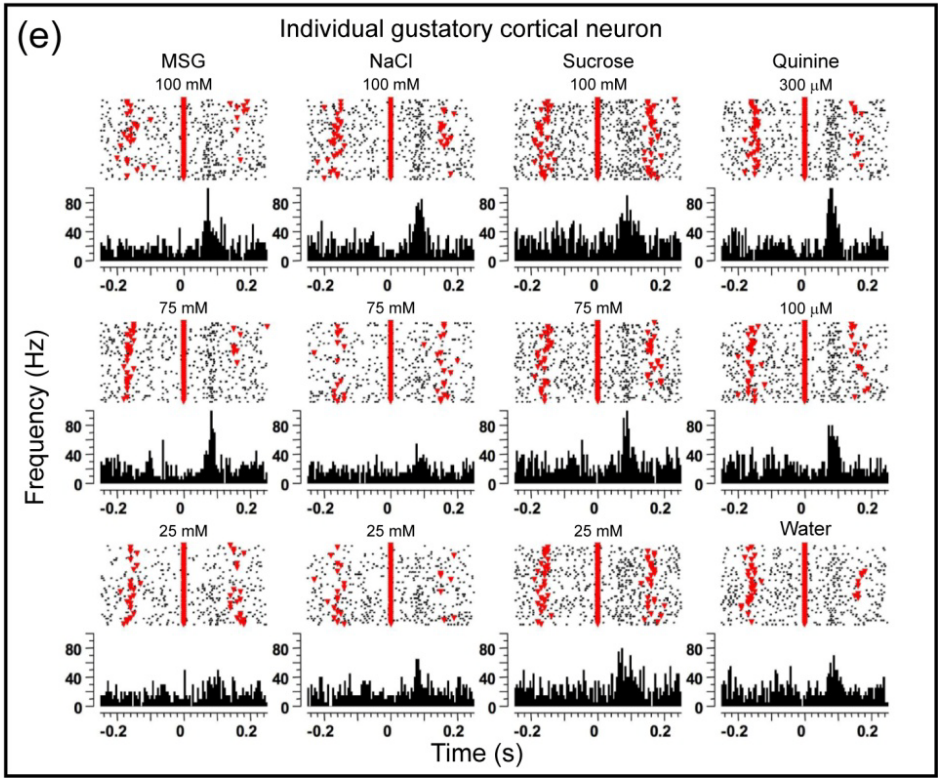




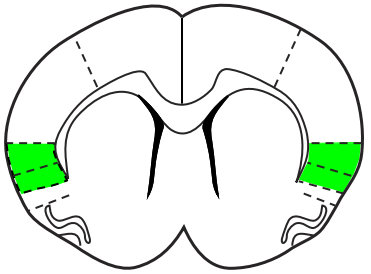
Mueller et al. Nature (2005)

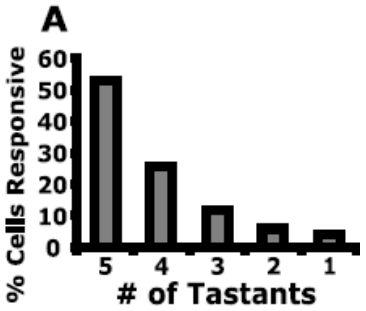
Codage de l'information sensorielle

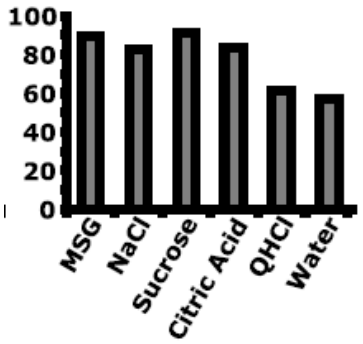




Cortical neurons



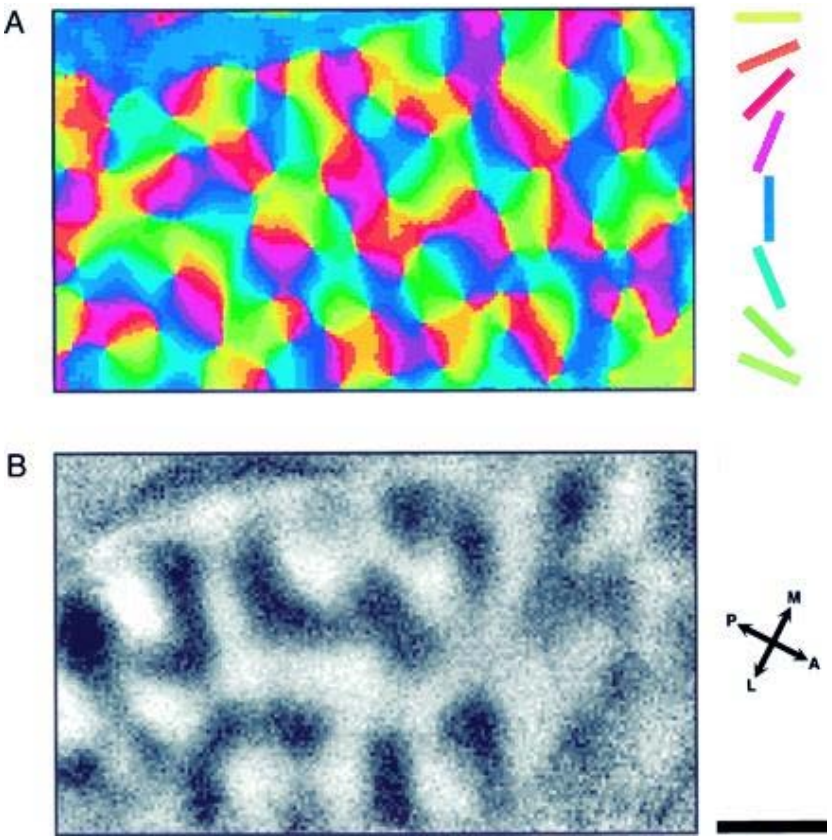




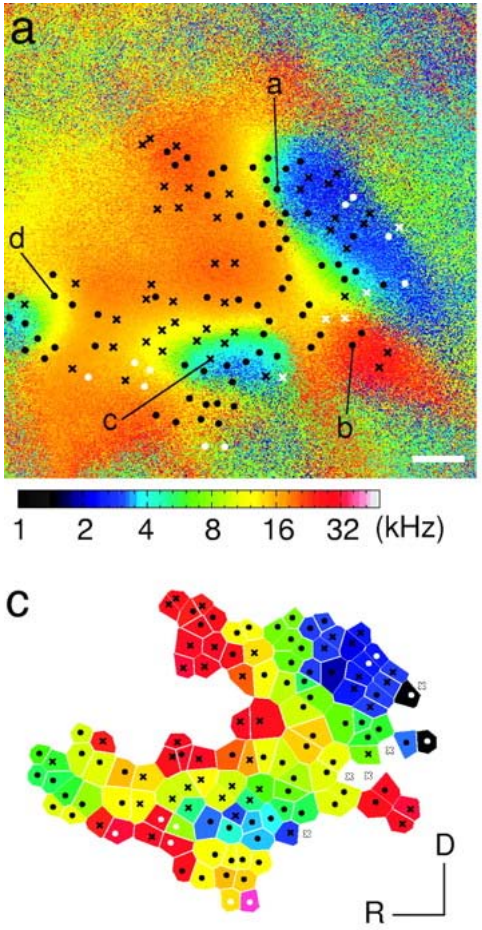
Stapleton et al. J Neurosci (2006)

Représentation sensorielle dans le cortex

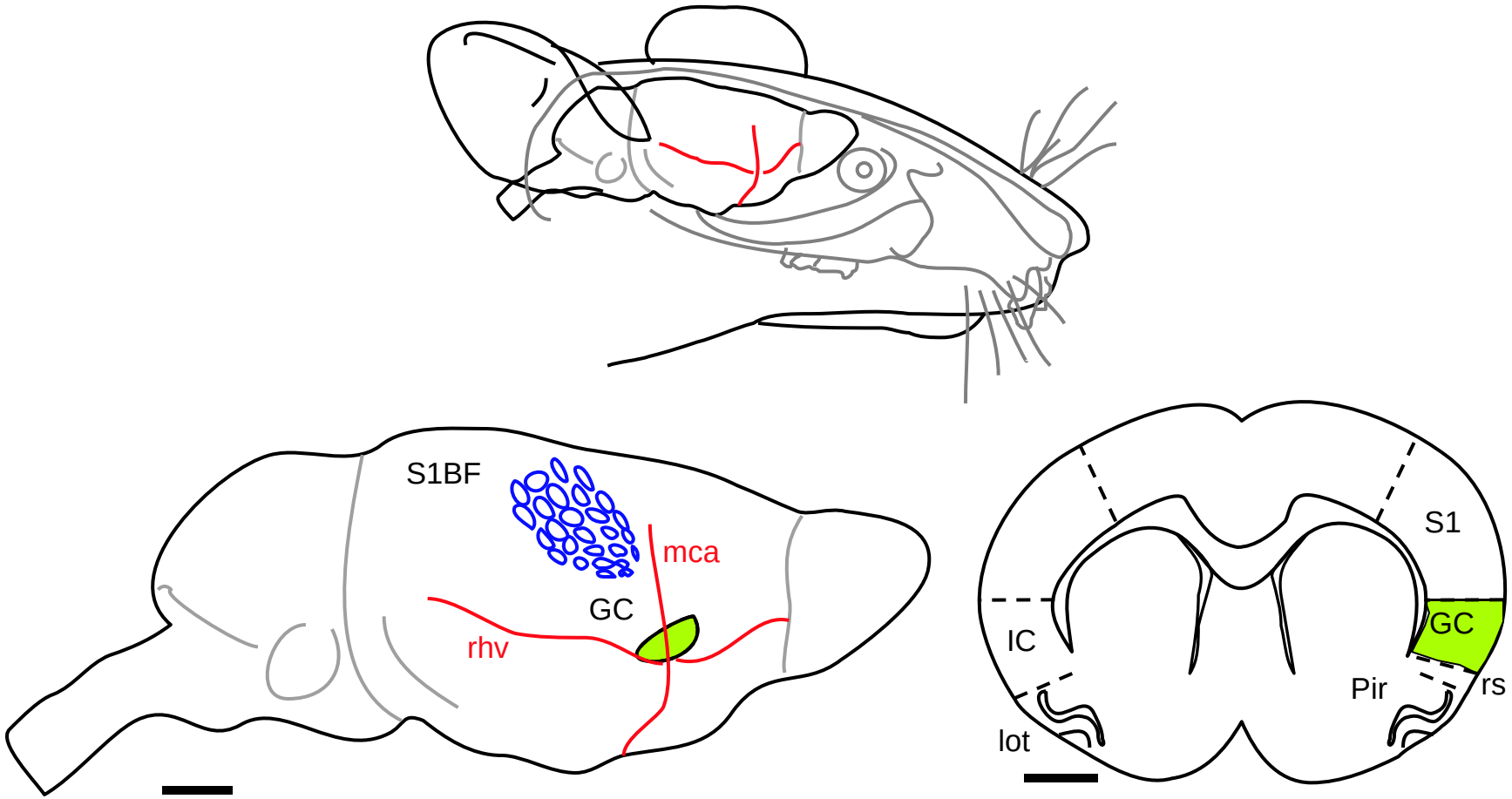
Vision



Audition

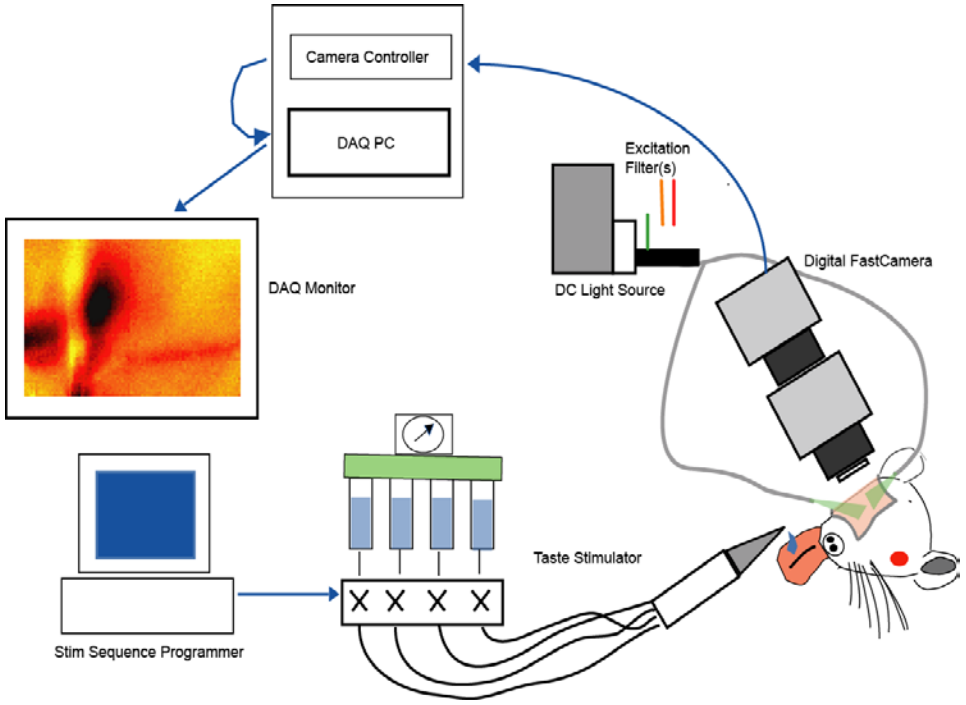


Location of the gustatory cortex in the rodent brain



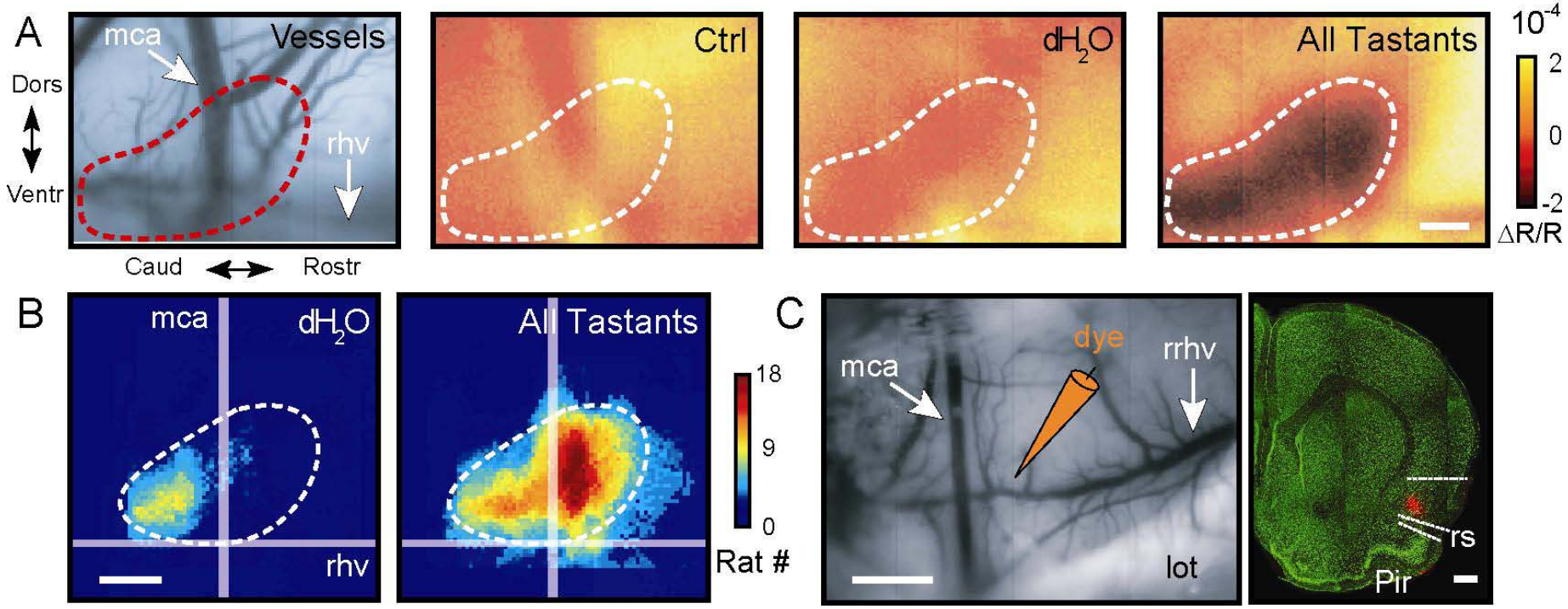
Methods – Intrinsic imaging

- Changes in Reflectance upon activation
- Functional Population Activity
- Good Spatial Resolution



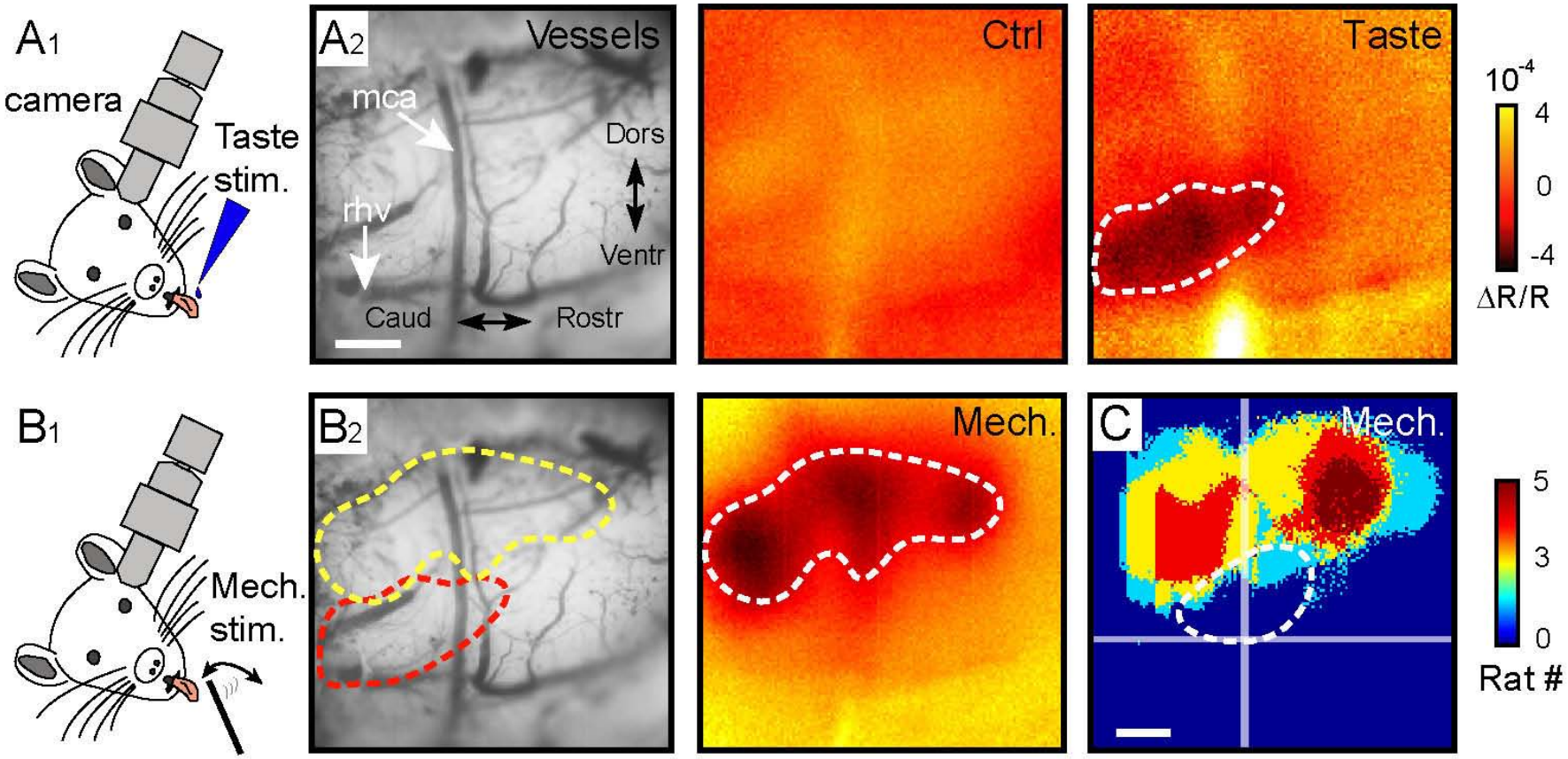
- Successfully used to establish spatial organization of other sensory areas

Functional localization of the gustatory cortex

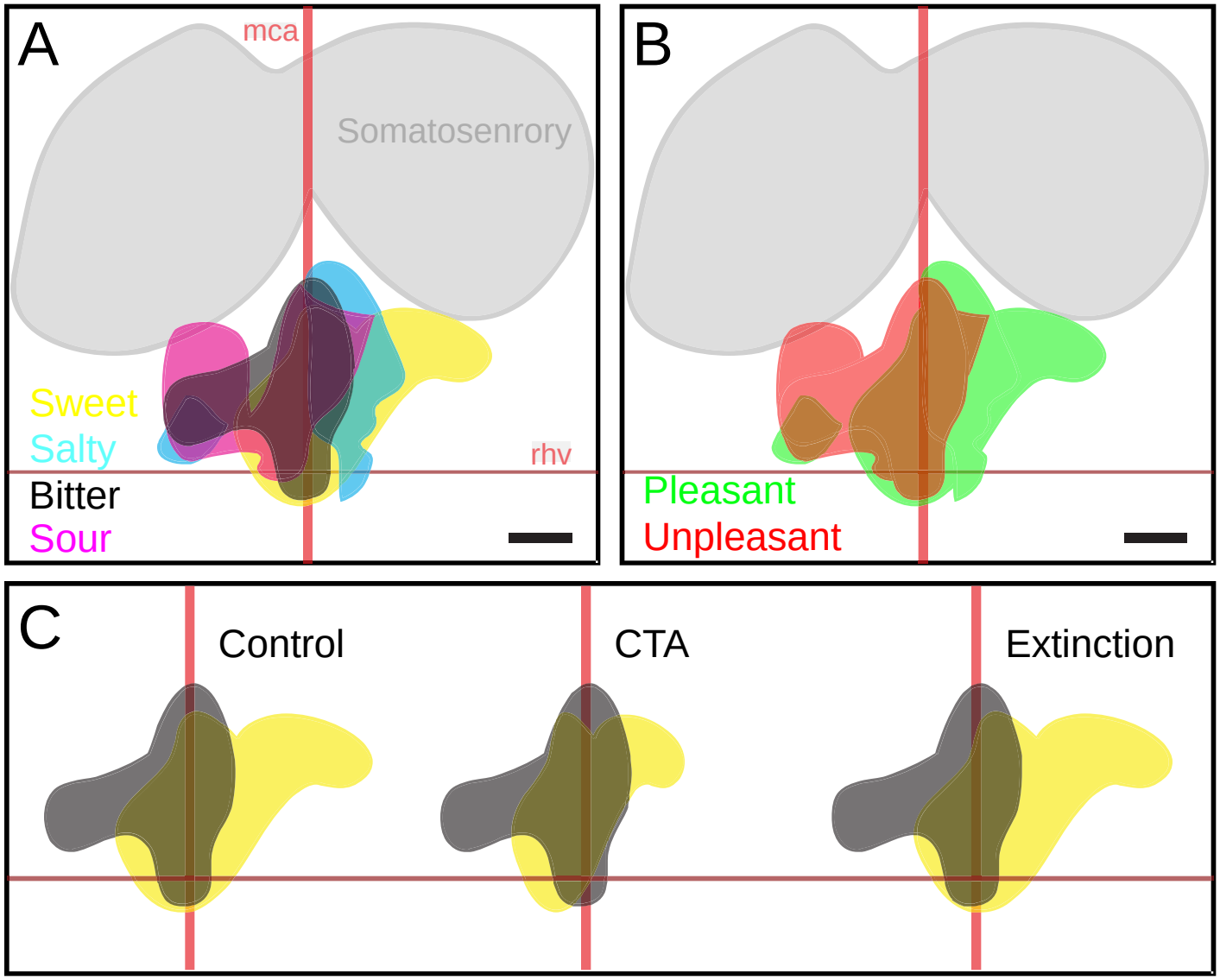


Accolla, Bathellier, Petersen and Carleton. Journal of Neuroscience (2007) 27:1396-1404

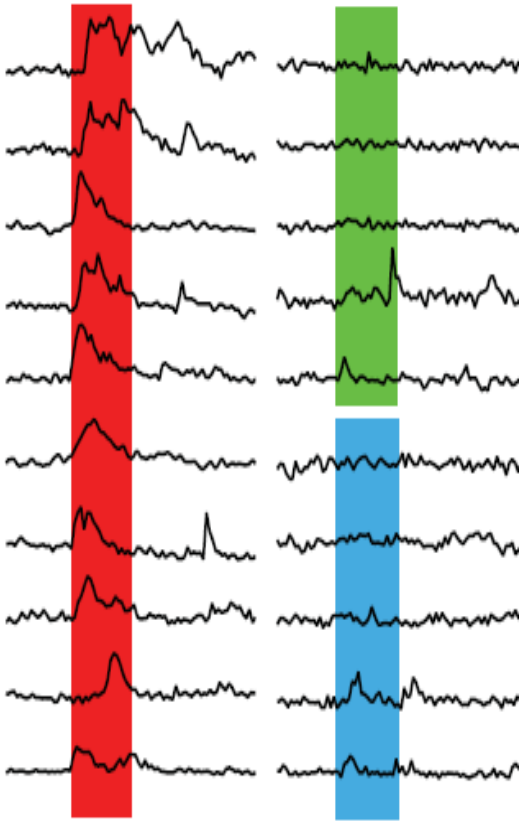
Signals are taste specific

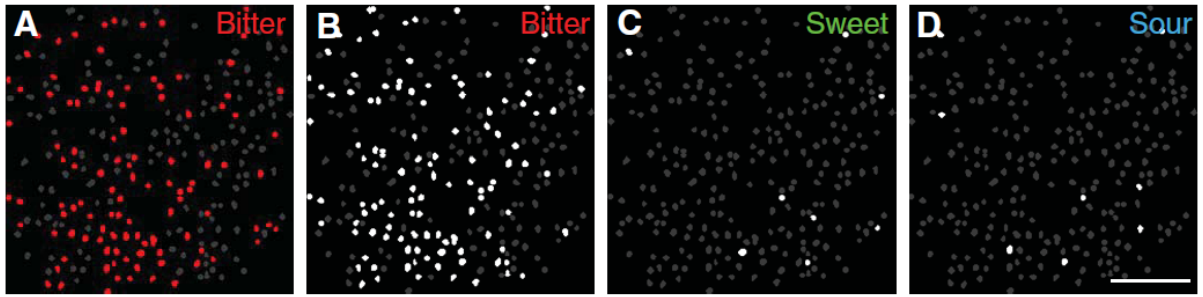


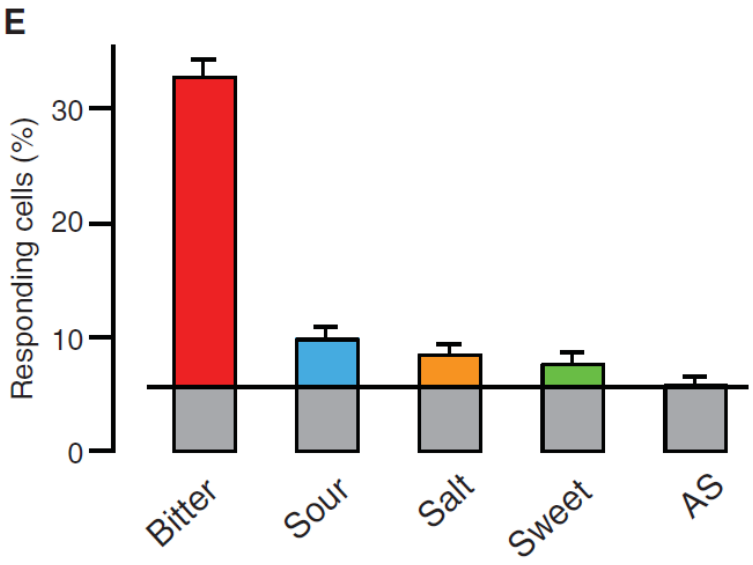
Represention des goûts dans le cortex

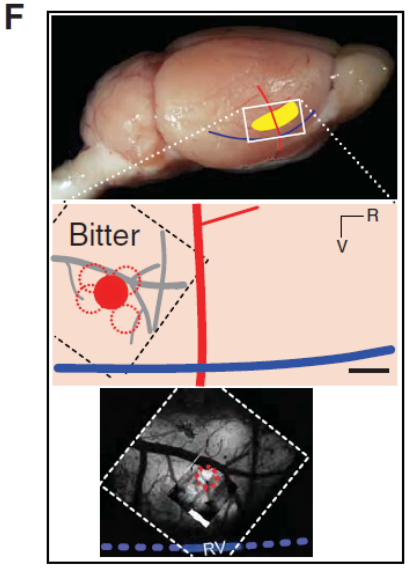


Gustotopic map in the taste cortex





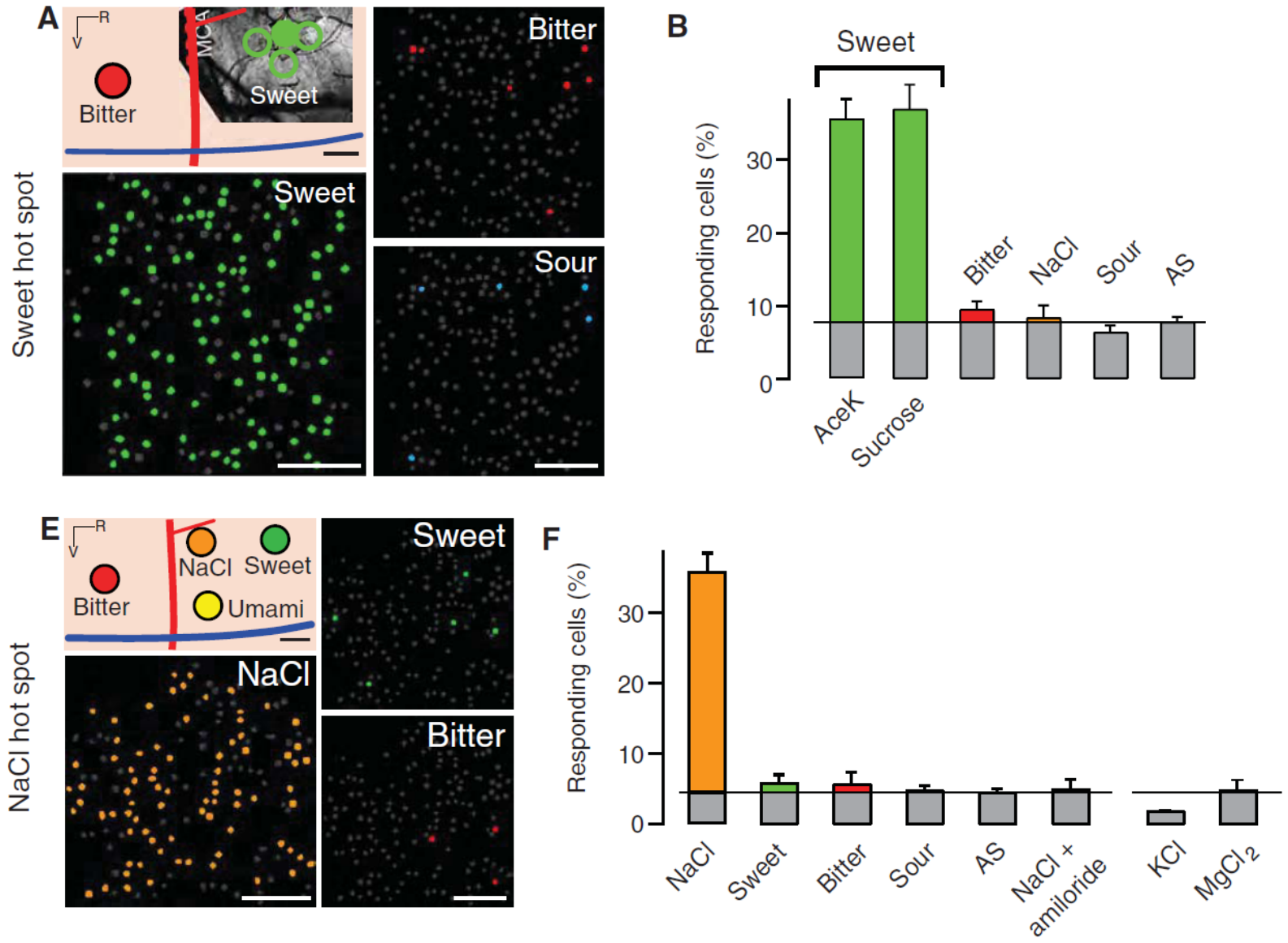




A Gustotopic Map of Taste Qualities in the Mammalian Brain

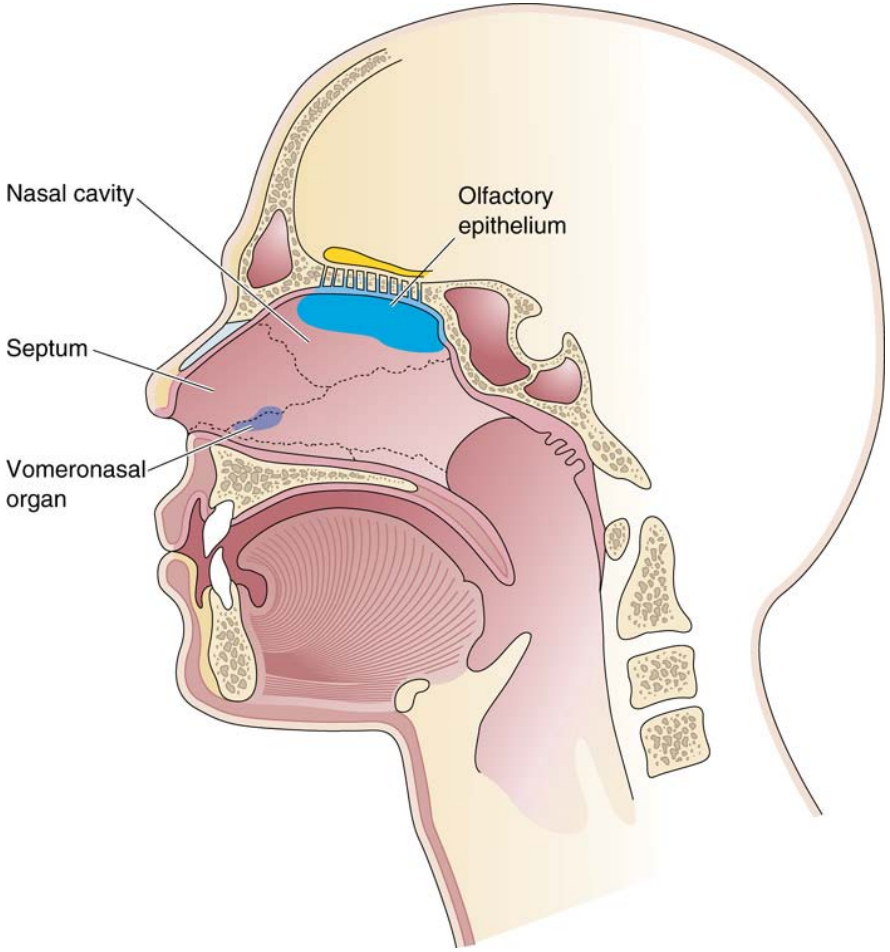
Xiaoke Chen,[1] Mariano Gabitto,[1] Yueqing Peng,[1] Nicholas J. P. Ryba,[2] Charles S. Zuker[1,3]*

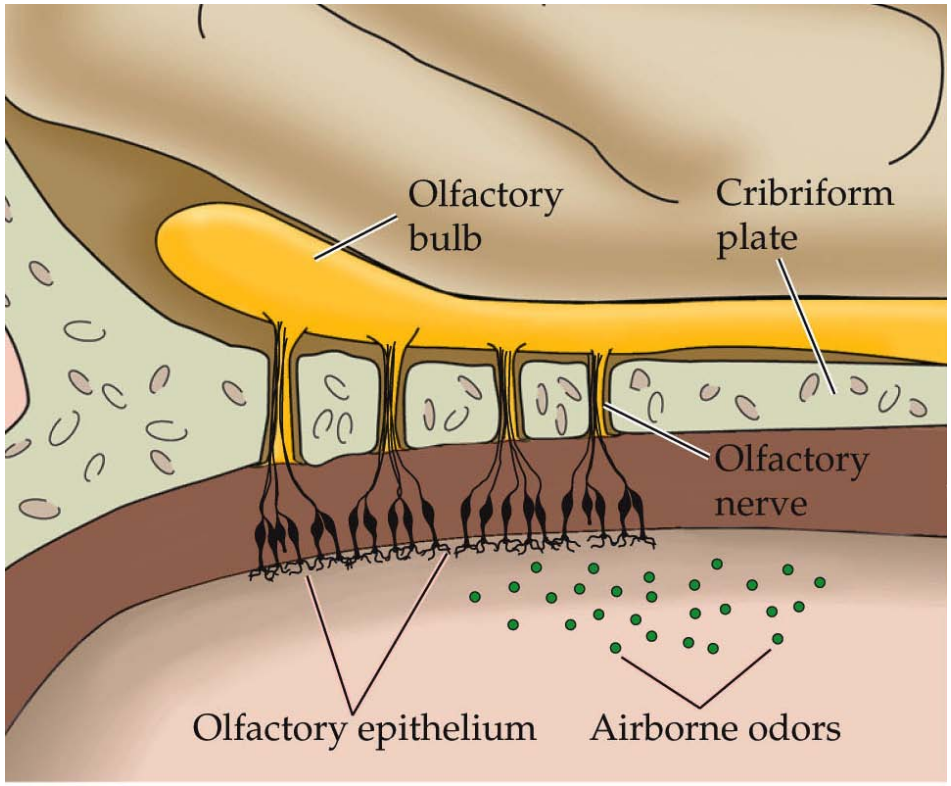
Gustotopic map in the taste cortex



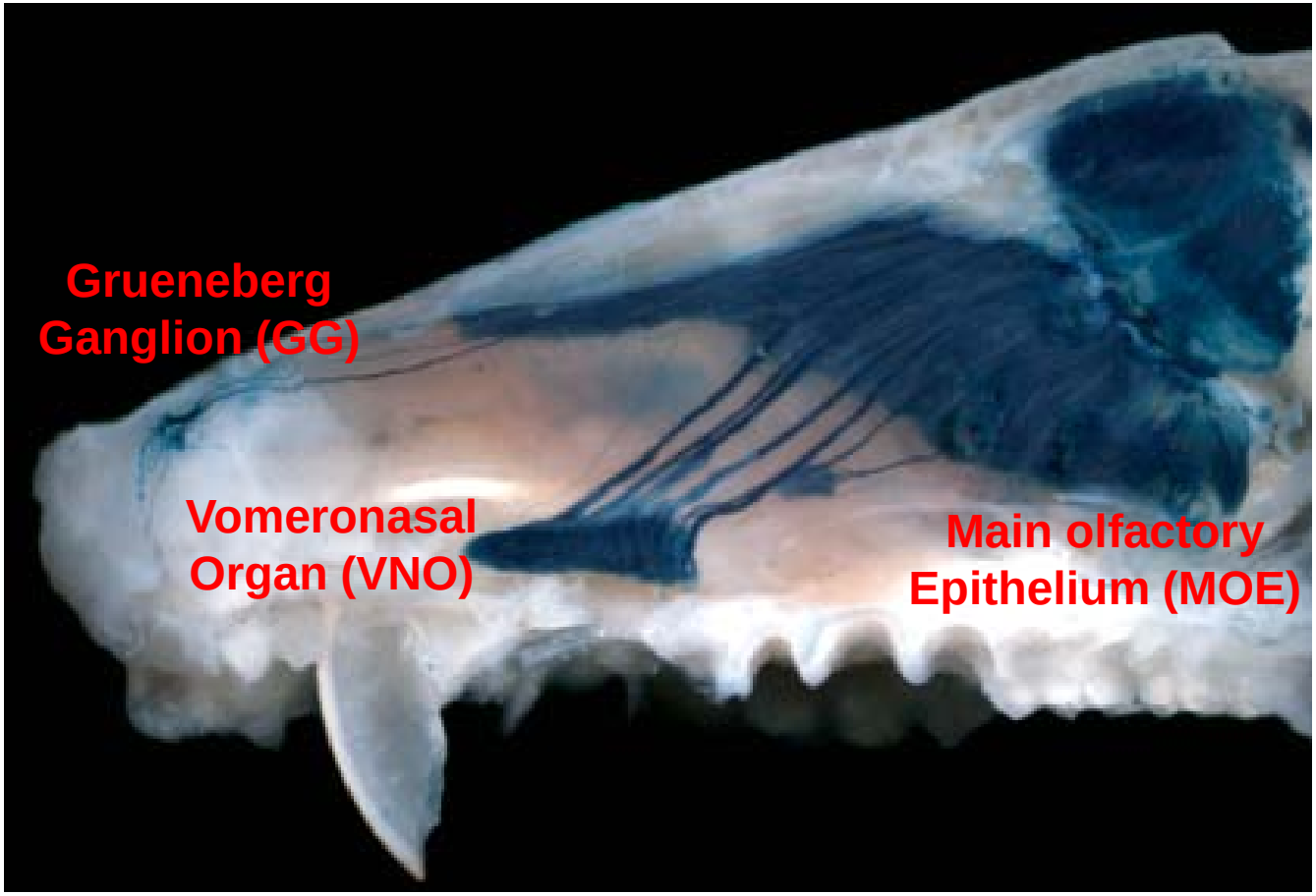
OLFACTION

Organization of the human olfactory system





Organization of the olfactory systems



(Omp-TauLacZ) Tg mouse

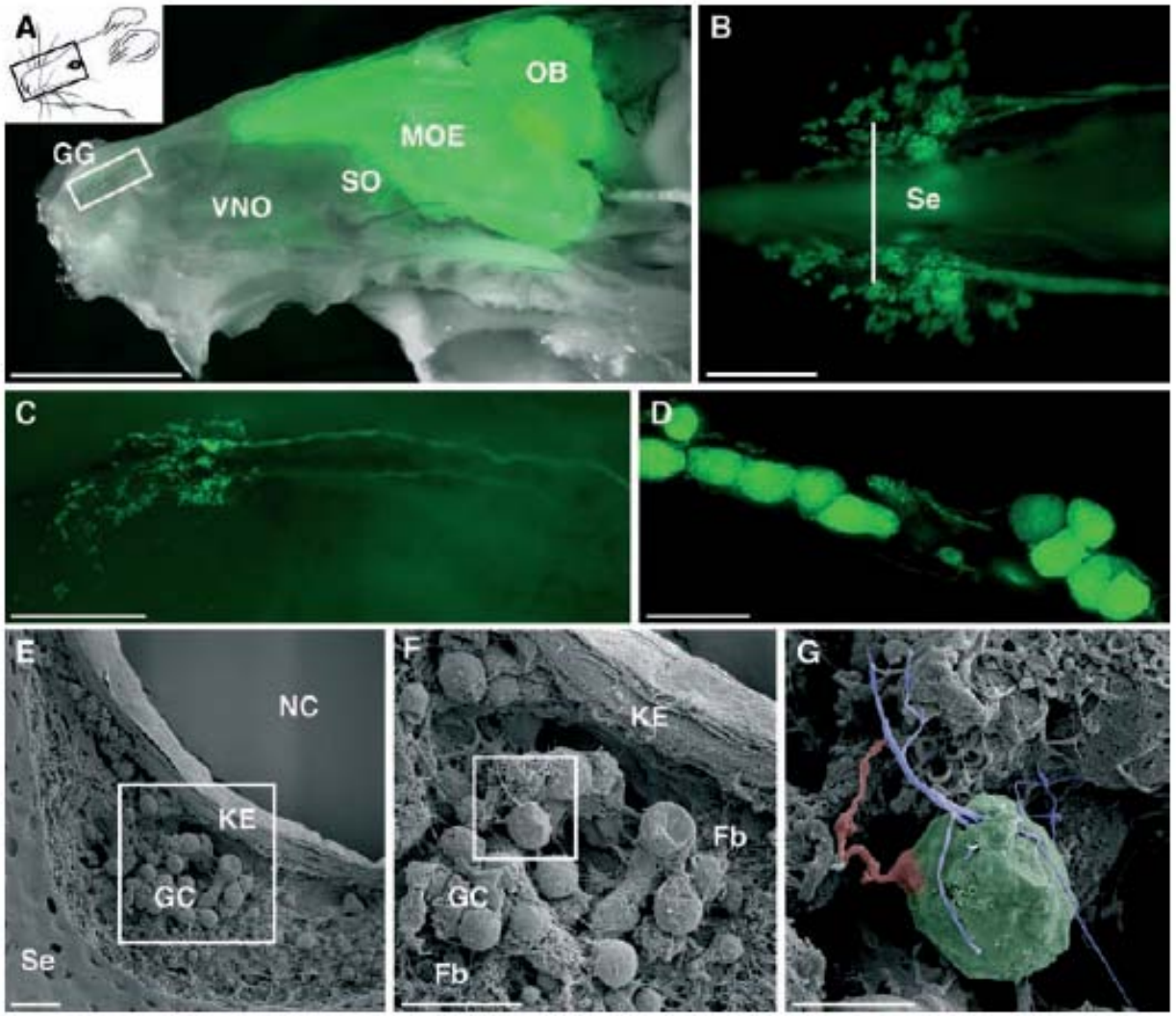
Photo: courtesy of Prof. Rodriguez (UNIGE)

Grueneberg ganglion

Grueneberg Ganglion Cells Mediate Alarm Pheromone Detection in Mice

Julien Brechbühl, Magali Klaey, Marie-Christine Broillet*

22 AUGUST 2008 VOL 321 SCIENCE



Grueneberg ganglion

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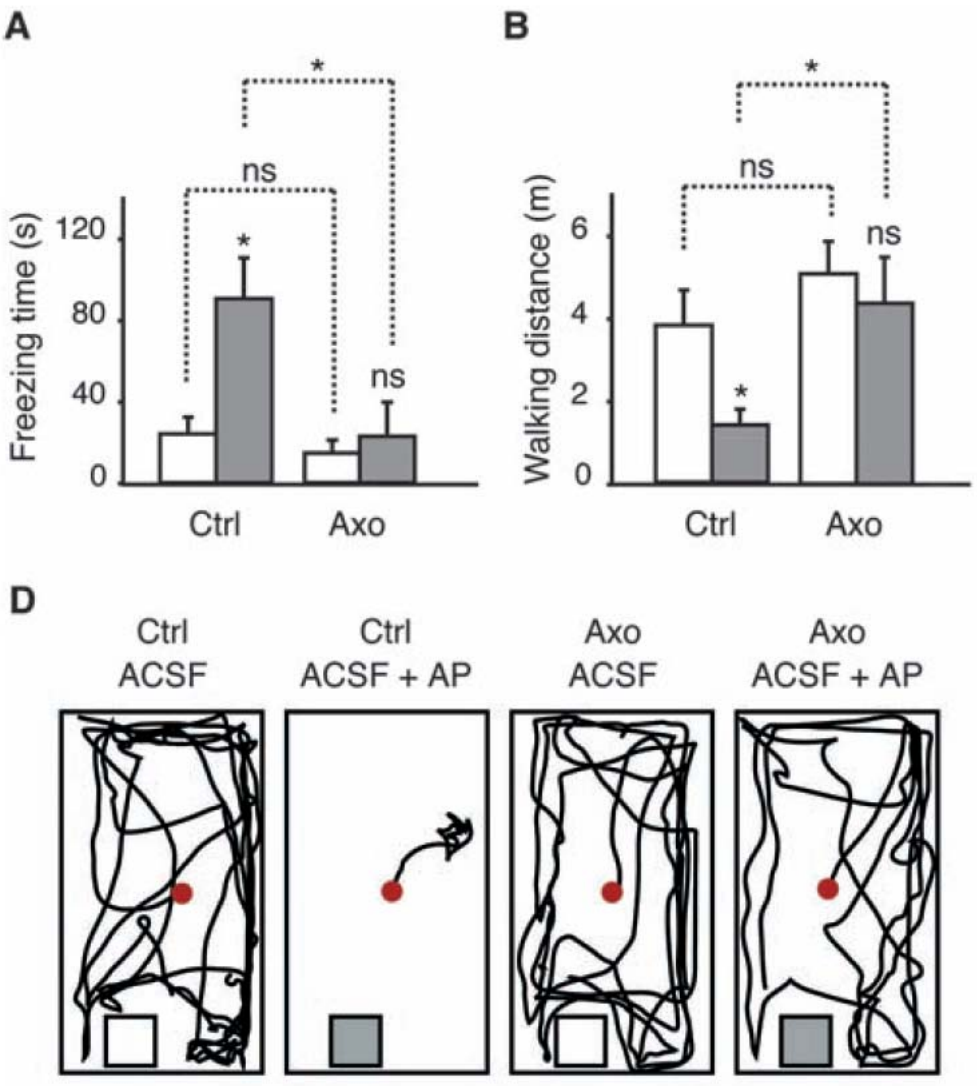
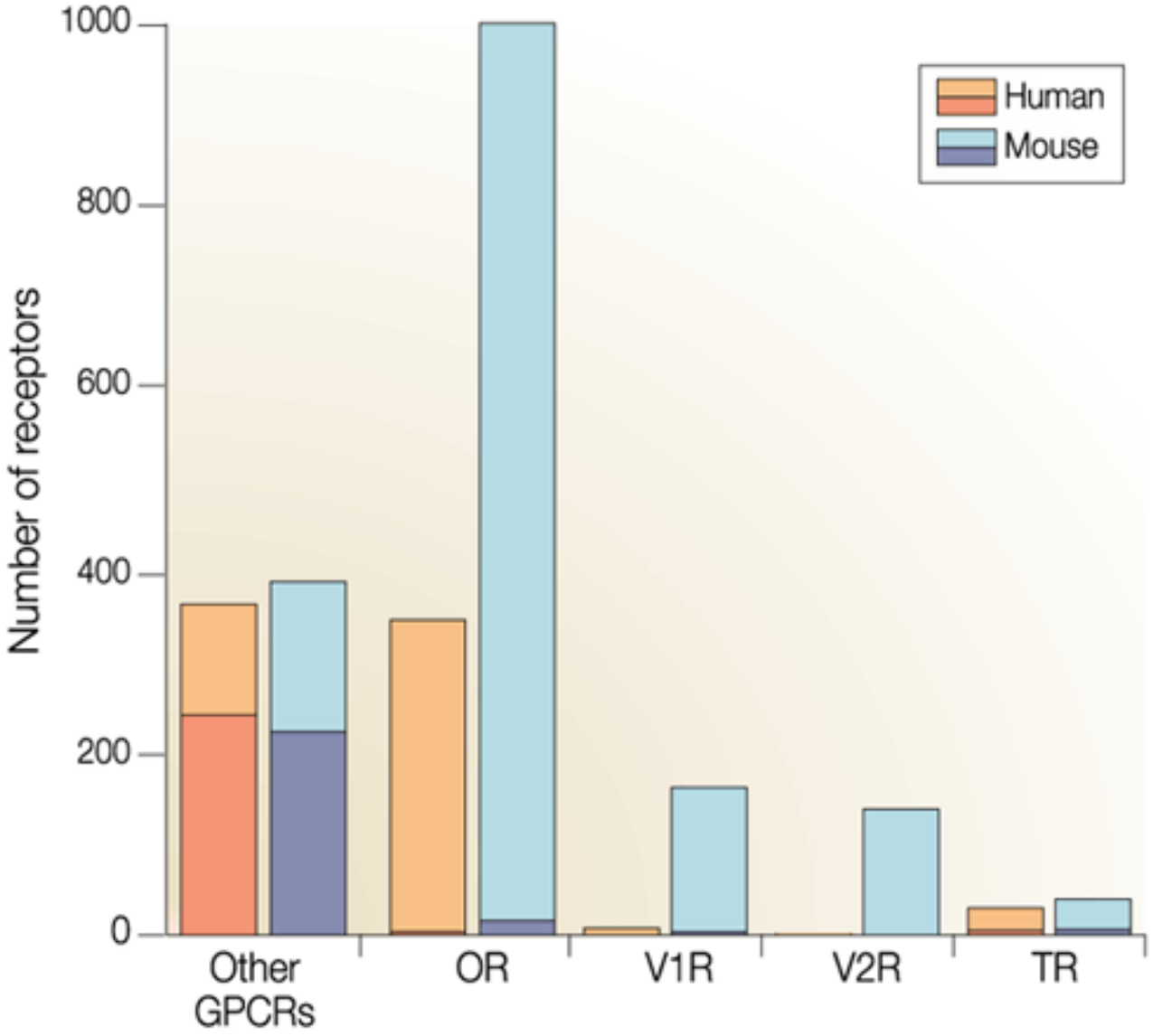
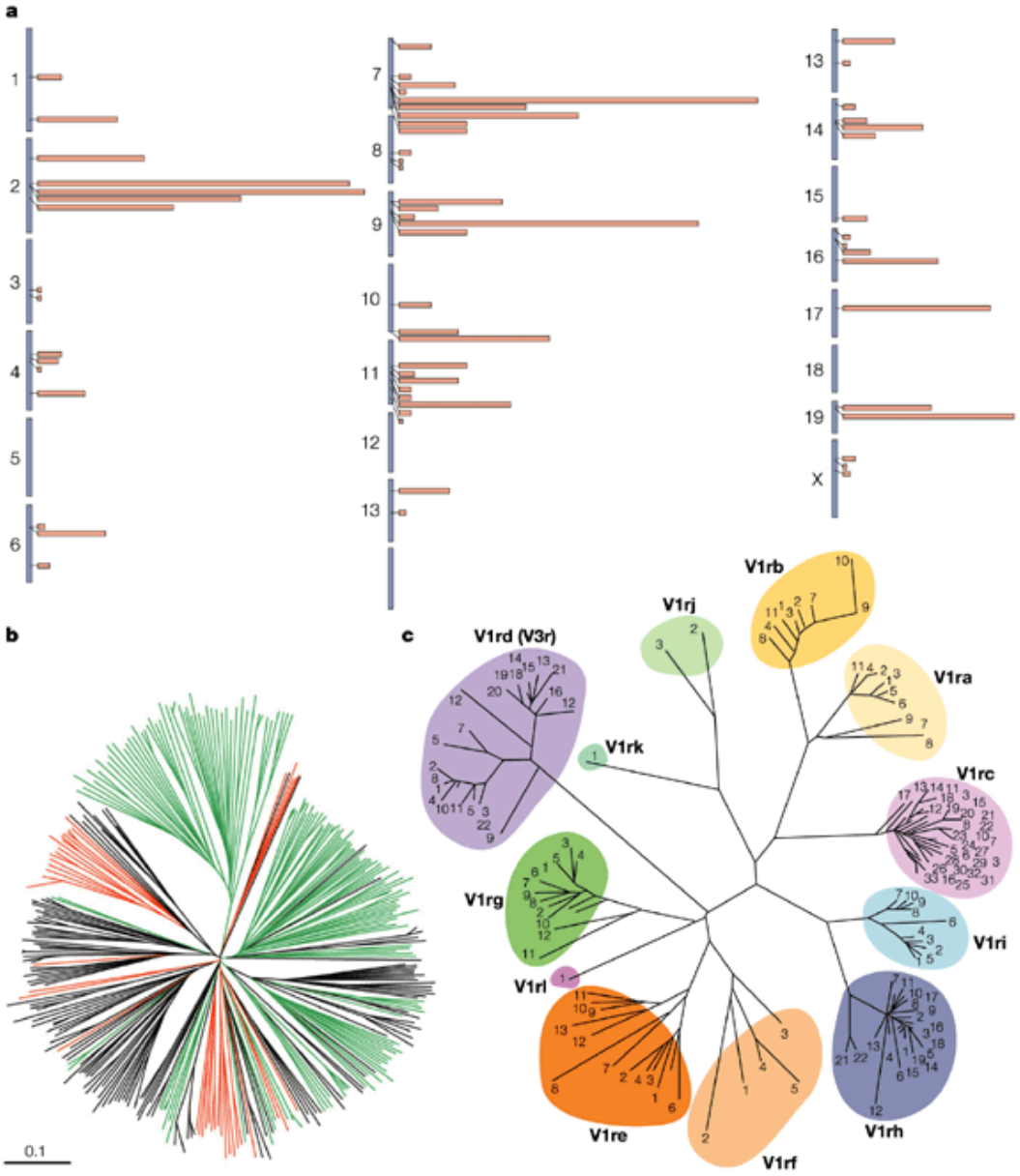


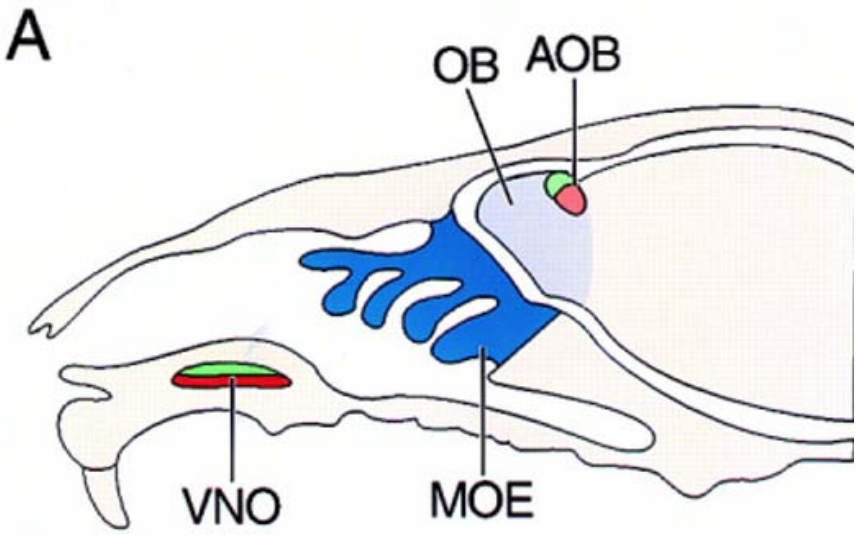
Chemical senses receptors

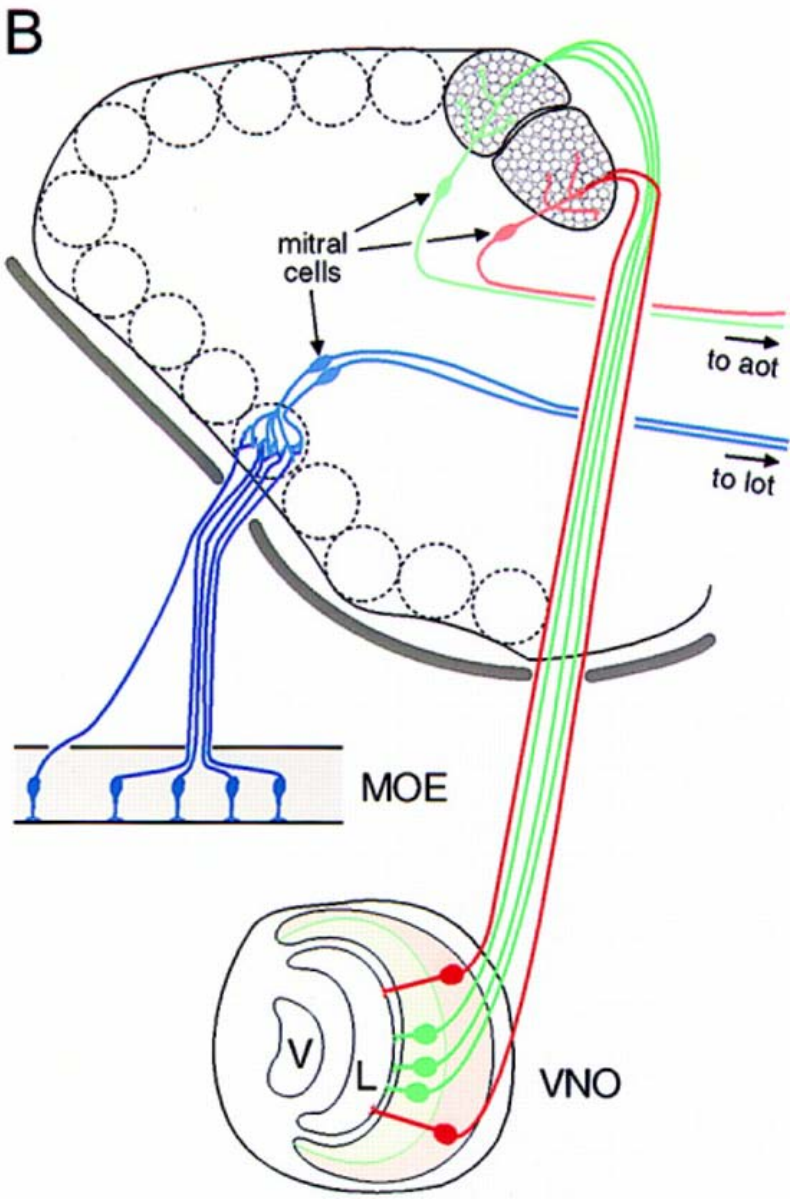


Vomeronasal receptors



Organization of the olfactory systems



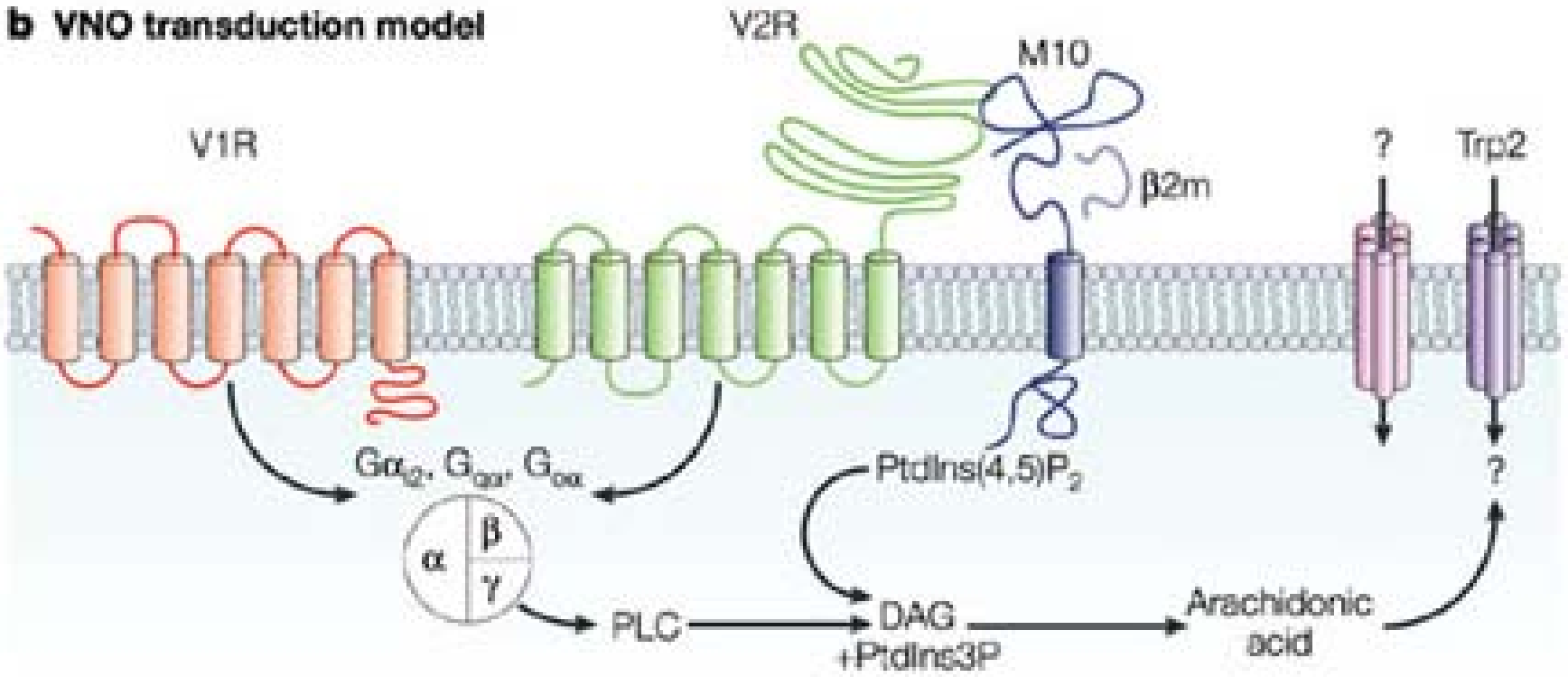


OR

V2R

V1R

Transduction in the VNO

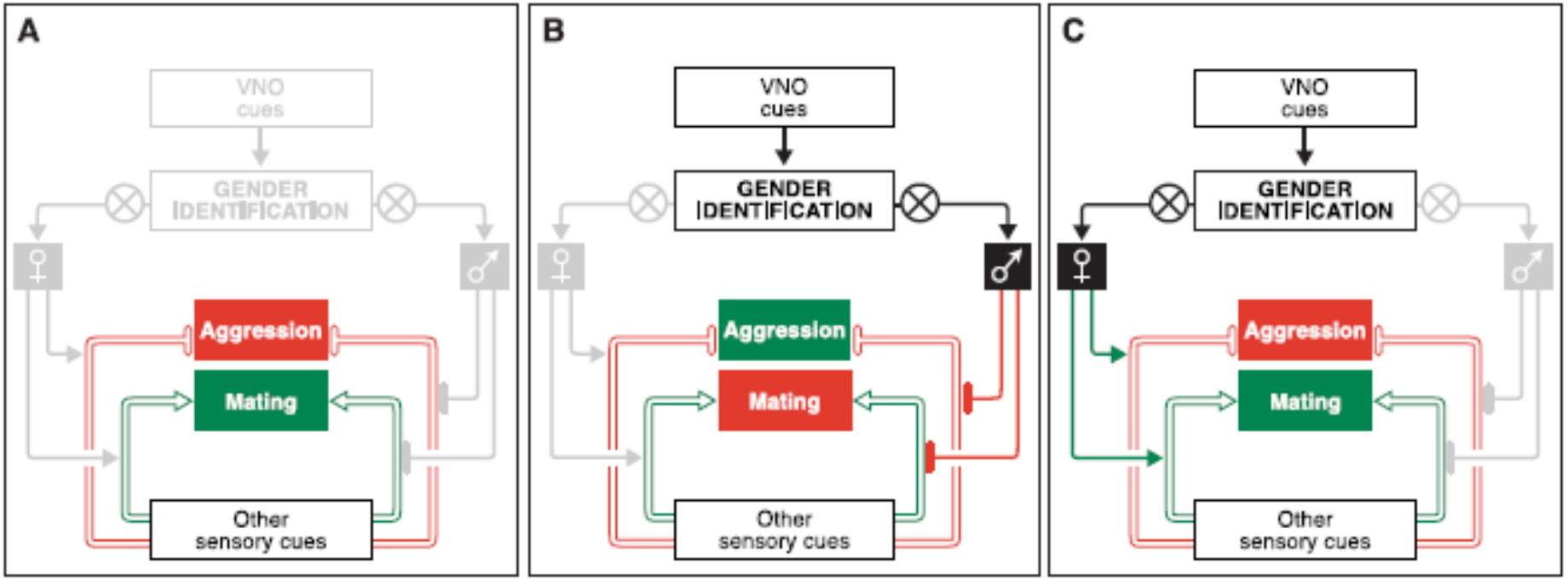


Sexual behavior controlled by the vomeronasal organ

Loss of Sex Discrimination and Male-Male Aggression in Mice Deficient for TRP2

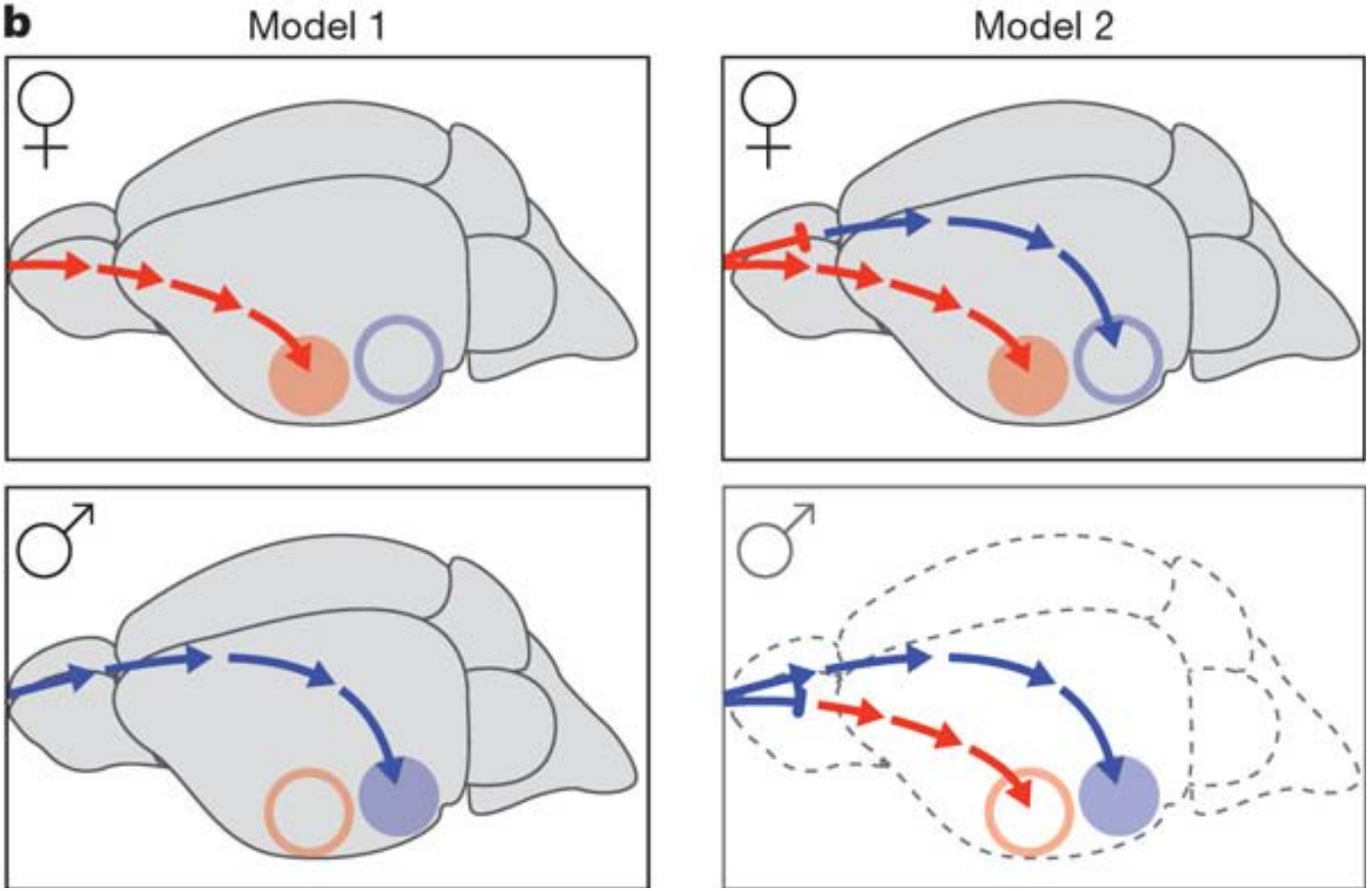
Lisa Stowers,[1] Timothy E. Holy,[2*] Markus Meister,[2]
Catherine Dulac,[1†] Georgy Koentges[1‡]

SCIENCE VOL 295 22 FEBRUARY 2002



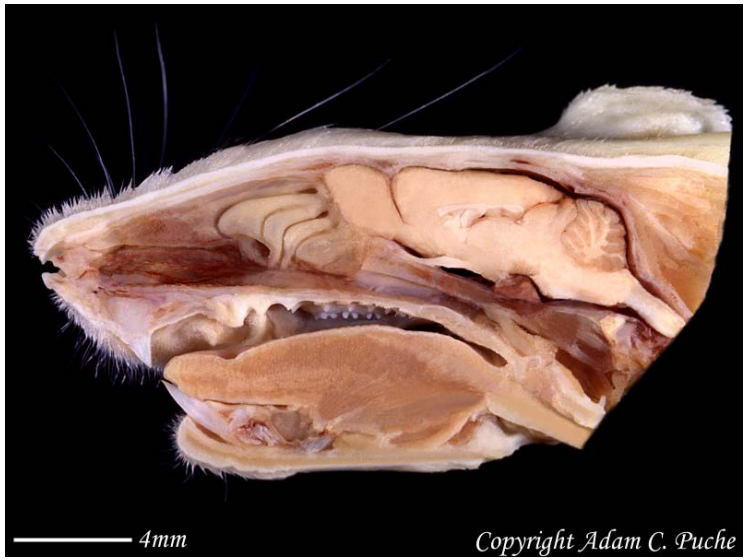
mouse detected by a ♂ TRP2$^{-/-}$ | ♂ mouse detected by a ♂ WT | ♀ mouse detected by a ♂ WT

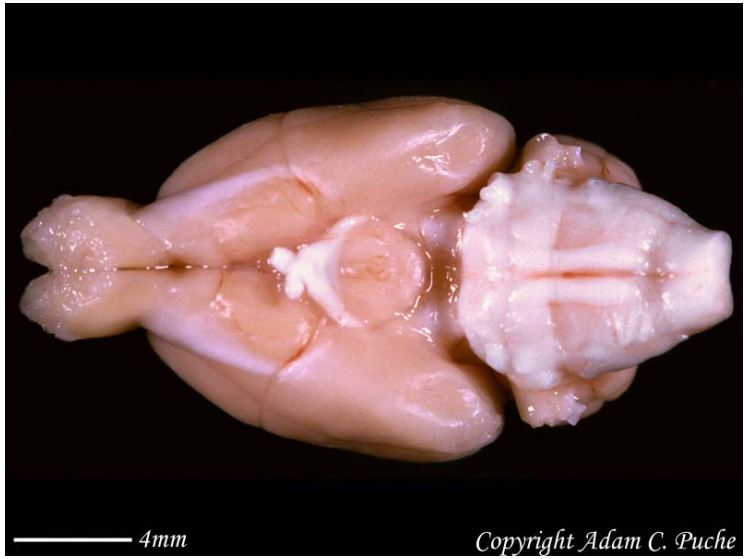
Sexual behavior controlled by the vomeronasal organ



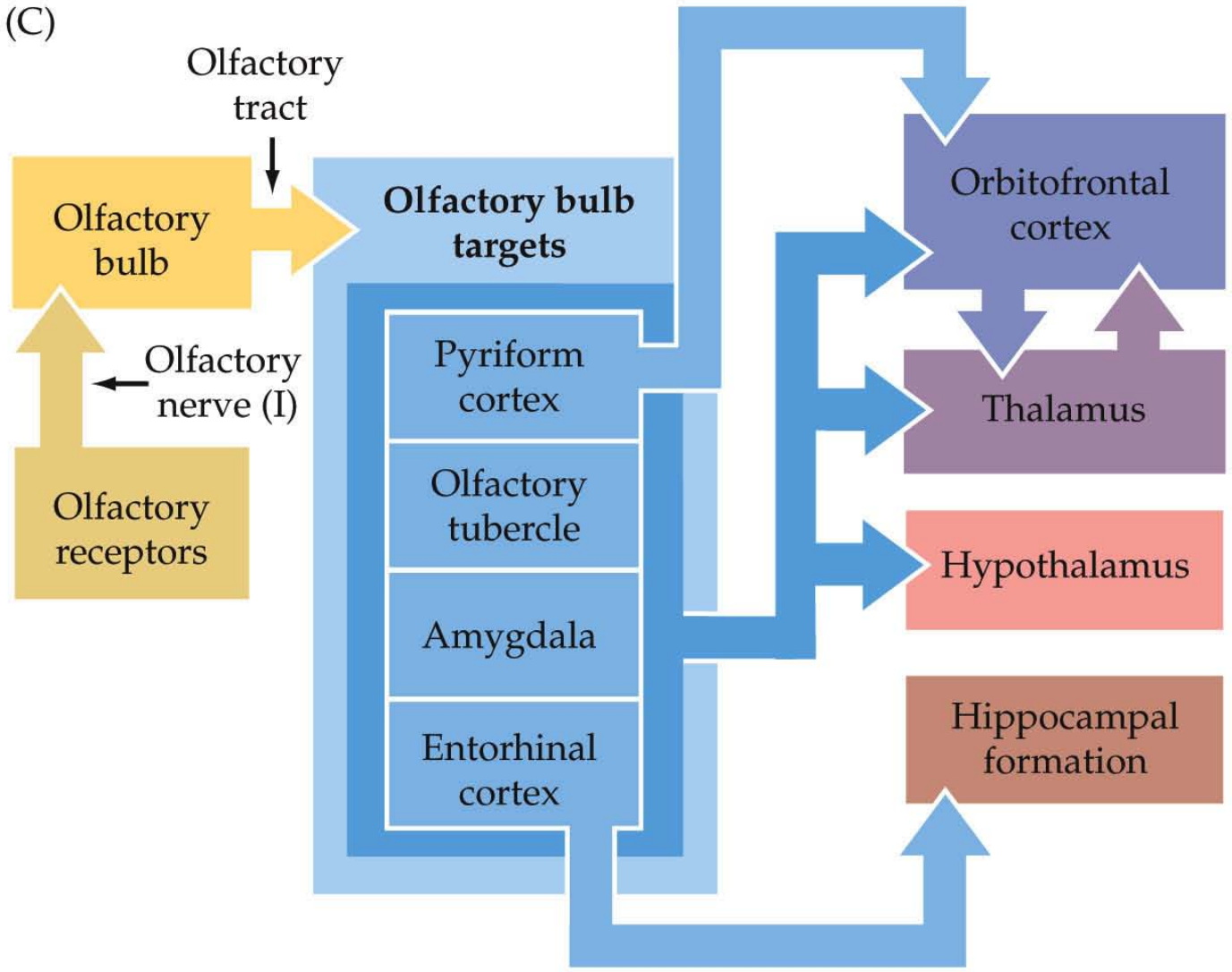
A functional circuit underlying male sexual behaviour in the female mouse brain
Tali Kimchi, Jennings Xu & Catherine Dulac
Nature **448**, 1009-1014 (2007)

Organization of the olfactory system



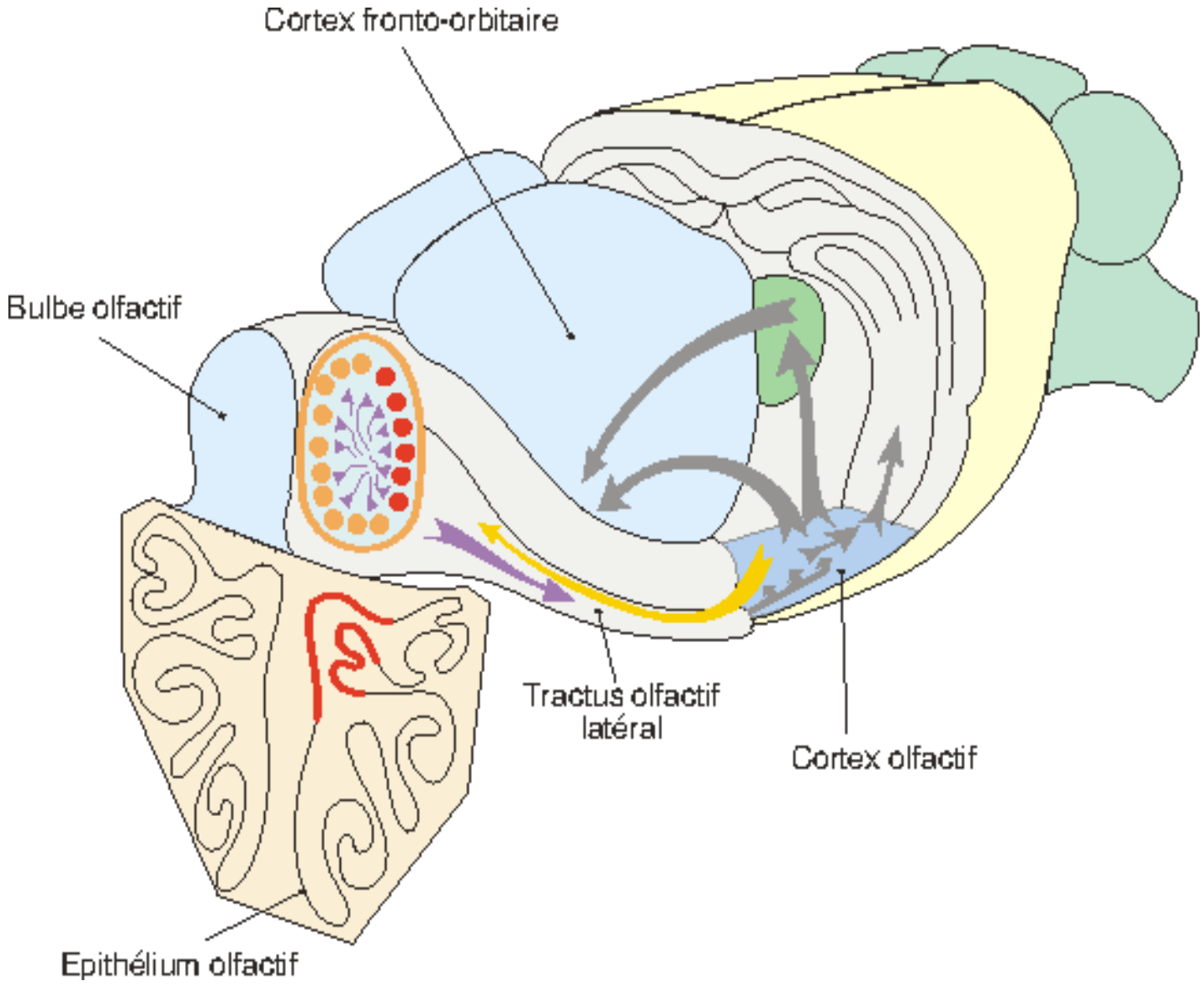


Organization of the main olfactory system

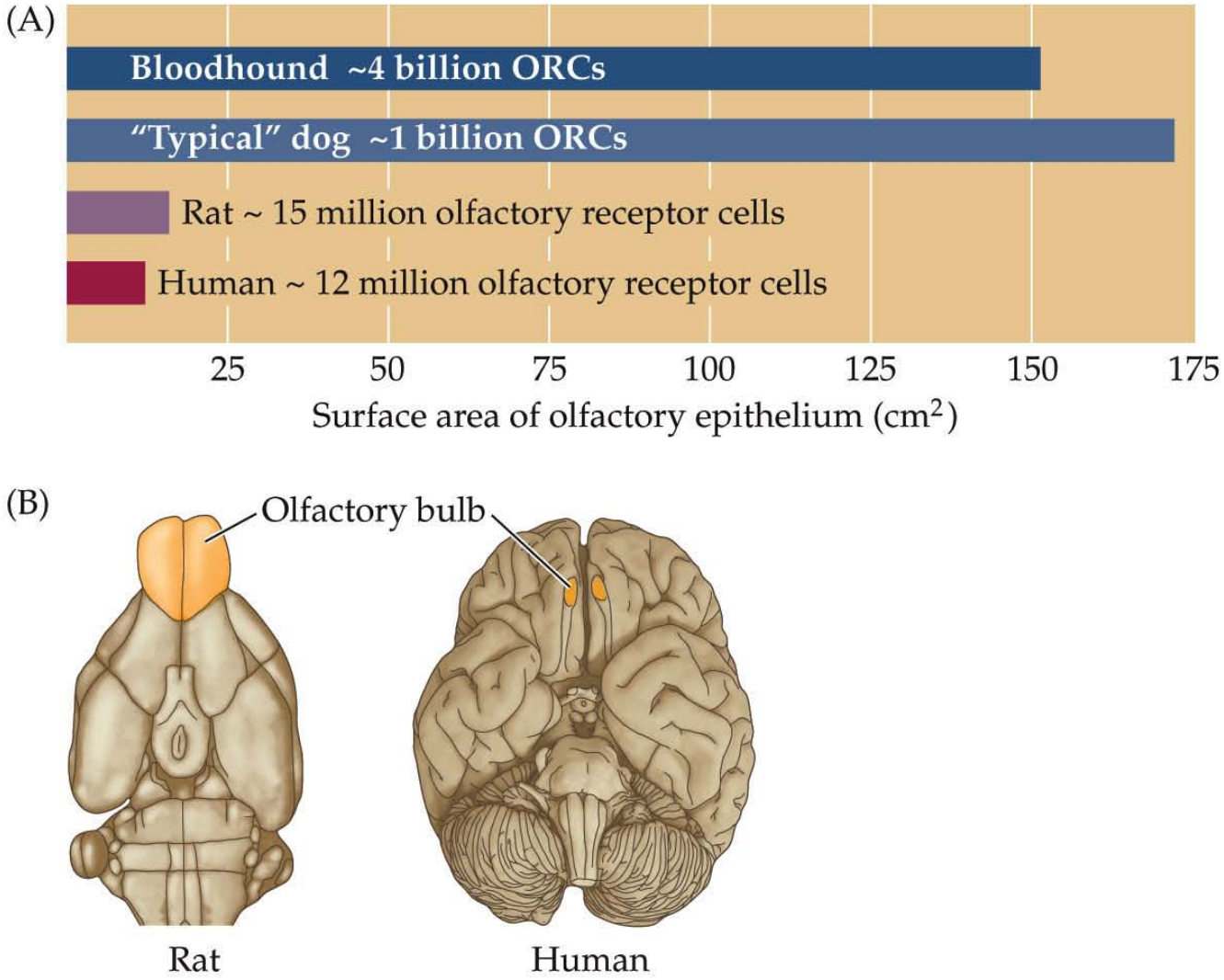


NEUROSCIENCE, Fourth Edition, Figure 15.1 (Part 3)

Organization of the main olfactory system

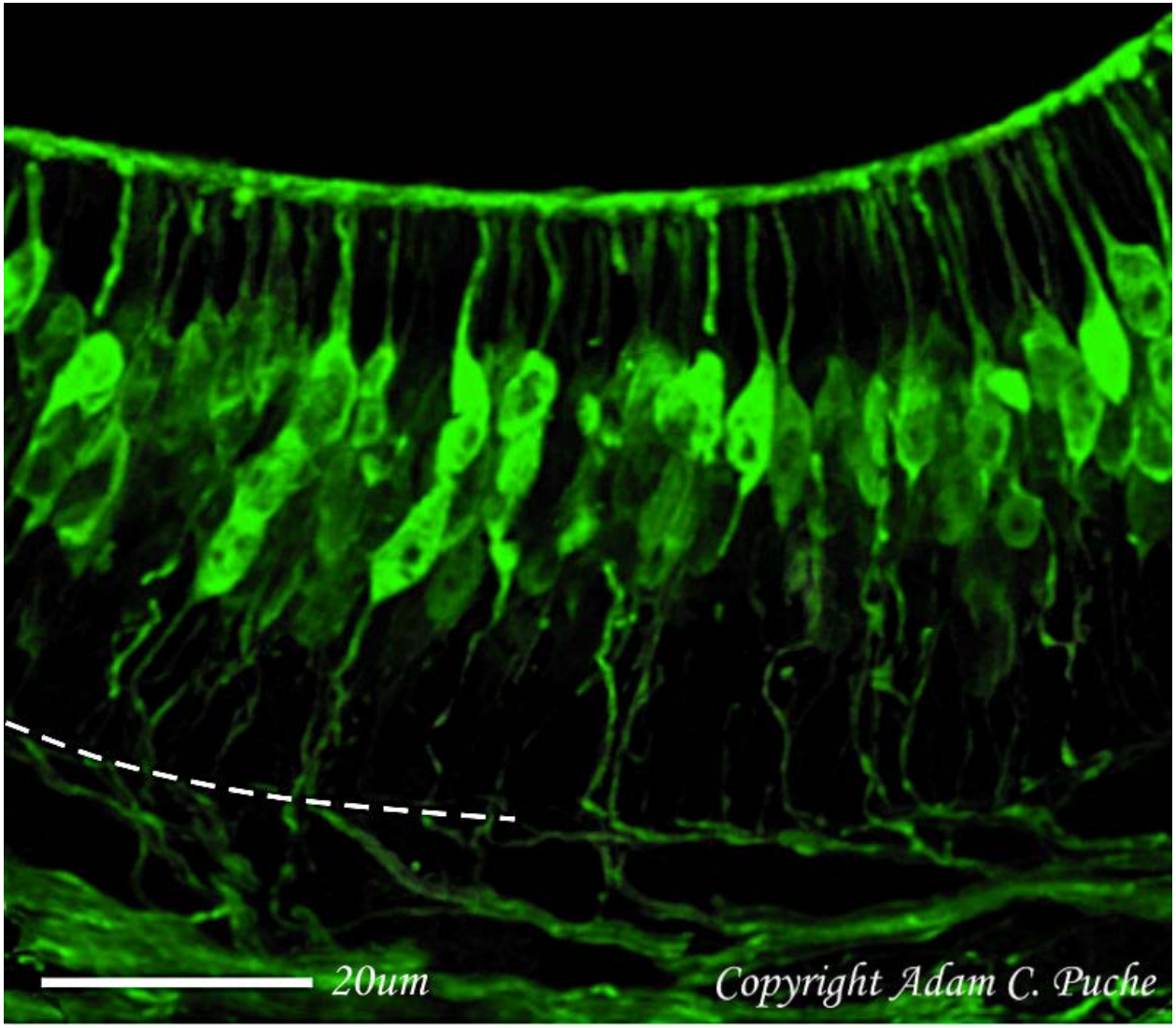


The main olfactory epithelium

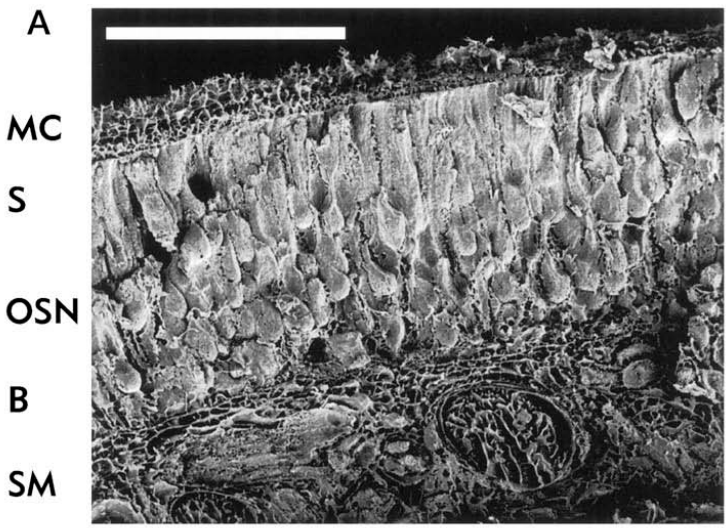


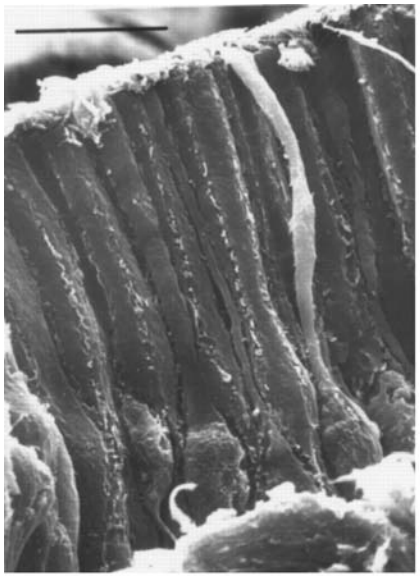
***NEUROSCIENCE, Fourth Edition,* Figure 15.2 (Part 1)**

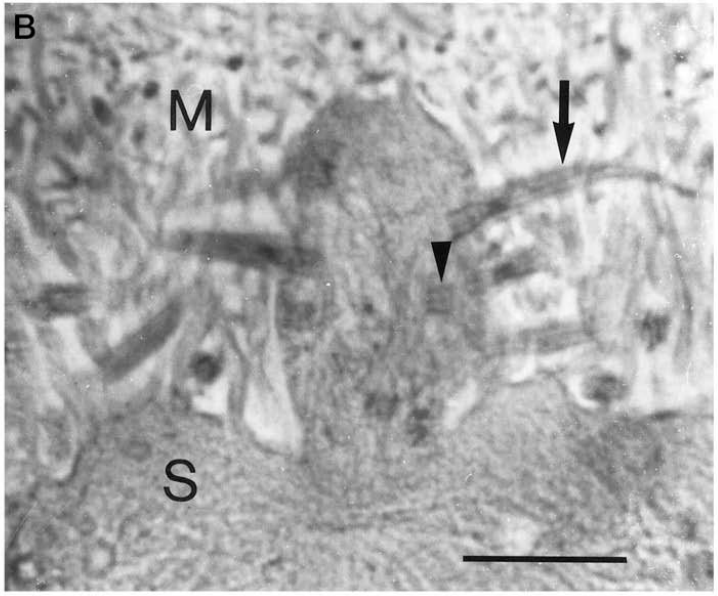
Sensory neurons in the main olfactory epithelium

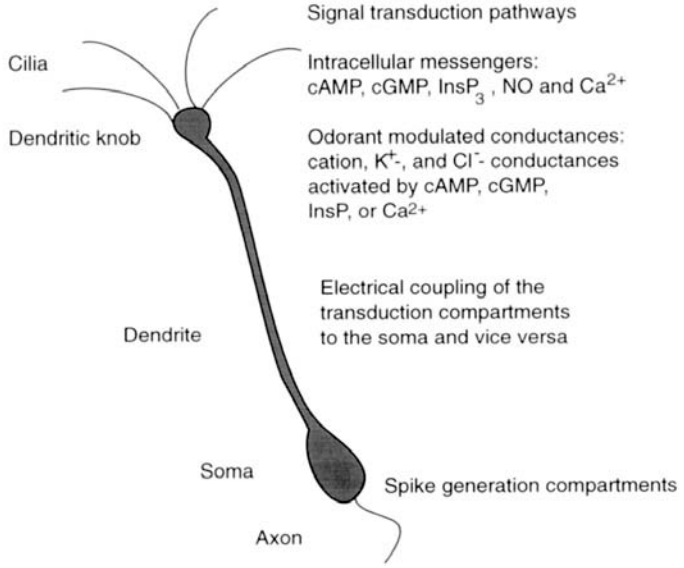


Sensory neurons in the main olfactory epithelium

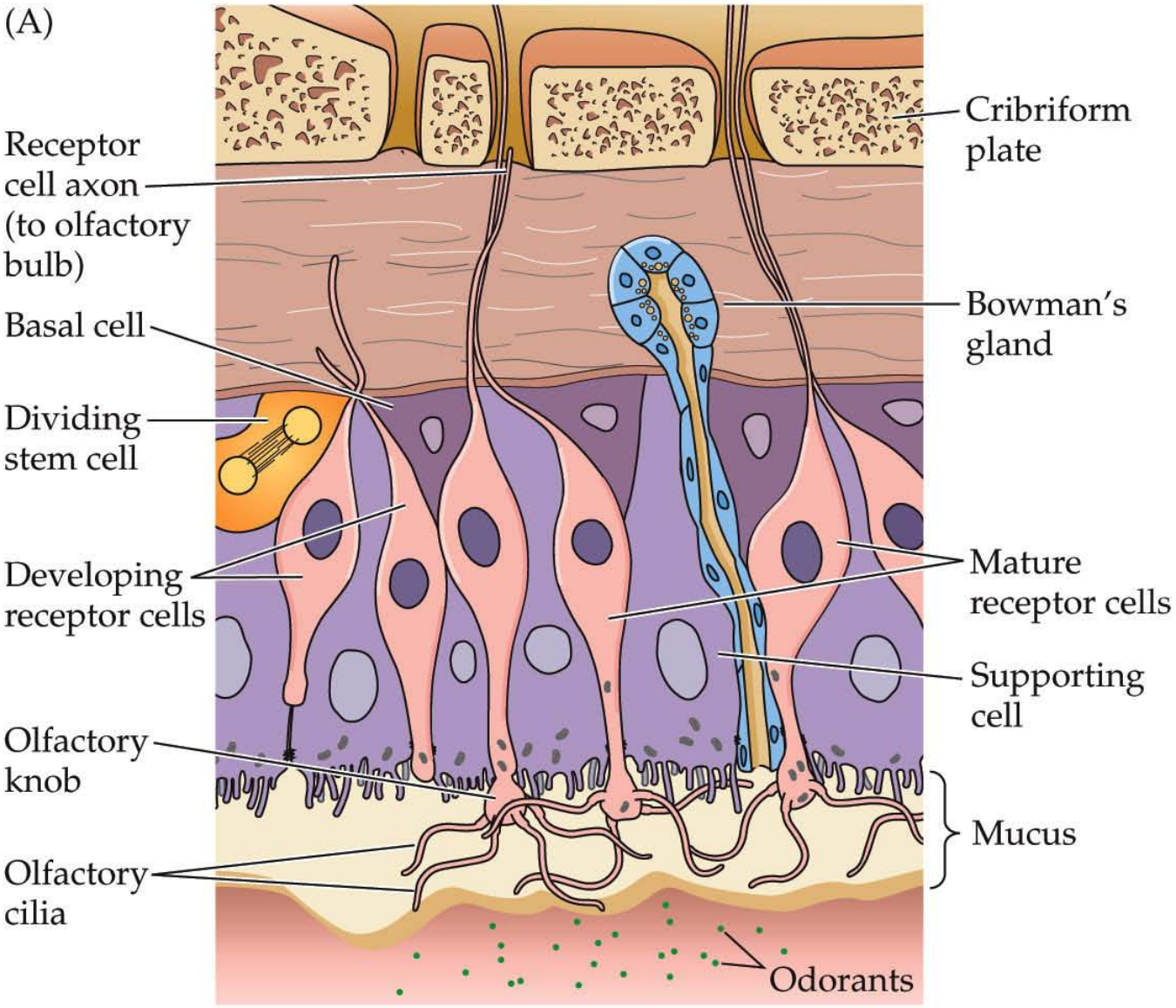






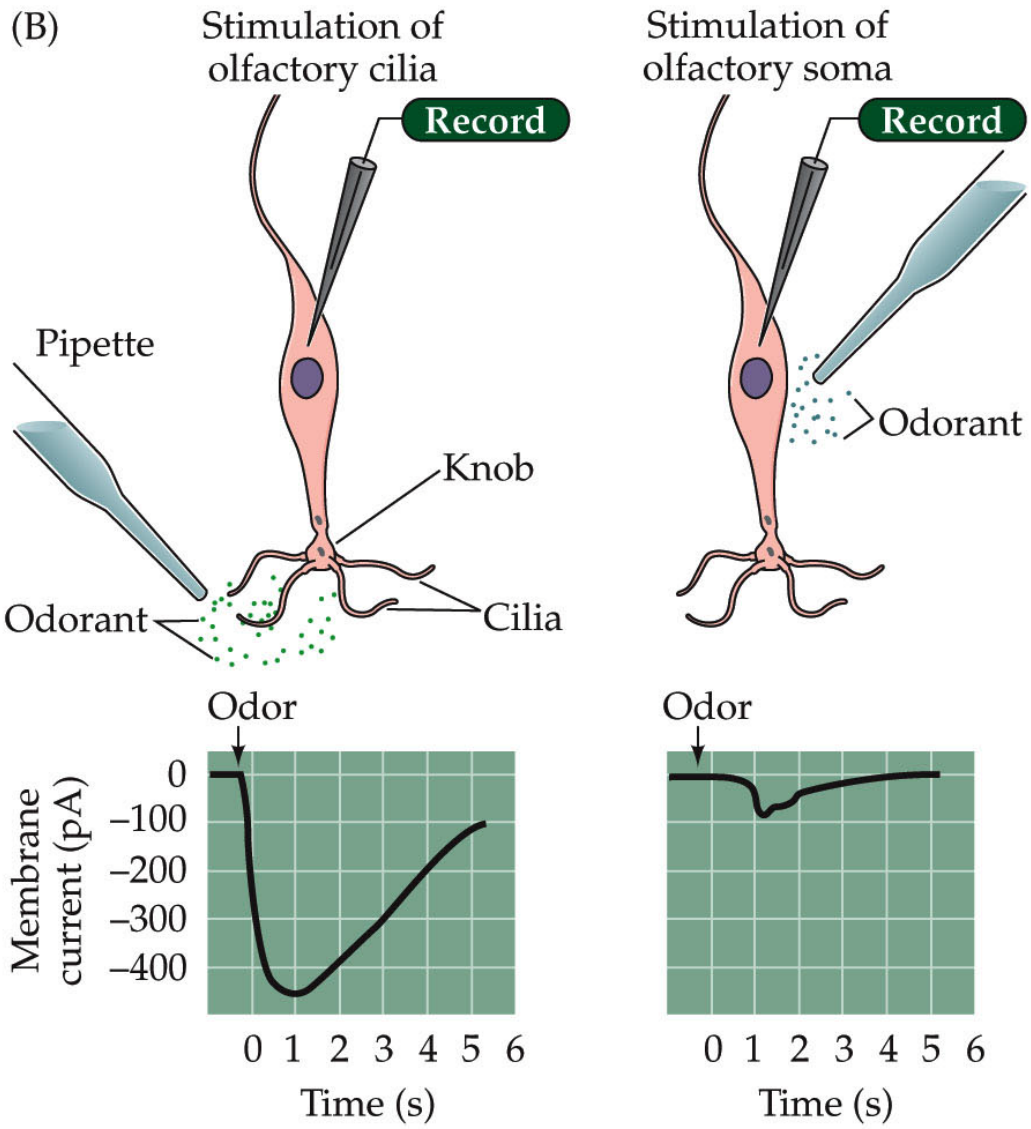


Organization of the main olfactory epithelium



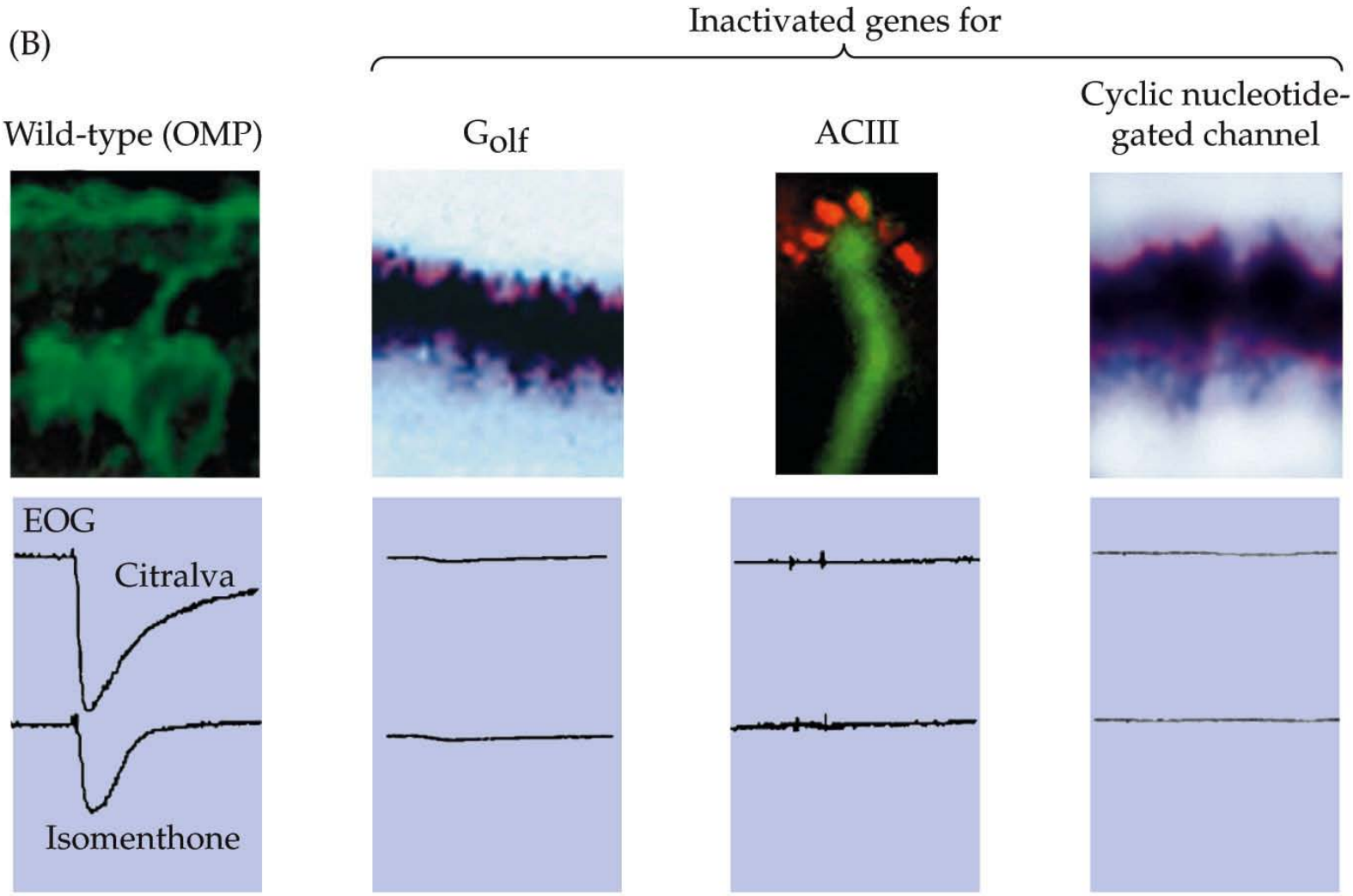
NEUROSCIENCE, Fourth Edition, Figure 15.6 (Part 1)

Transduction in the MOE



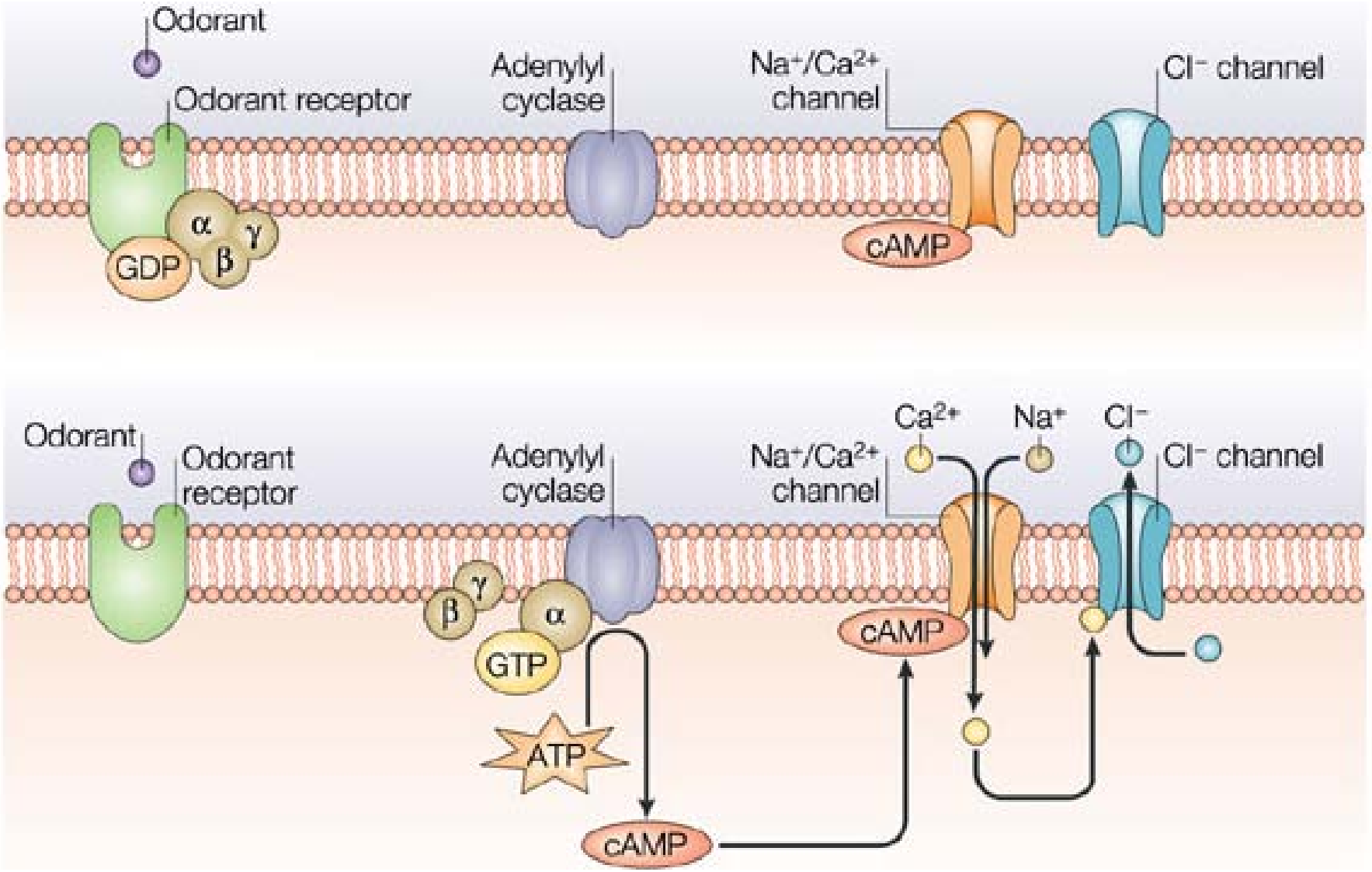
***NEUROSCIENCE, Fourth Edition*, Figure 15.6 (Part 2)**

Transduction in the MOE

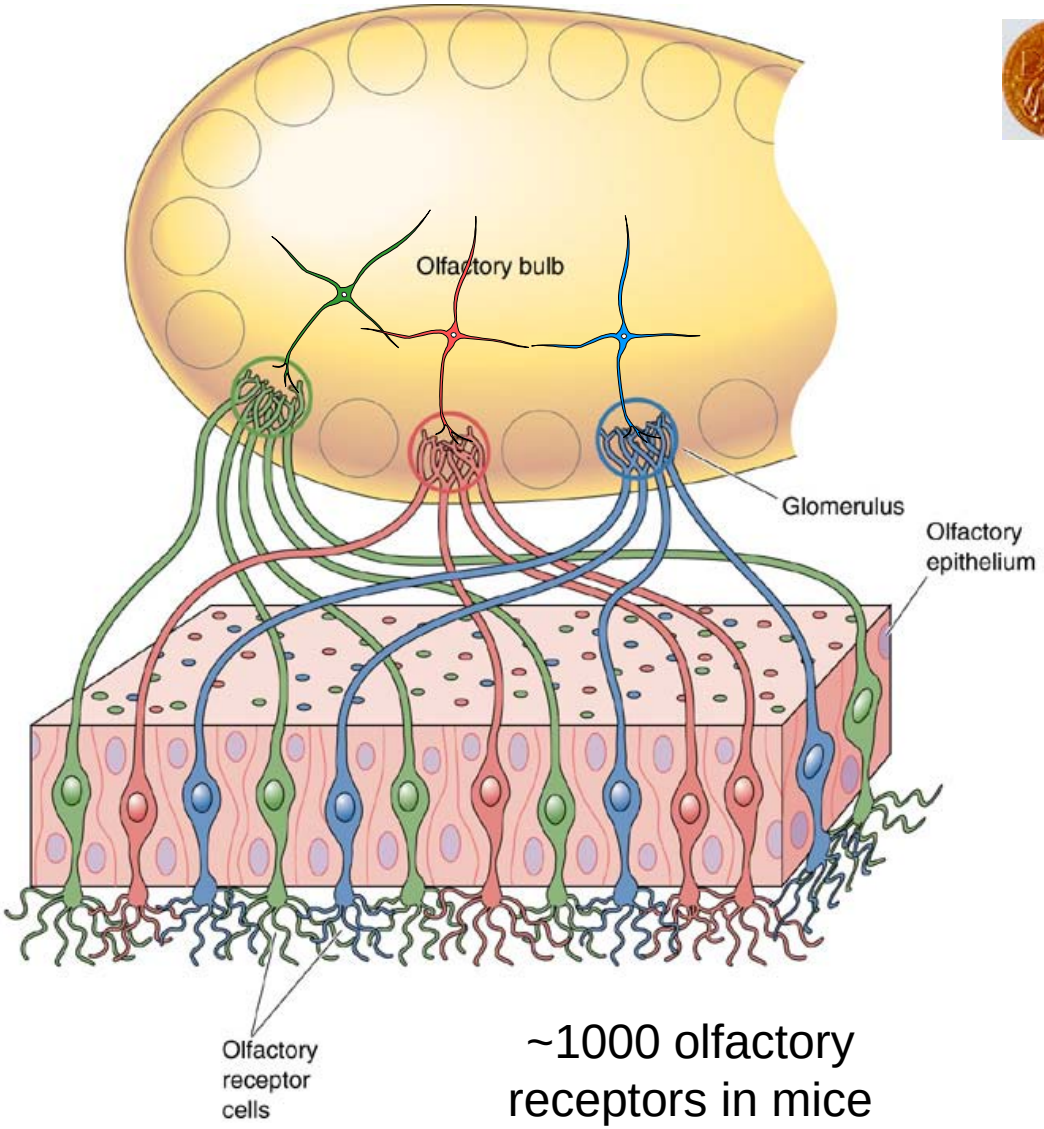


***NEUROSCIENCE, Fourth Edition,* Figure 15.9 (Part 2)**

Transduction in the MOE



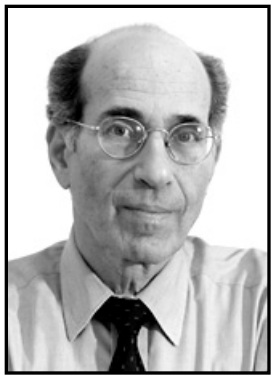
Organization of the olfactory system



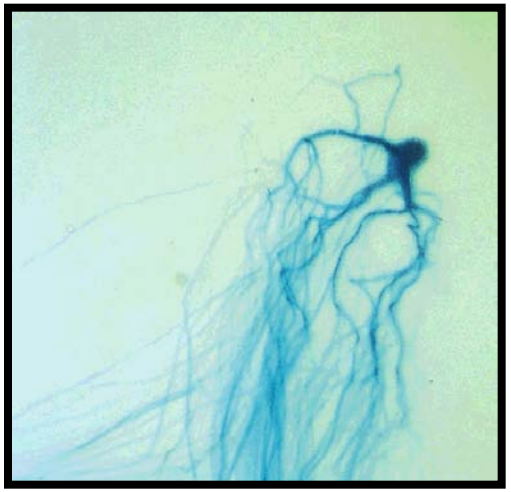
~1000 olfactory receptors in mice

The Nobel Prize in Physiology or Medicine 2004

L. Buck

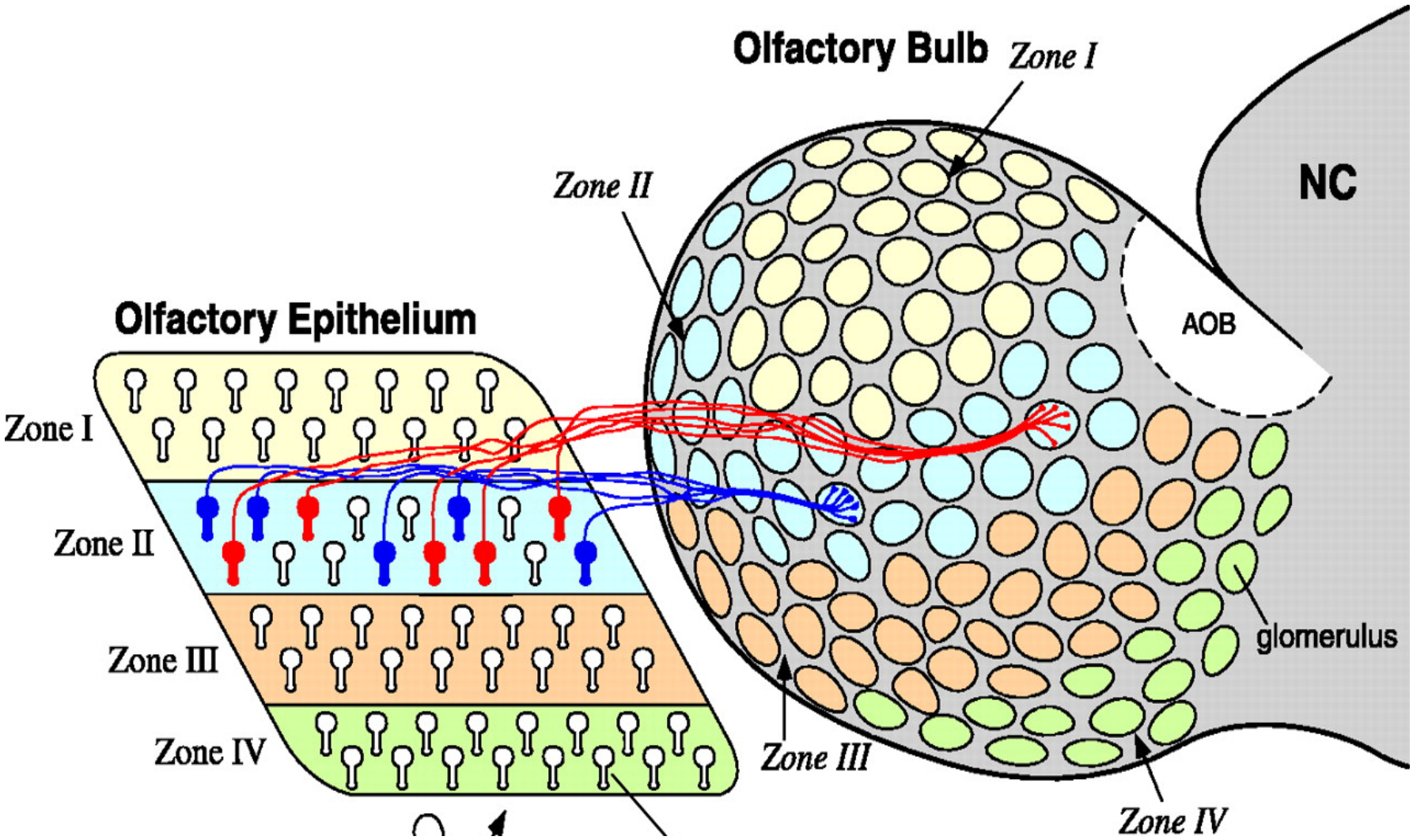


R. Axel

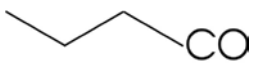


(M50-TauLacZ) Tg mouse

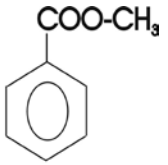
Zonal organization



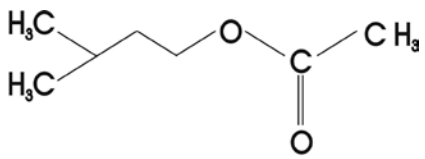
Simplex and complex odors



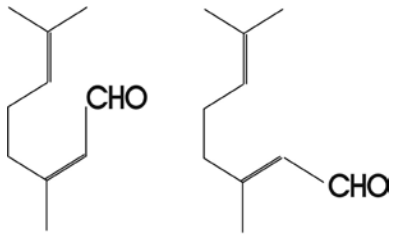
Butanal



Methyl Benzoate

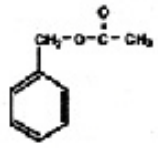


Iso-Amylacetate

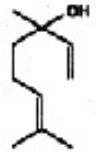


Citral

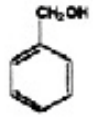
Jasmine



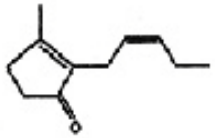
benzyl acetate
(major component)



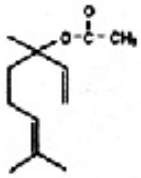
d - linalool



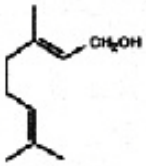
benzyl alcohol



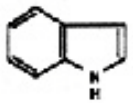
jasmone
(peculiar component)



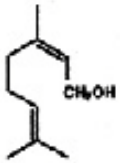
linalyl acetate



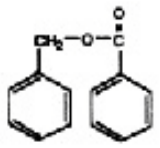
geraniol



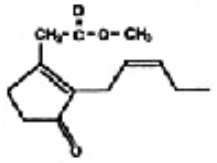
indole



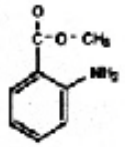
nerol



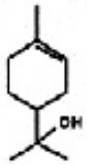
benzyl benzoate



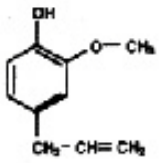
methyl jasmonate
(peculiar component)



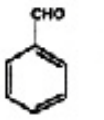
methyl anthranilate



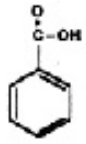
α - terpineol



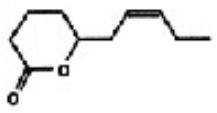
eugenol



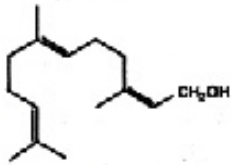
benzaldehyde



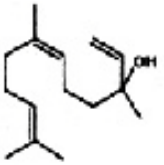
benzoic acid



jasmine lactone
(peculiar component)

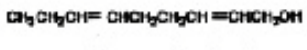


farnesol

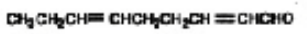


nerolidol

p - cresol



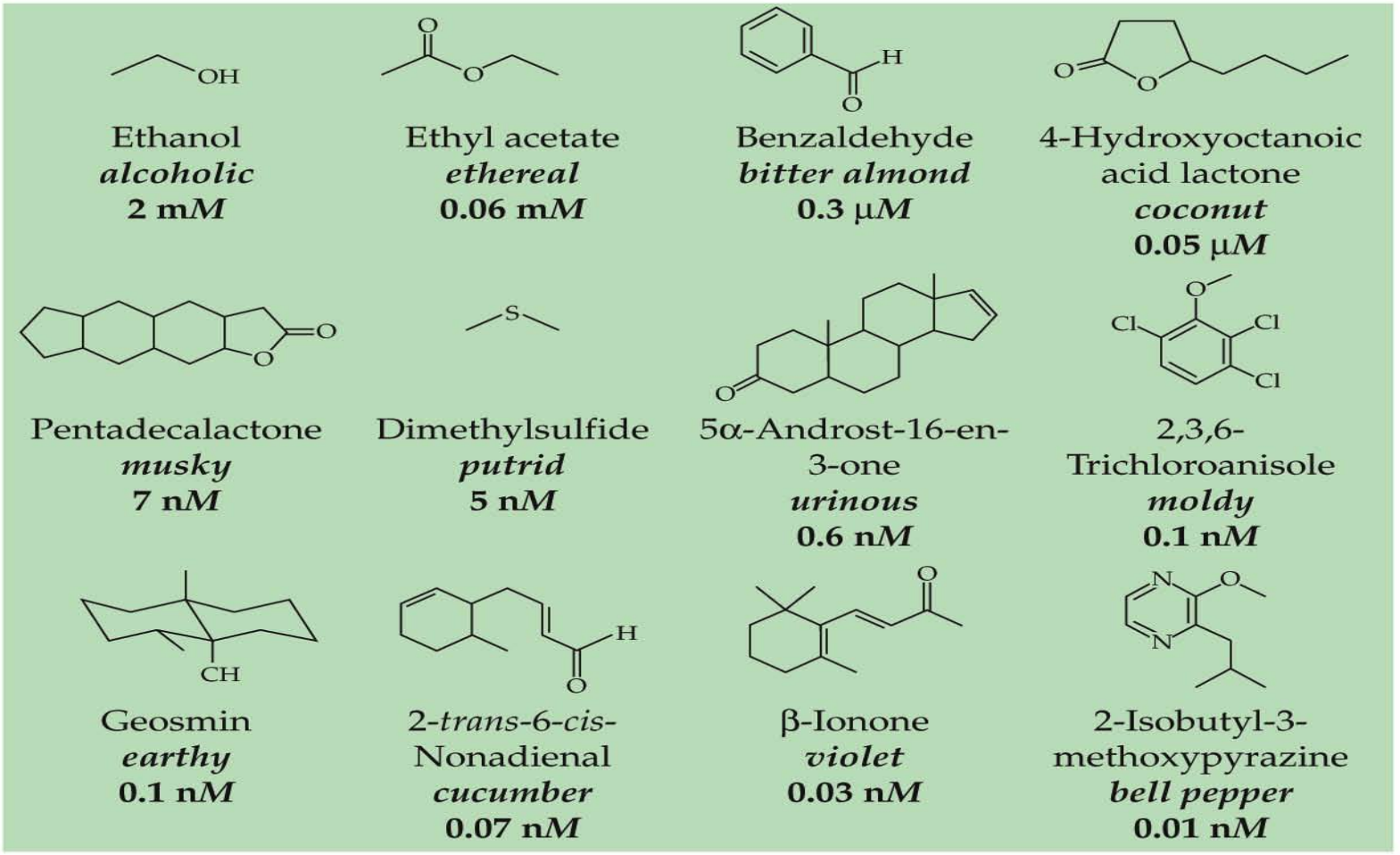
nonadiene - 2 , 6 - ol



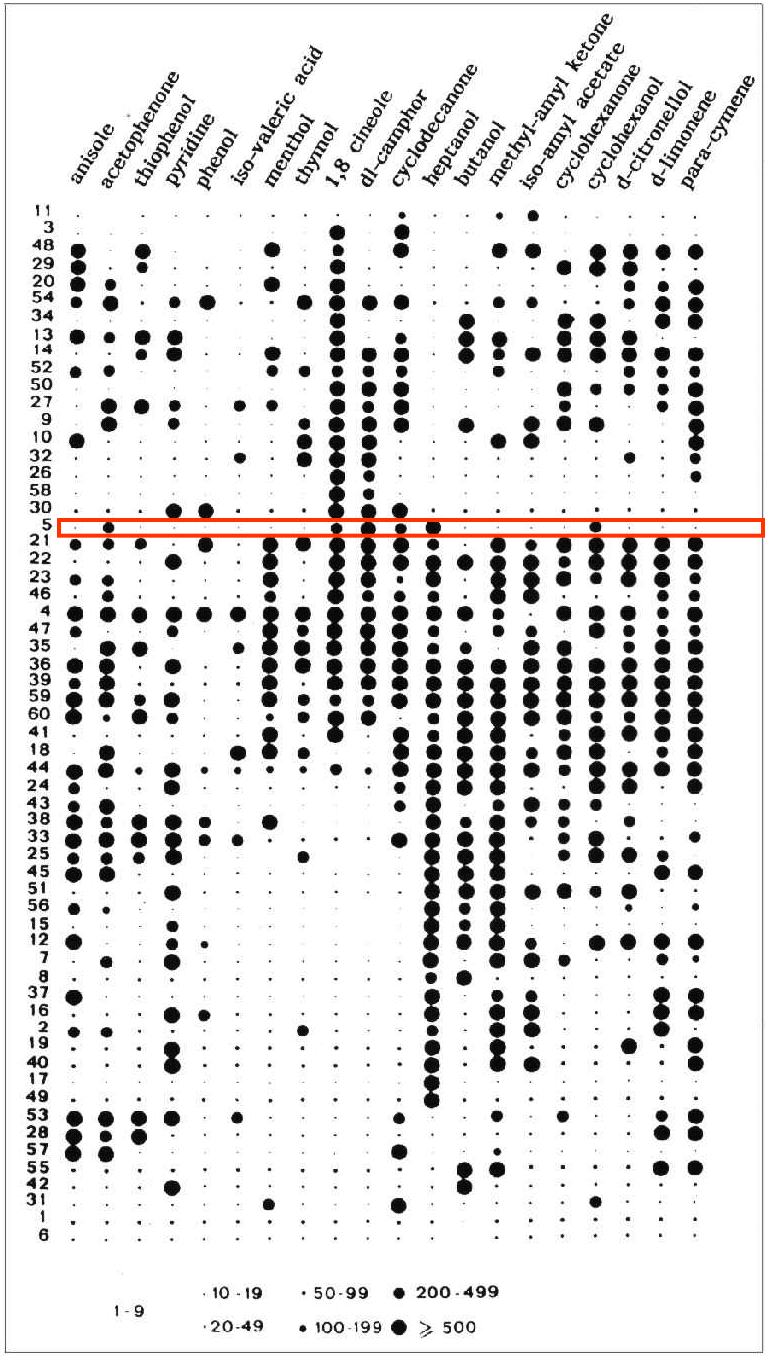
nonadiene -2 , 6 - al

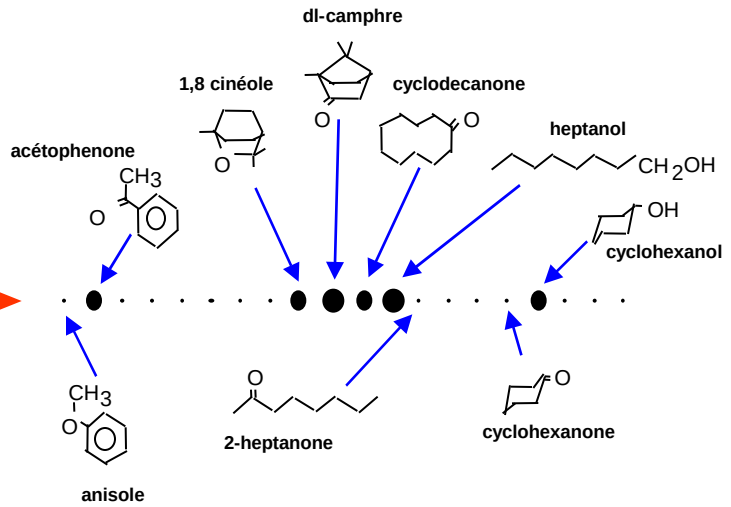
Odor detection in mammals

(C)



***NEUROSCIENCE, Fourth Edition,* Figure 15.2 (Part 2)**

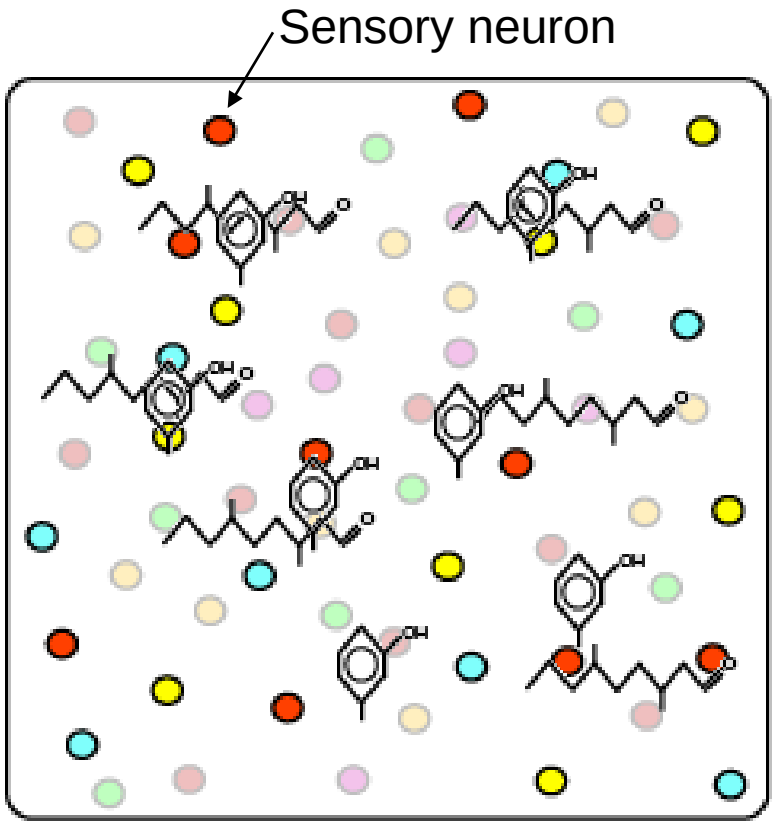




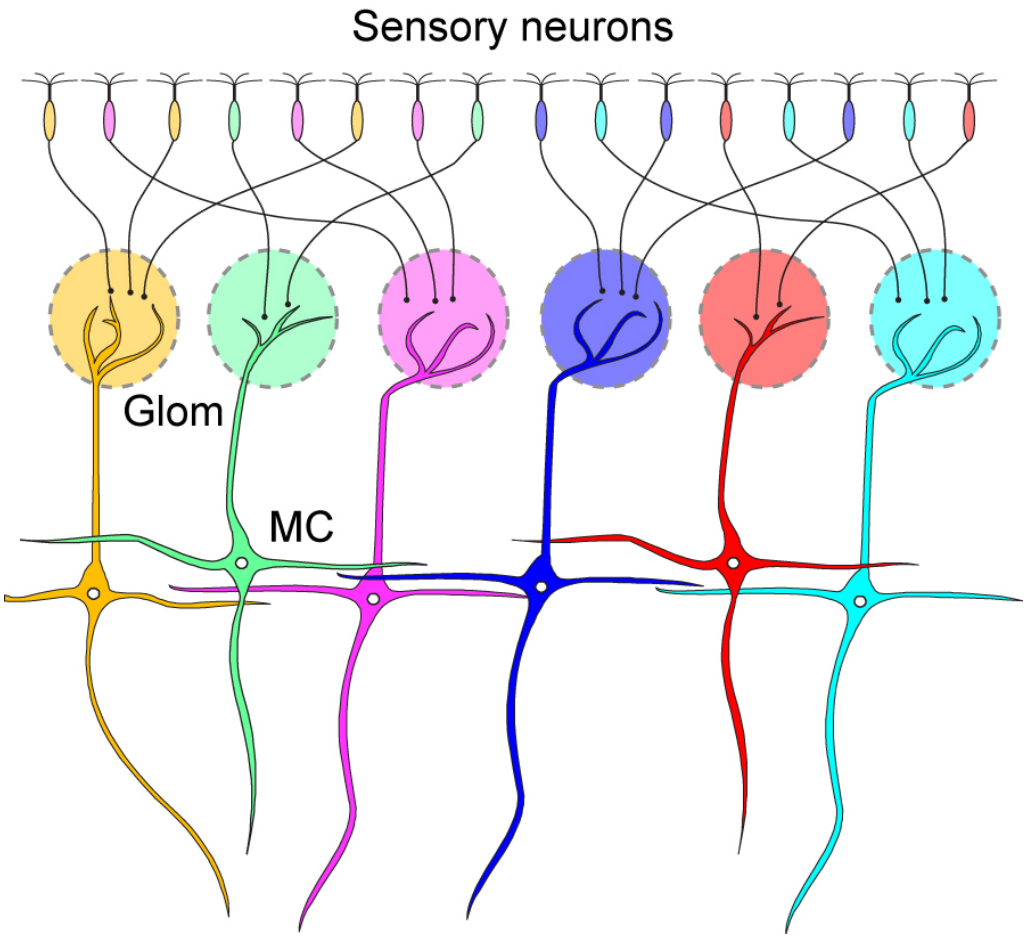
Sicard, G. and Holley, A. (1984). Receptor cell responses to odorants: similarities and differences among odorants. Brain Research, 292, (2), 283-96.

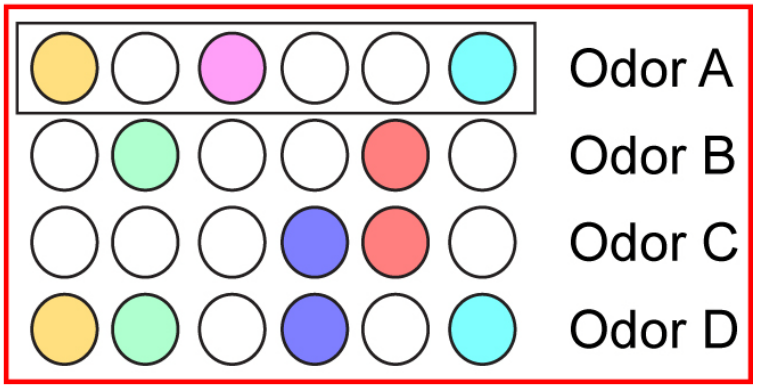
Chemodetection

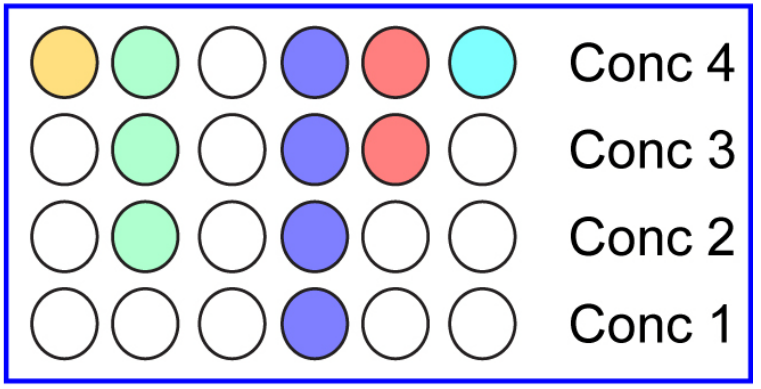
- **One receptor is not specific of a single molecule**
- **Different odors are detected by different sets of receptors**



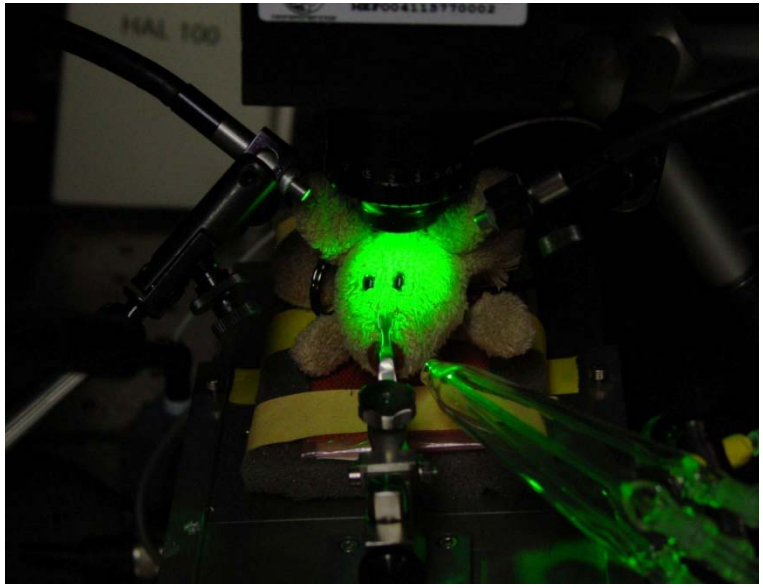
Odor coding = Combinatorial coding

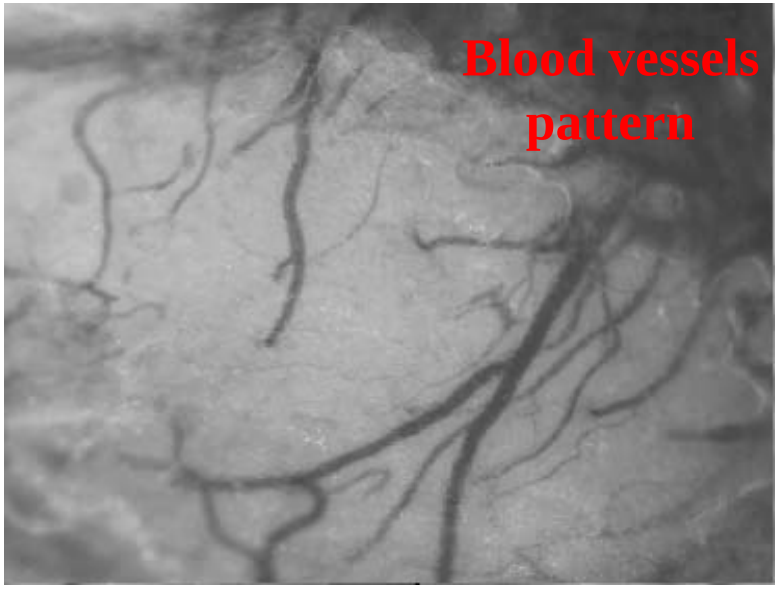


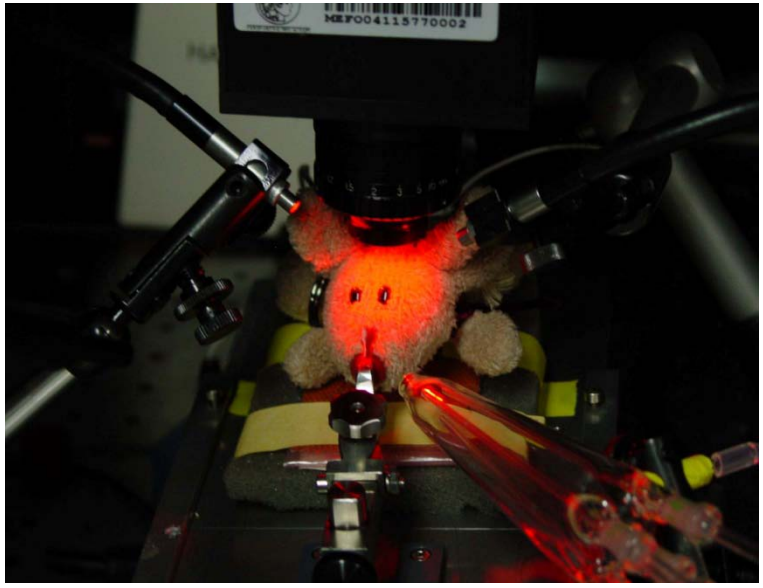


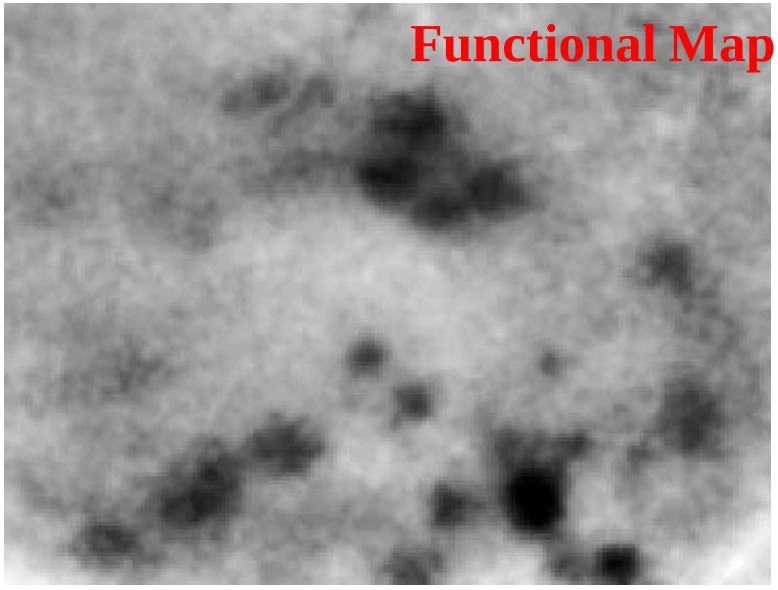


Imaging odor maps



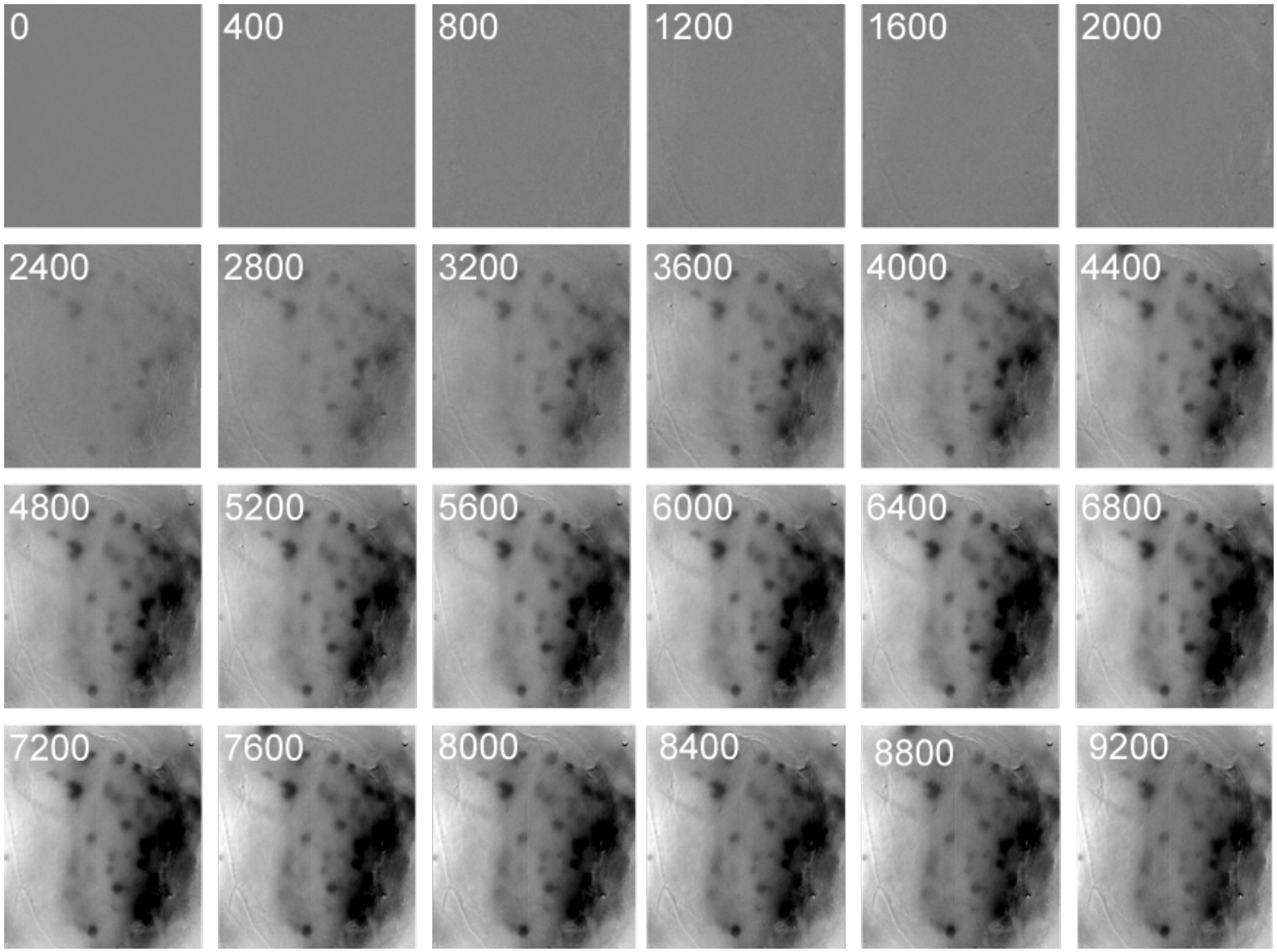






IOS imaging of odorant evoked activity in the olfcatory bulb

Functional organization of cortical regions

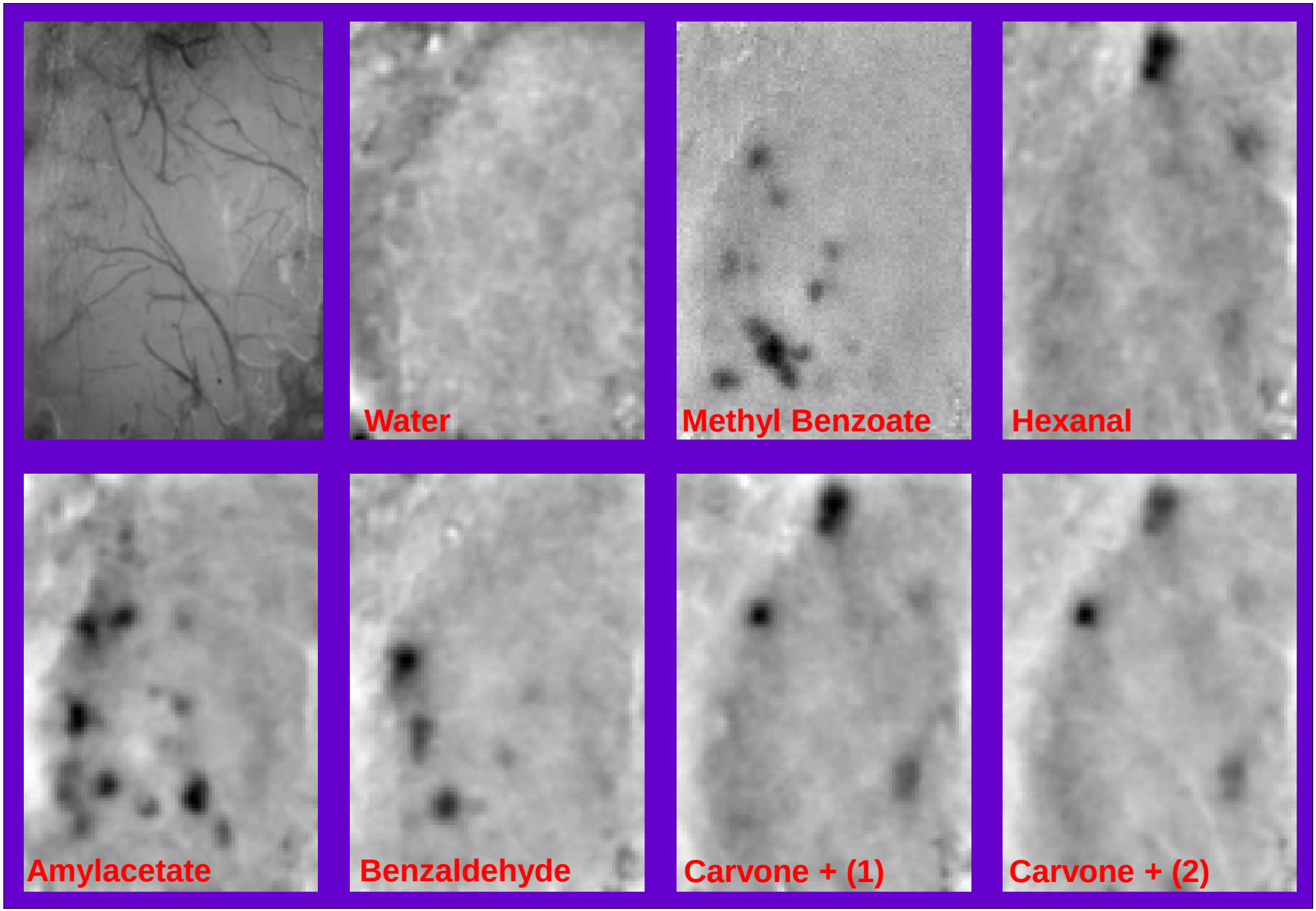


IOS imaging of odorant evoked activity in single trials

Amyl acetate

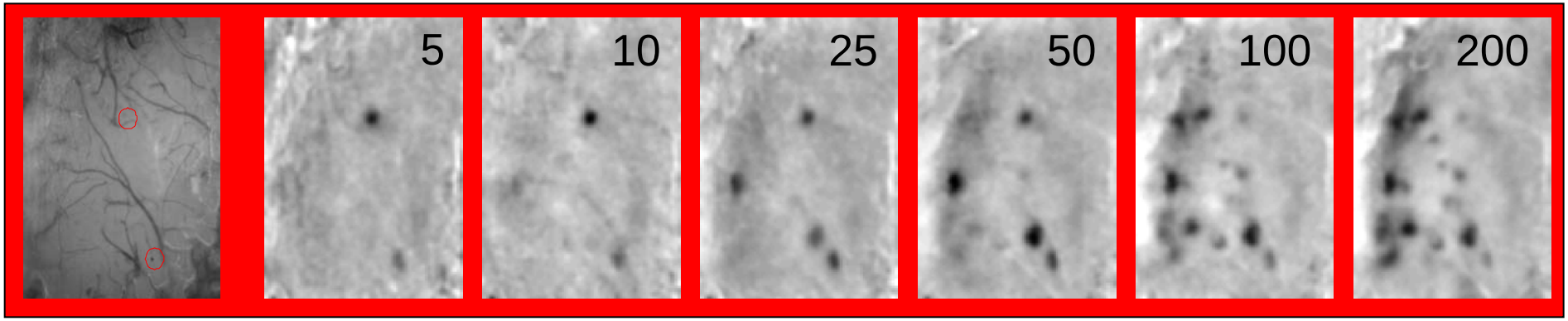
Ethyl Butyrate

Odor maps

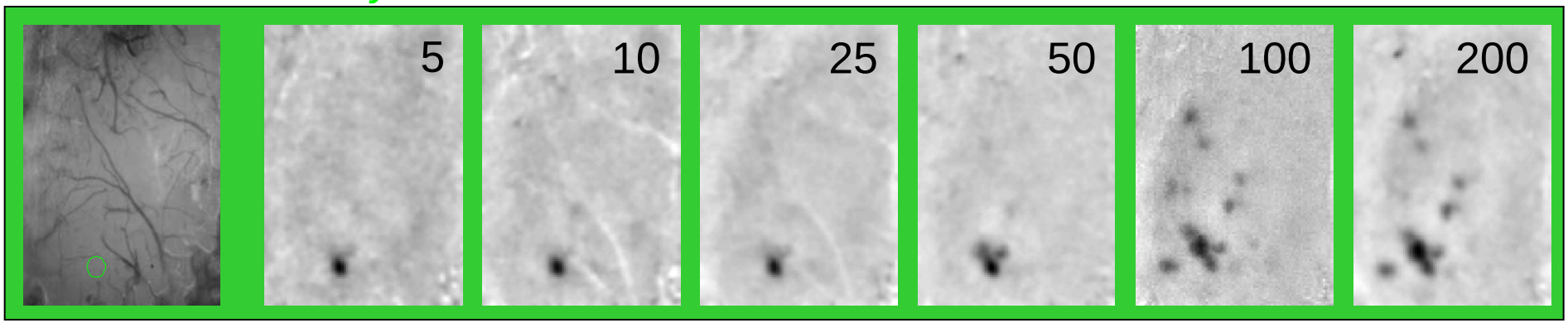

Water
Methyl Benzoate
Hexanal
Amylacetate
Benzaldehyde
Carvone + (1)
Carvone + (2)

Odor evoked glomeruli maps

Amylacetate



Methyl Benzoate

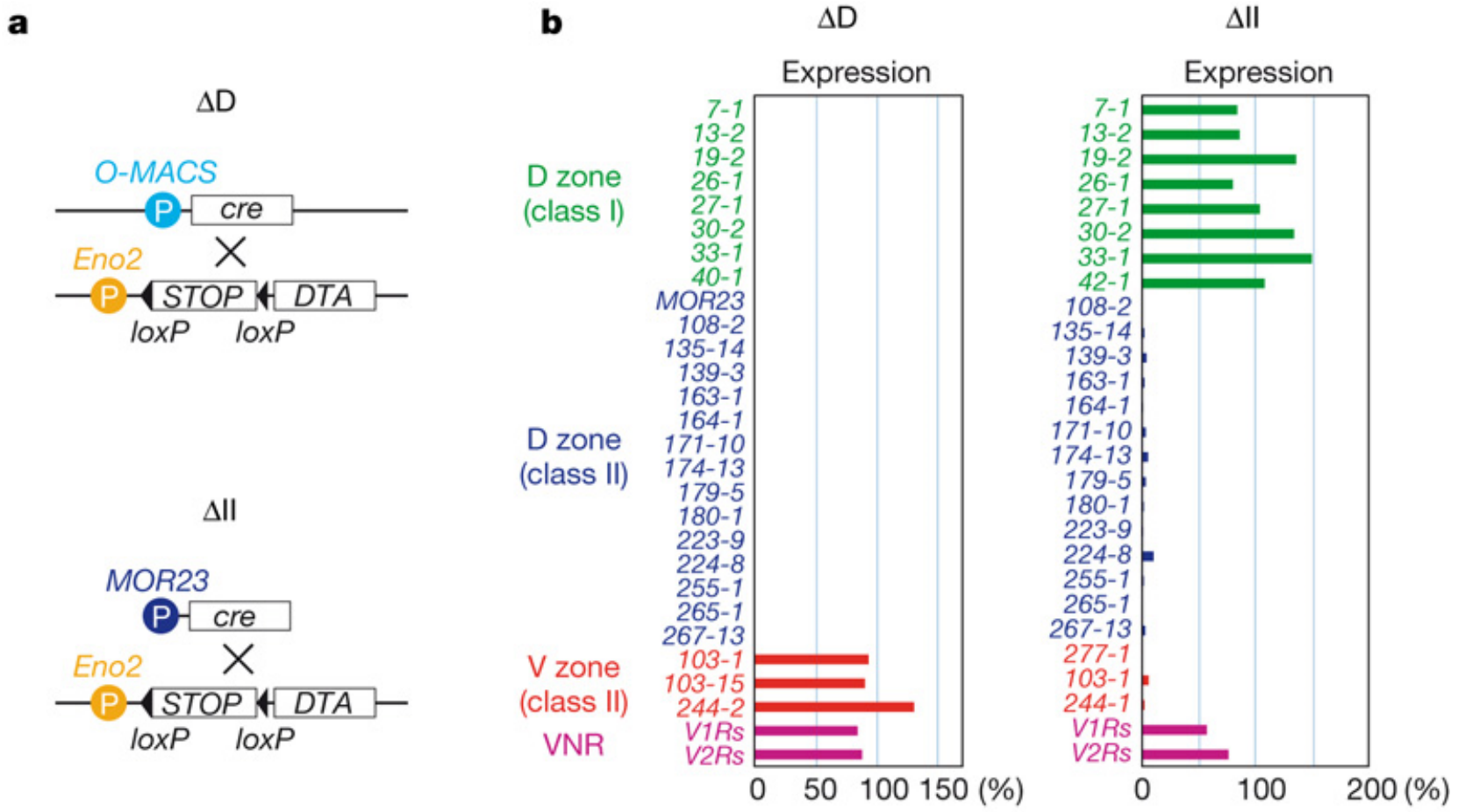


Olfactory mediated behavior

Innate versus learned odour processing in the mouse olfactory bulb

Vol 450 | 22 November 2007 | doi:10.1038/nature06281

Ko Kobayakawa[1]*, Reiko Kobayakawa[1]*, Hideyuki Matsumoto[2], Yuichiro Oka[1], Takeshi Imai[1], Masahito Ikawa[3], Masaru Okabe[3], Toshio Ikeda[4], Shigeyoshi Itohara[4], Takefumi Kikusui[5], Kensaku Mori[2] & Hitoshi Sakano[1]

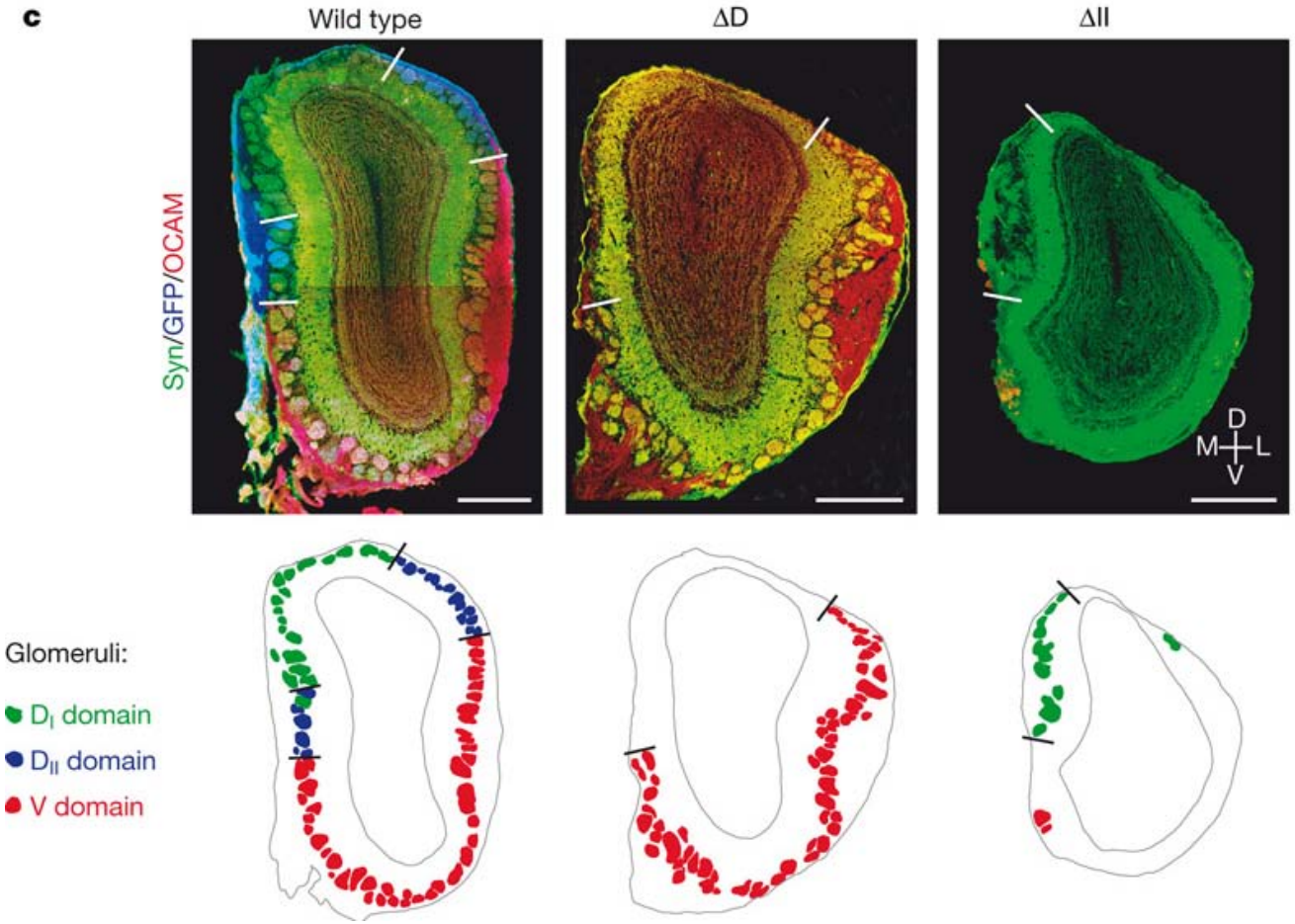


Organization of the olfactory system

Innate versus learned odour processing in the mouse olfactory bulb

Vol 450 | 22 November 2007 | doi:10.1038/nature06281

Ko Kobayakawa[1]*, Reiko Kobayakawa[1]*, Hideyuki Matsumoto[2], Yuichiro Oka[1], Takeshi Imai[1], Masahito Ikawa[3], Masaru Okabe[3], Toshio Ikeda[4], Shigeyoshi Itohara[4], Takefumi Kikusui[5], Kensaku Mori[2] & Hitoshi Sakano[1]



Anosmia: loss of the sense of smell

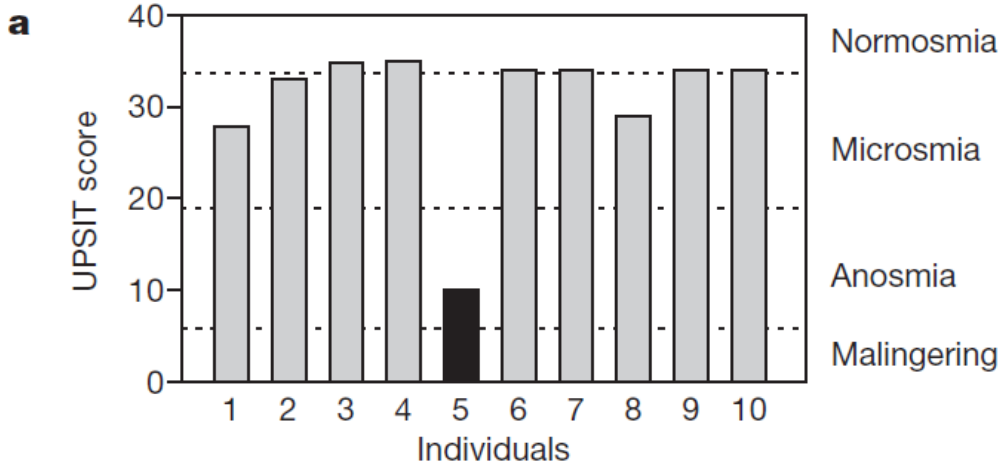
Loss-of-function mutations in sodium channel $Na_v1.7$ cause anosmia

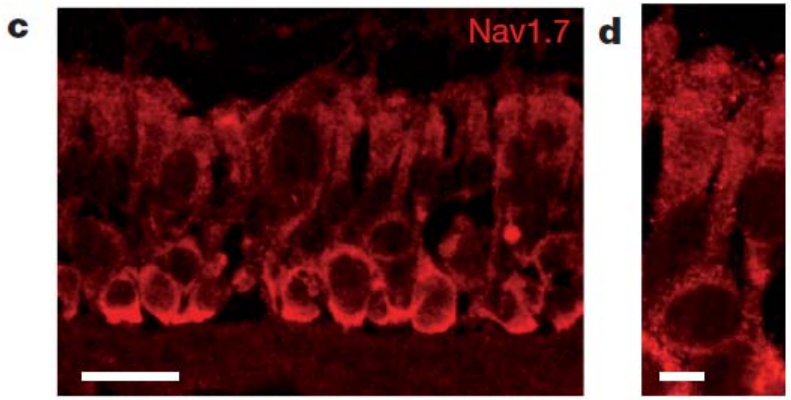
Jan Weiss[1]*, Martina Pyrski[1]*, Eric Jacobi[1], Bernd Bufe[1], Vivienne Willnecker[2], Bernhard Schick[2], Philippe Zizzari[3], Samuel J. Gossage[4], Charles A. Greer[5], Trese Leinders-Zufall[1], C. Geoffrey Woods[6], John N. Wood[4,7] & Frank Zufall[1]

Loss of function of the gene *SCN9A*, encoding the voltage-gated sodium channel $Na_v1.7$, causes a congenital inability to experience pain in humans. Here we show that $Na_v1.7$ is not only necessary for pain sensation but is also an essential requirement for odour perception in both mice and humans. We examined human patients with loss-of-function mutations in *SCN9A* and show that they are unable to sense odours. To establish the essential role of $Na_v1.7$ in odour perception, we generated conditional null mice in which $Na_v1.7$ was removed from all olfactory sensory neurons. In the absence of $Na_v1.7$, these neurons still produce odour-evoked action potentials but fail to initiate synaptic signalling from their axon terminals at the first synapse in the olfactory system. The mutant mice no longer display vital, odour-guided behaviours such as innate odour recognition and avoidance, short-term odour learning, and maternal pup retrieval. Our study creates a mouse model of congenital general anosmia and provides new strategies to explore the genetic basis of the human sense of smell.

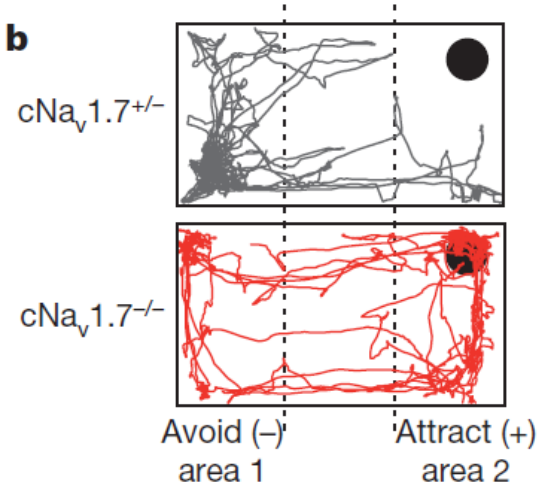
Anosmia: loss of the sense of smell

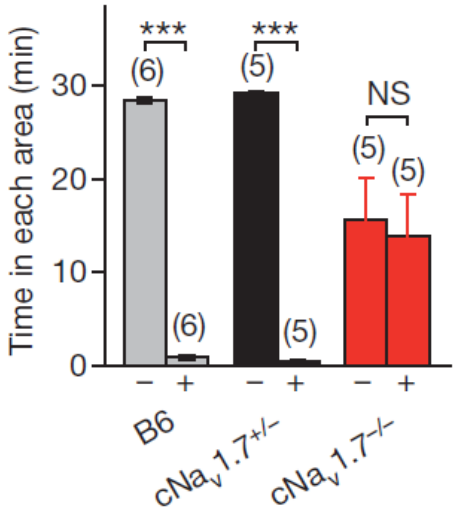
Human



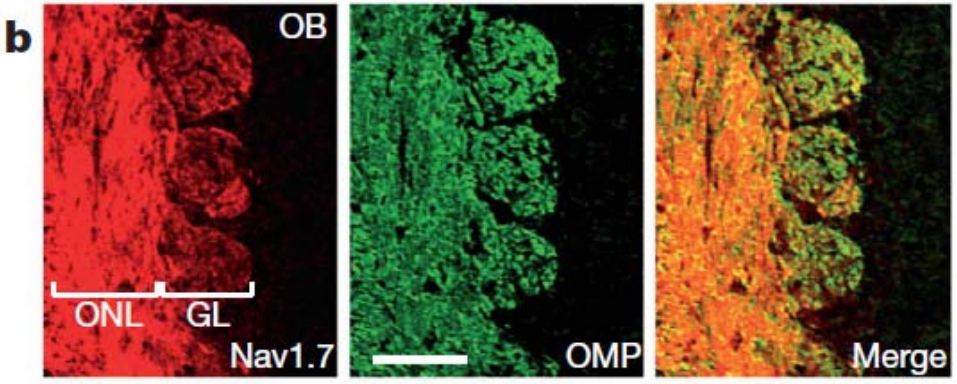


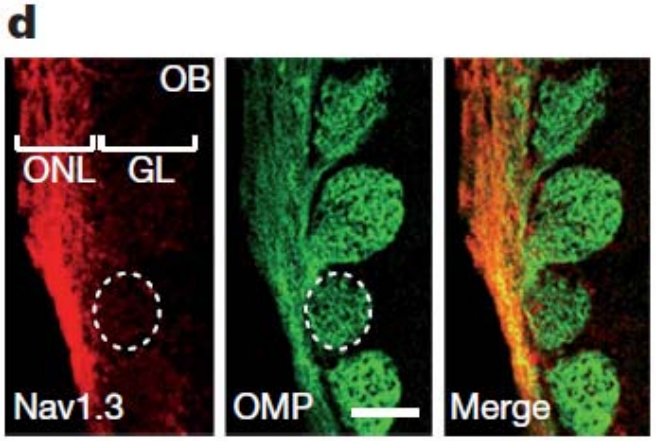
Mouse



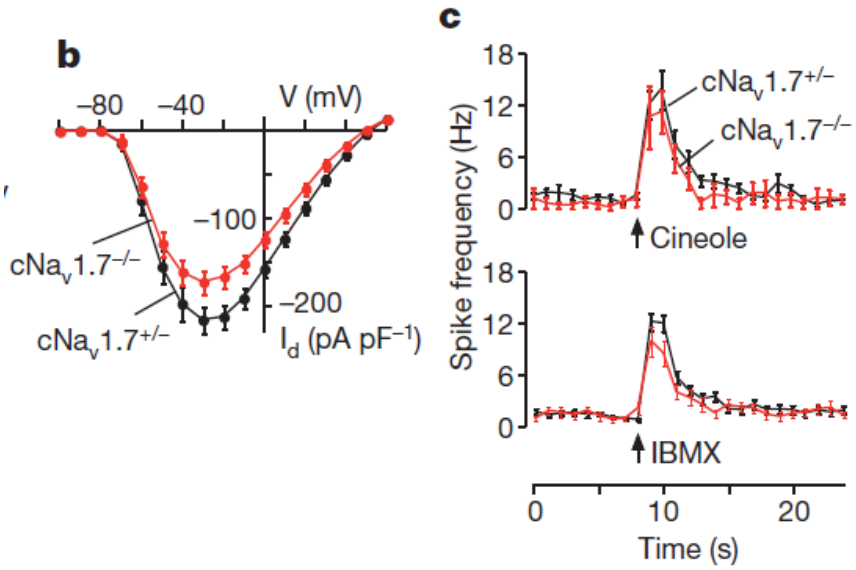


Anosmia: loss of the sense of smell

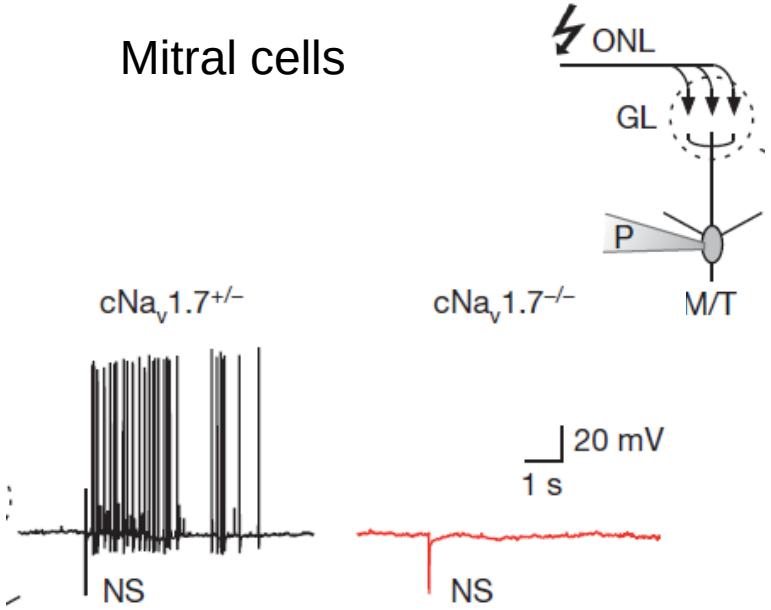




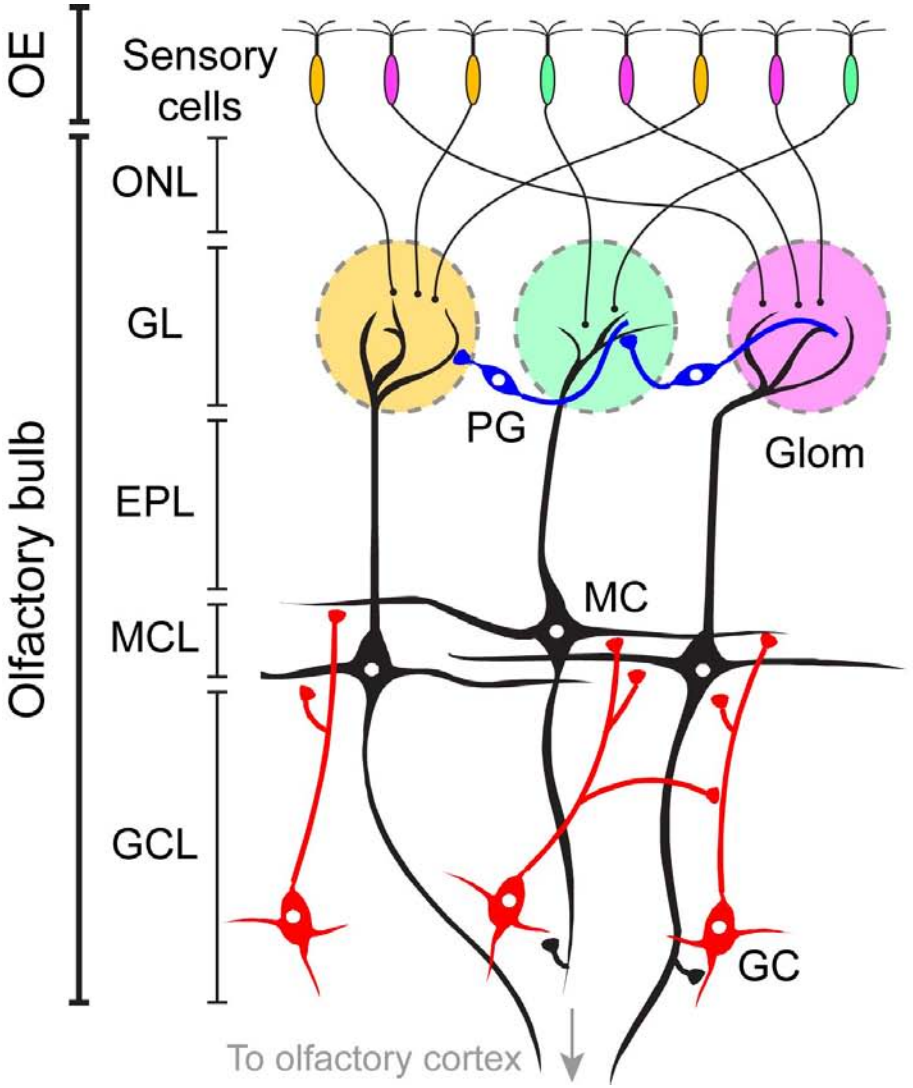
Sensory neurons

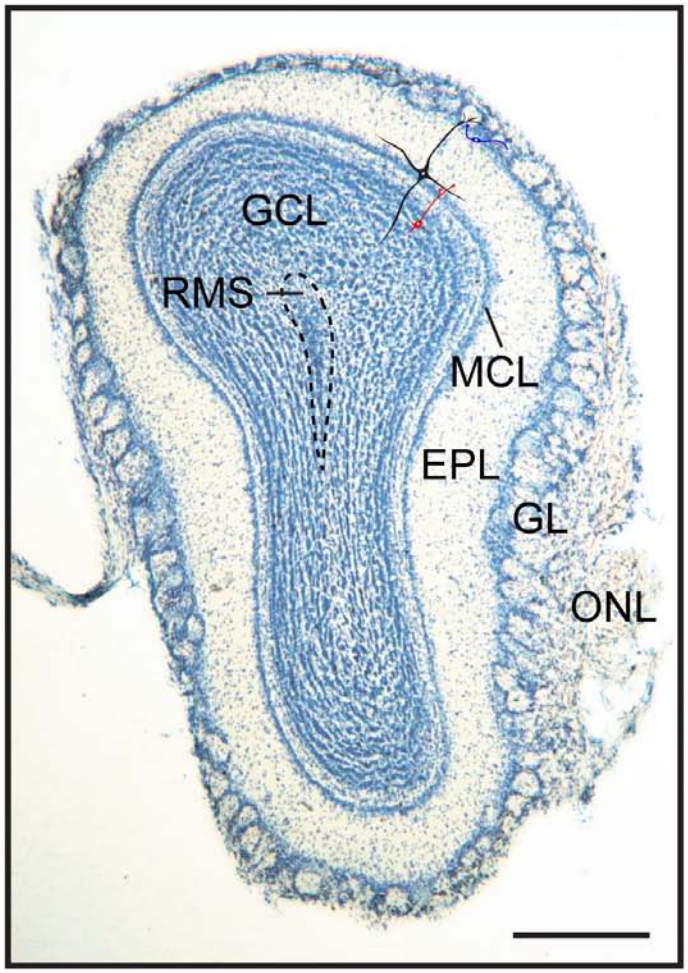


Mitral cells

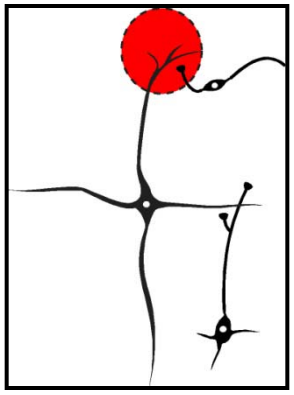


Olfactory bulb circuitry



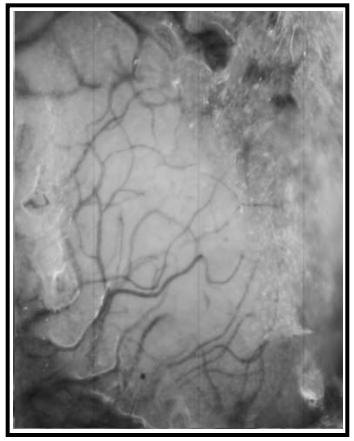


Spatial patterns of odor mixtures measured by intrinsic Imaging are highly similar in trained mice



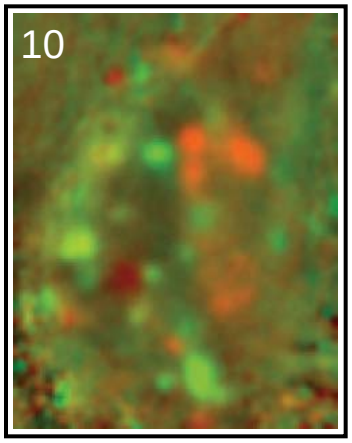
Olfactory bulb

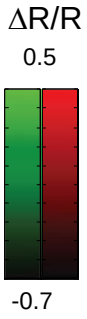
Vessels



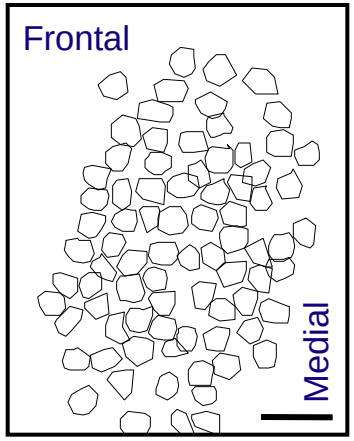
AA

EB





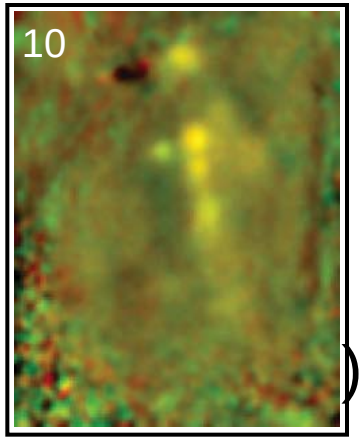
Glomeruli

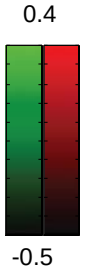


0.6 AA
0.4 EB

0.4 AA
0.6 EB

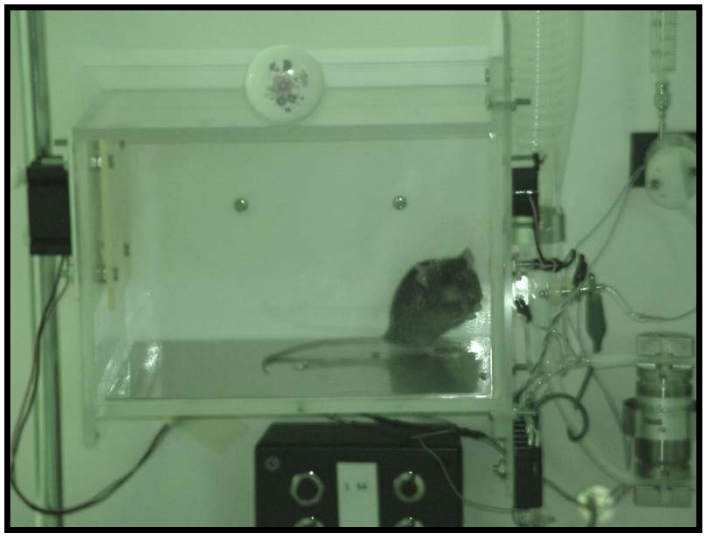
Odor

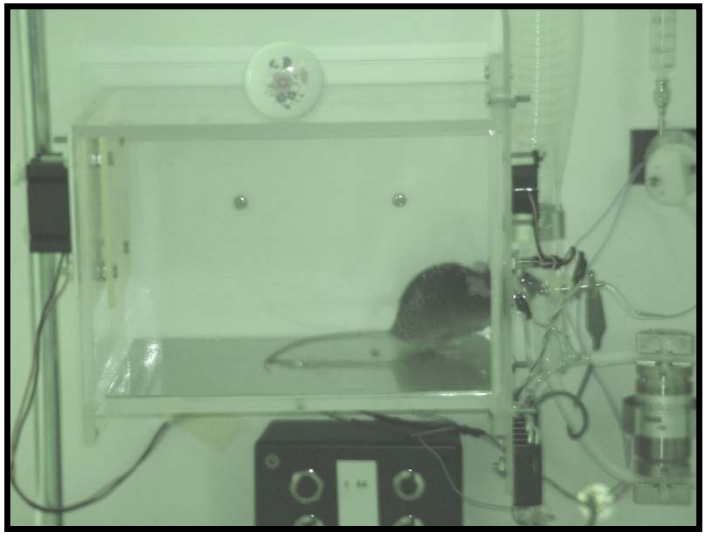


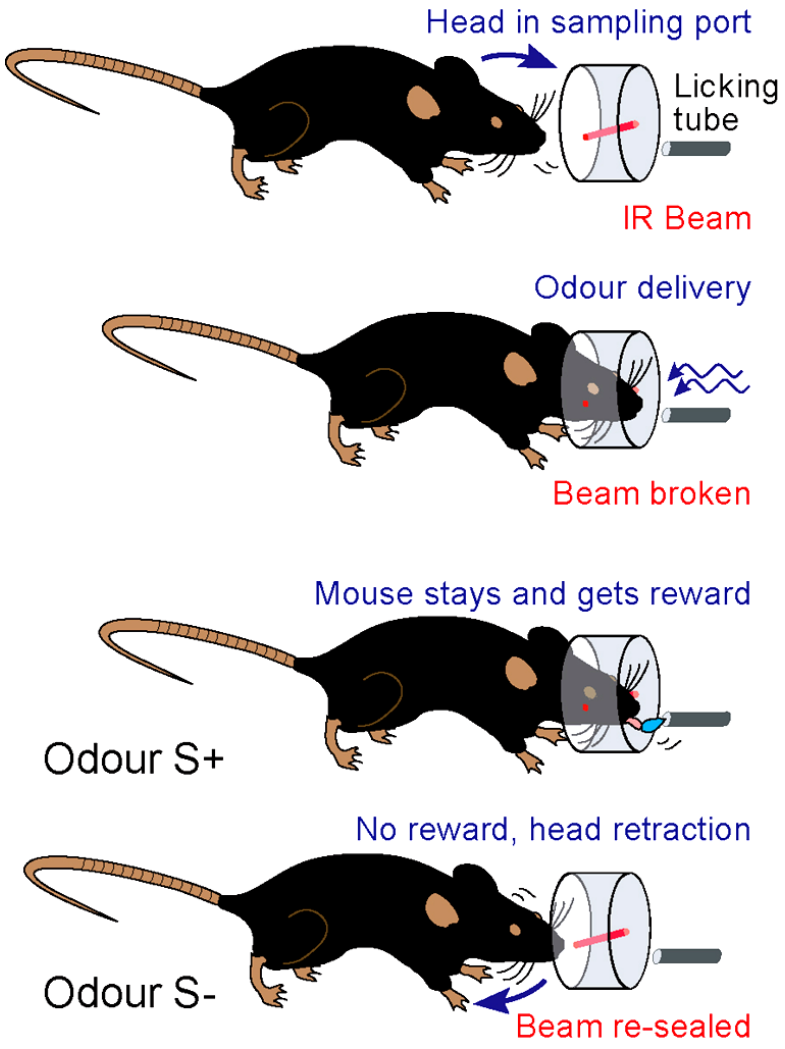


Abraham et al. (2004). Neuron. 44:865-76

Behavioural assessment of olfactory performances

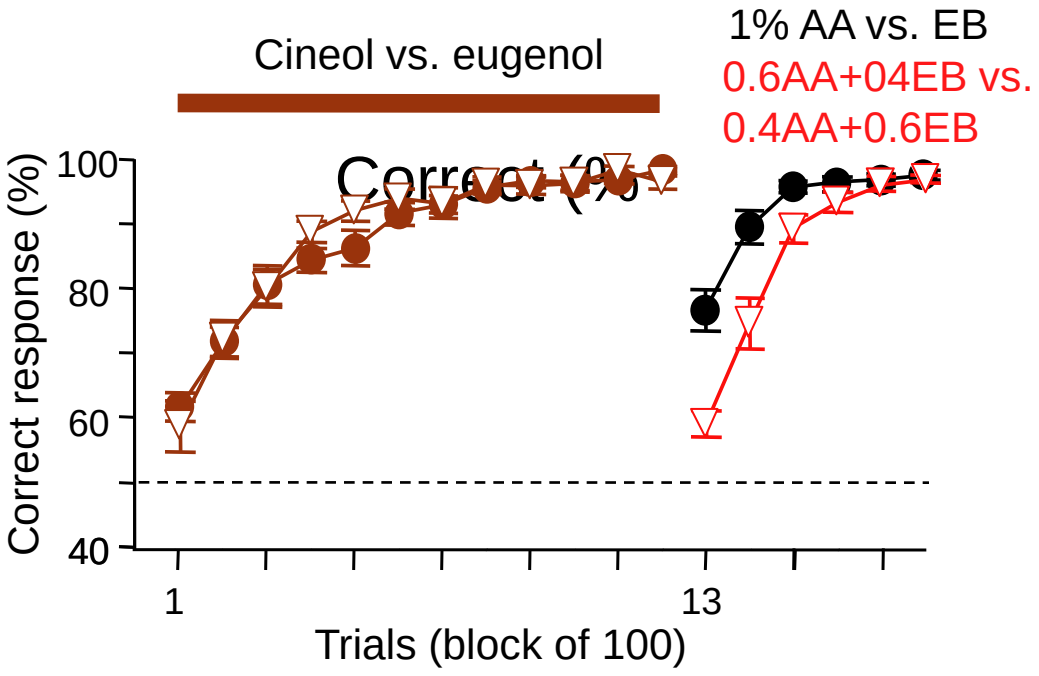


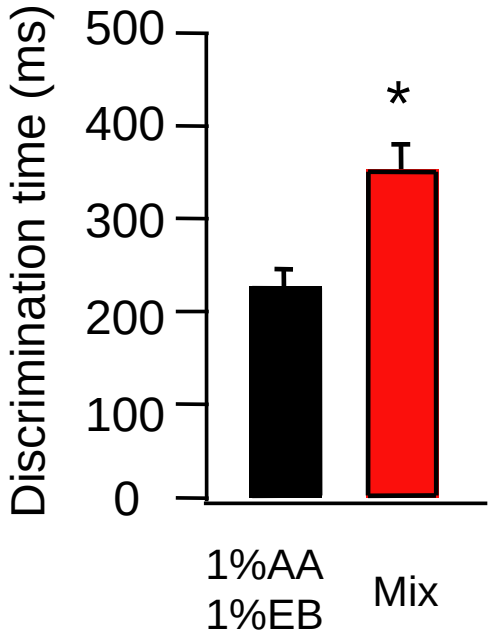




Abraham et al. (2004). Neuron. 44:865-76

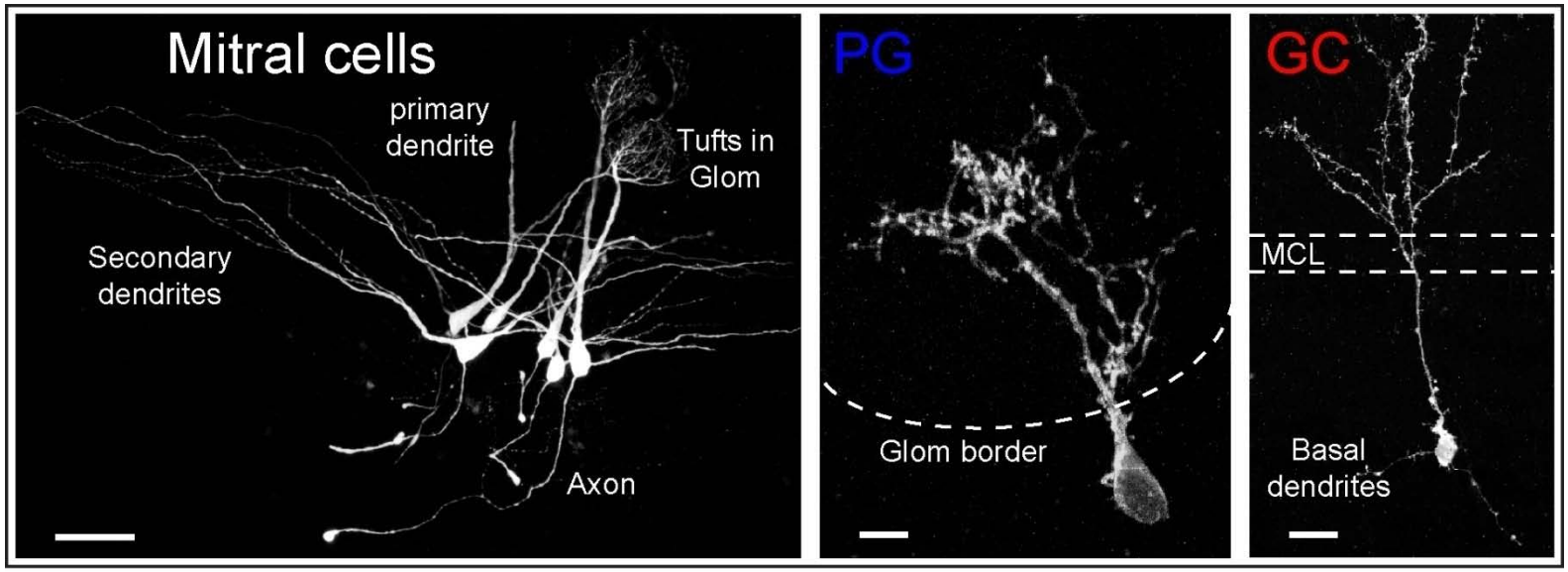
Mice can discriminate odors in a single sniff

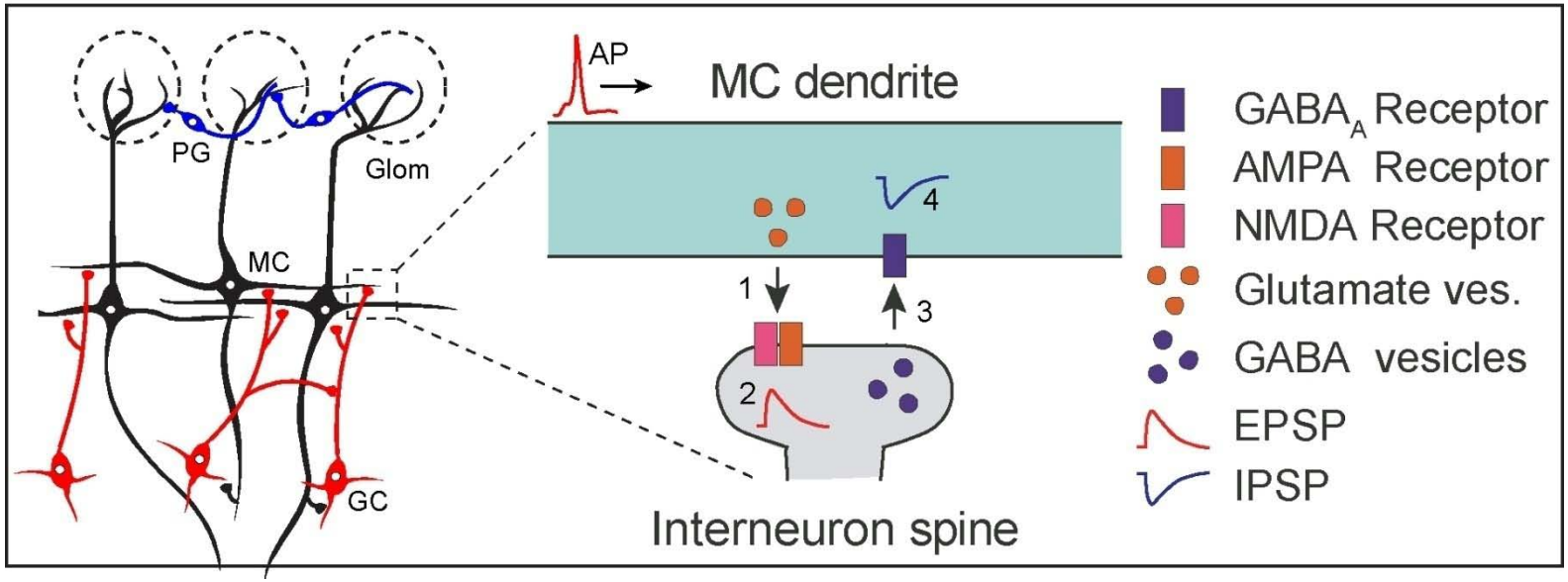




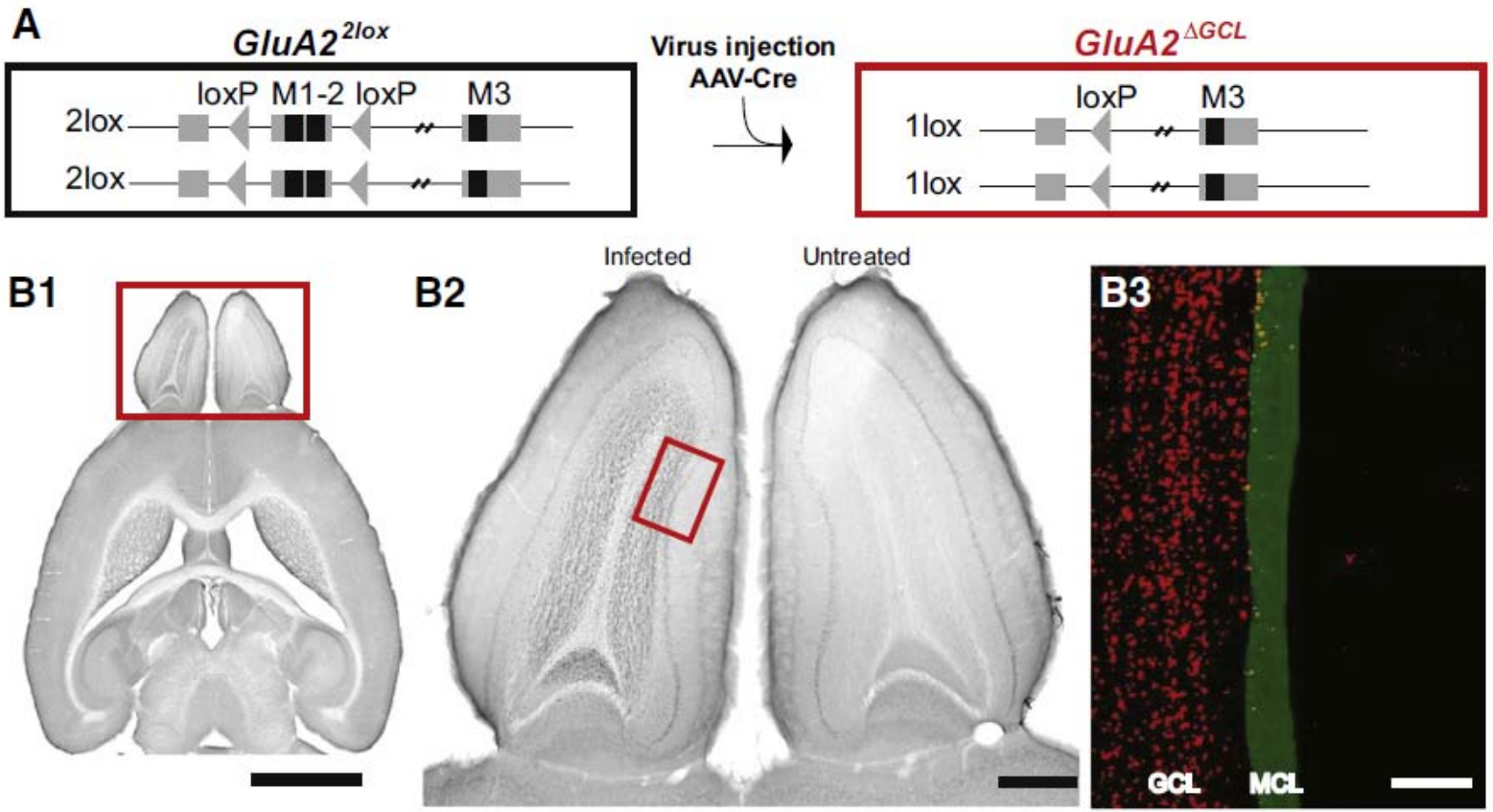
Abraham et al. (2004). Neuron. 44:865-76

Olfactory bulb circuitry





Genetic manipulation of granule cell inhibition



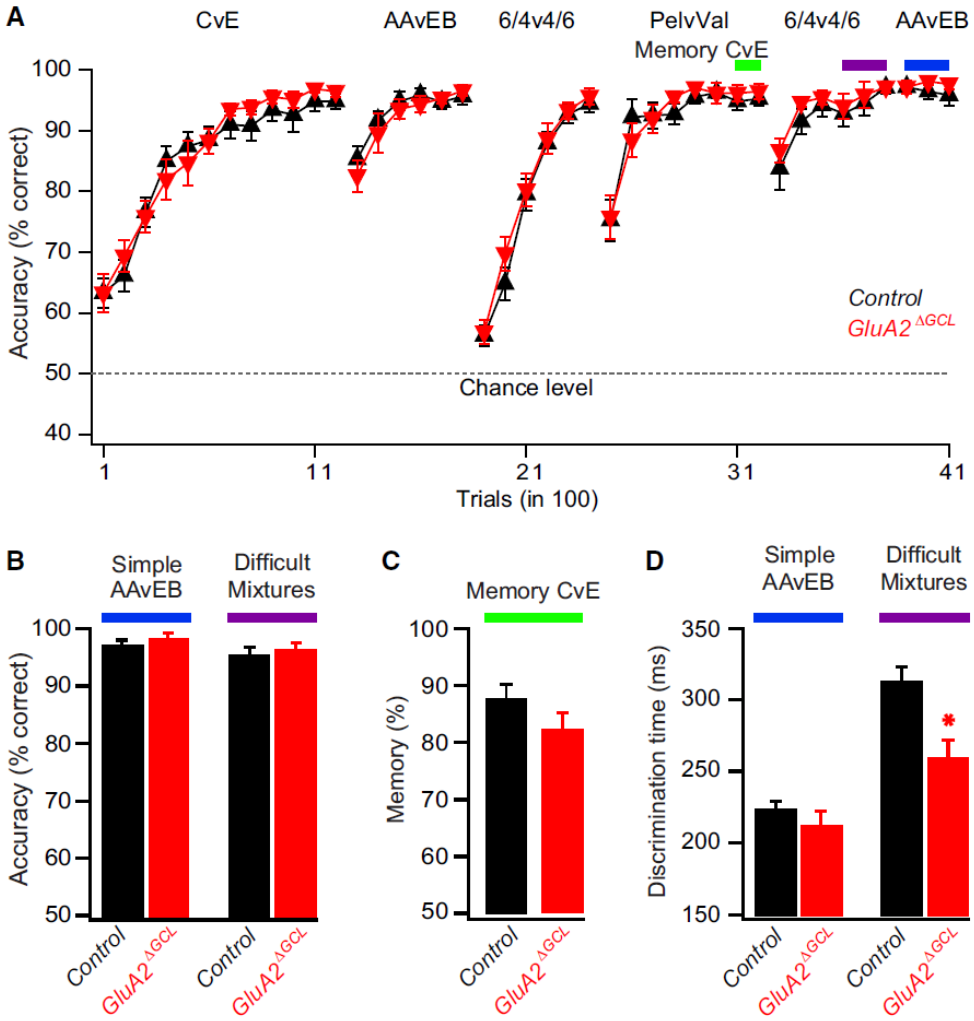
Synaptic Inhibition in the Olfactory Bulb Accelerates Odor Discrimination in Mice

Nixon M. Abraham,[1,2] Veronica Egger,[5] Derya R. Shimshek,[3] Robert Renden,[1] Izumi Fukunaga,[4] Rolf Sprengel,[3] Peter H. Seeburg,[3] Matthias Klugmann,[6,8] Troy W. Margrie,[7] Andreas T. Schaefer,[2,4,7,*] and Thomas Kuner[1,2,*]

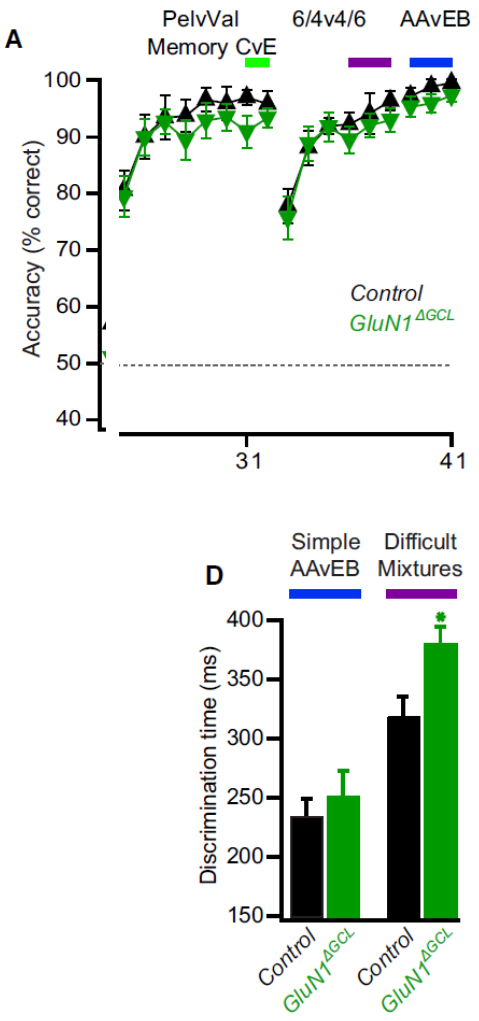
Neuron *65*, 399–411, February 11, 2010

Granule cell inhibition modulate odor discrimination

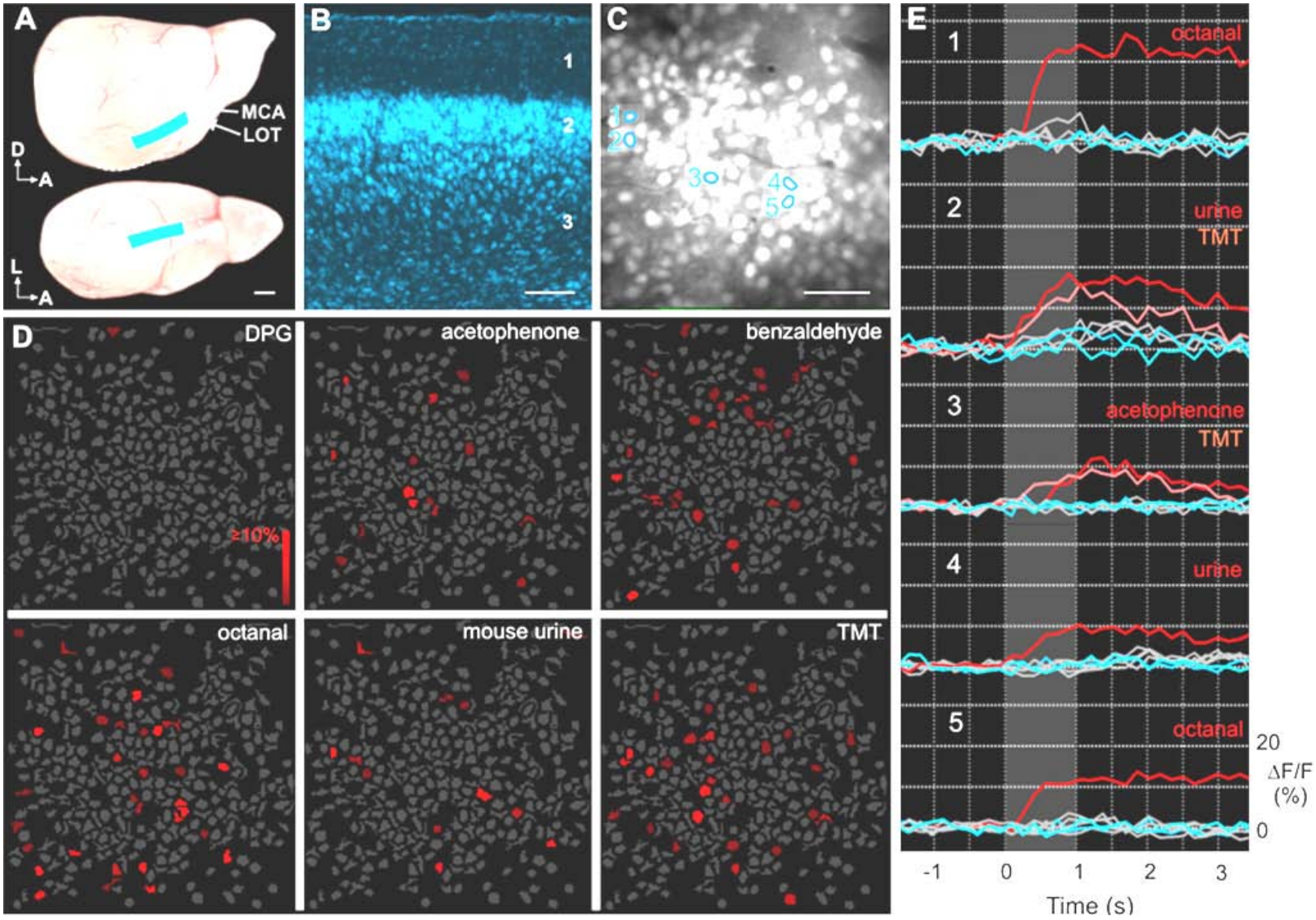
More inhibition



Less inhibition

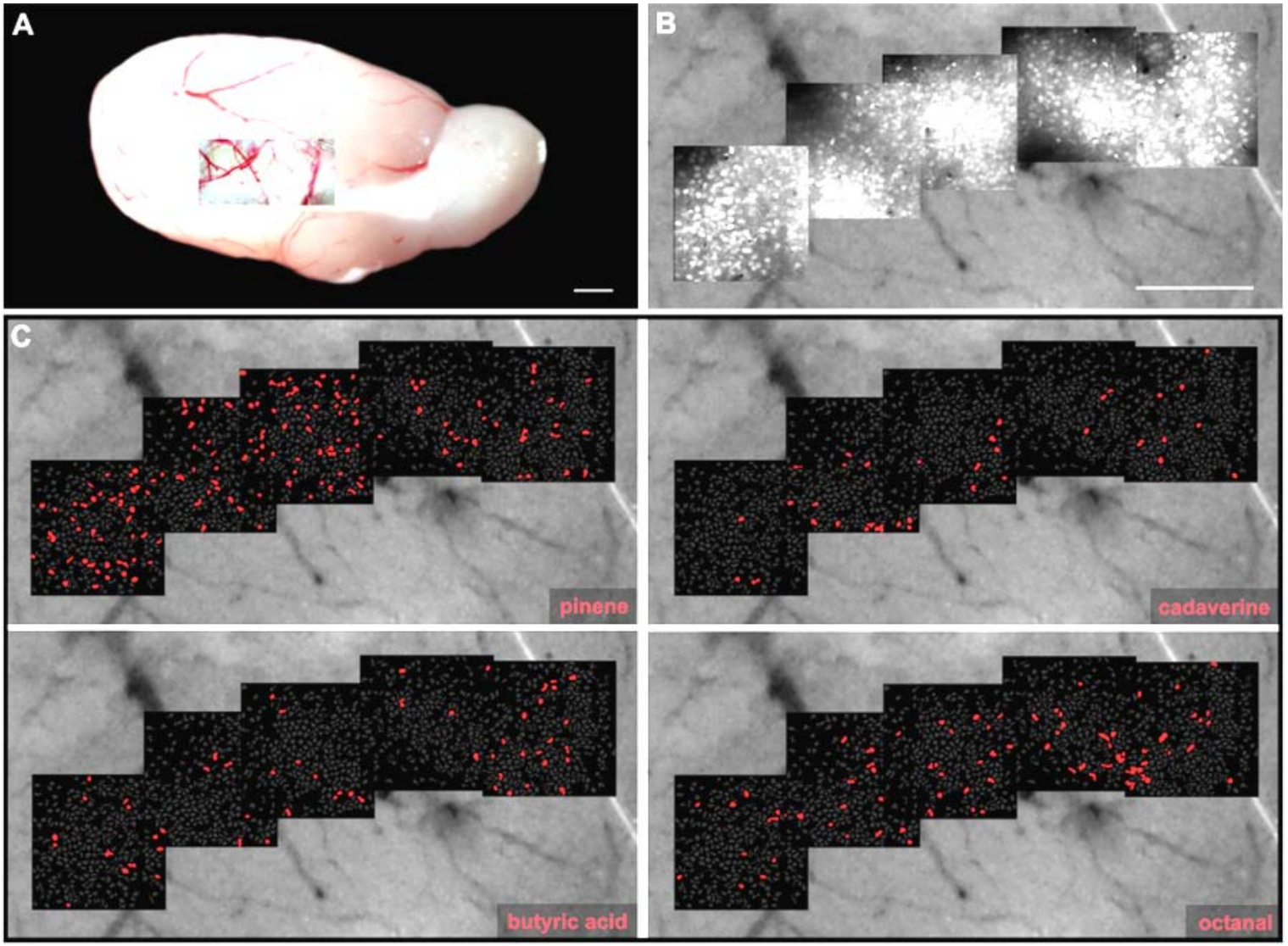


Odor representation in the olfactory cortex



Stettler and Richard Axel. Neuron (2009)

Odor representation in the olfactory cortex



Stettler and Richard Axel. Neuron (2009)