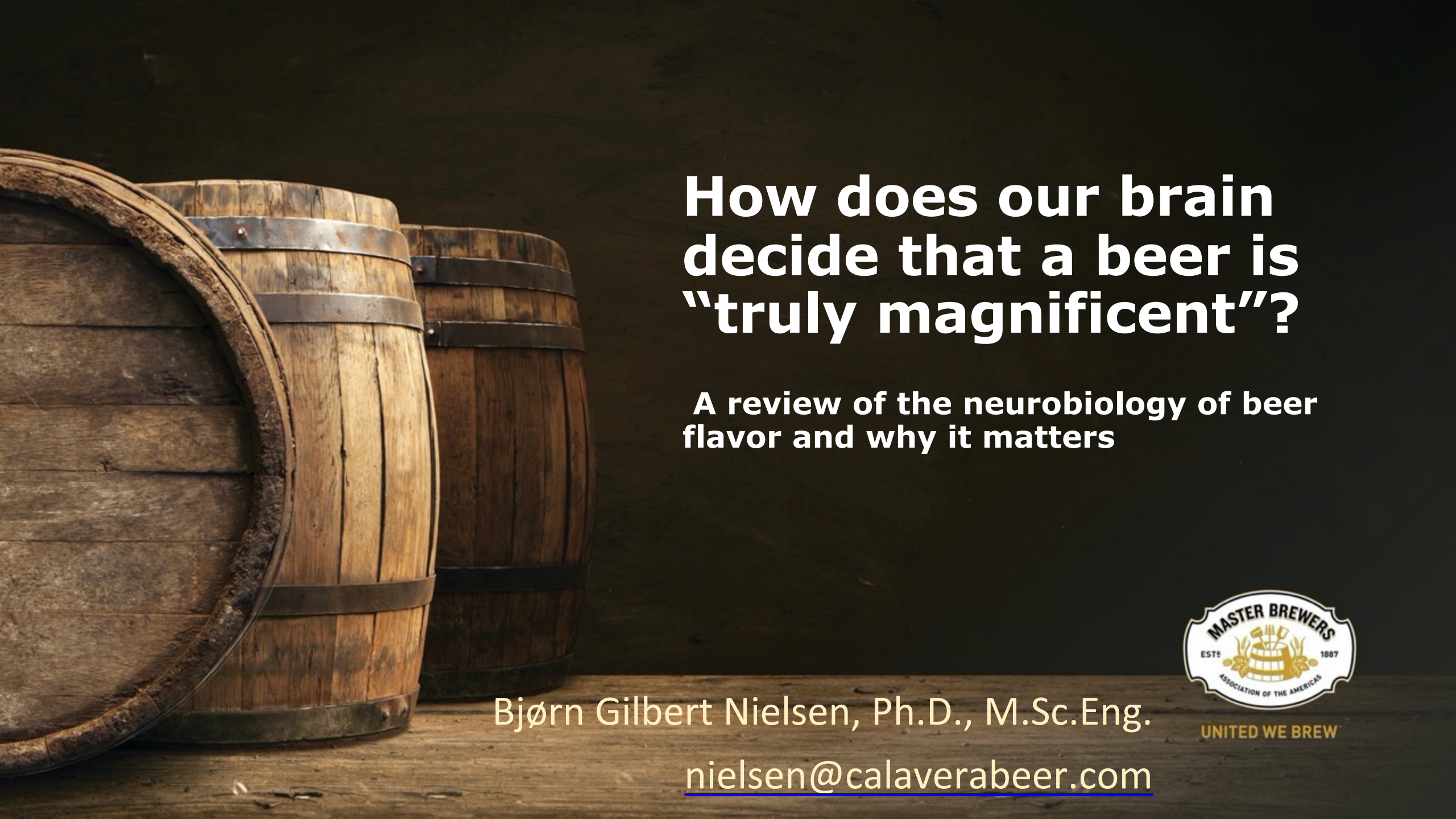


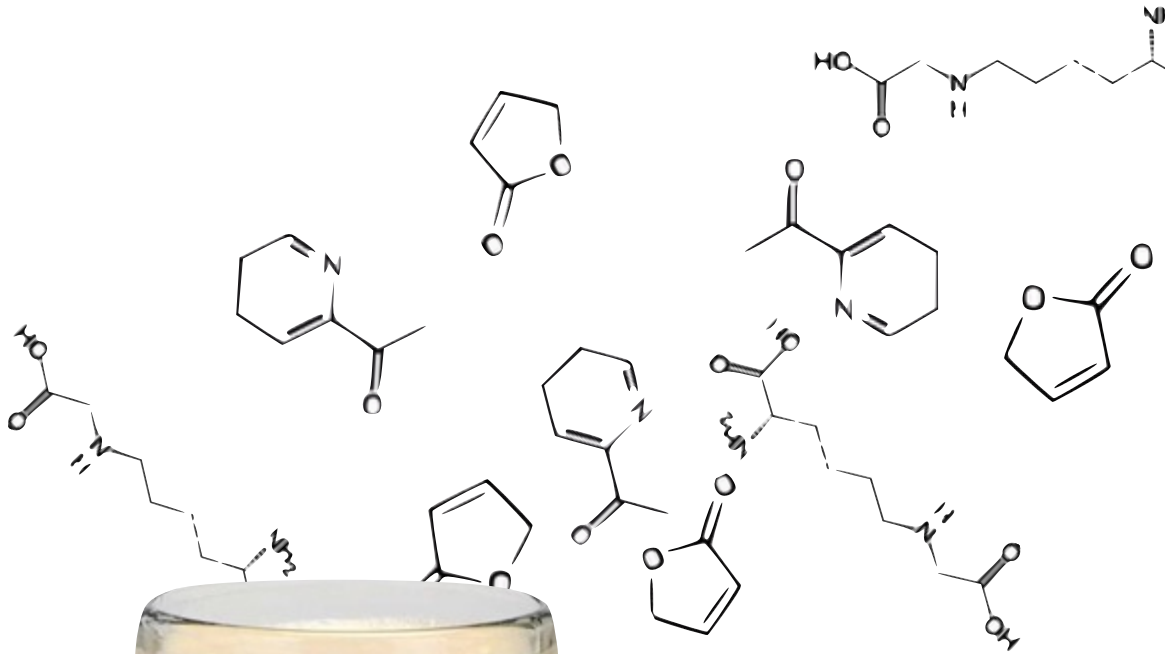
How does our brain decide that a beer is "truly magnificent"?

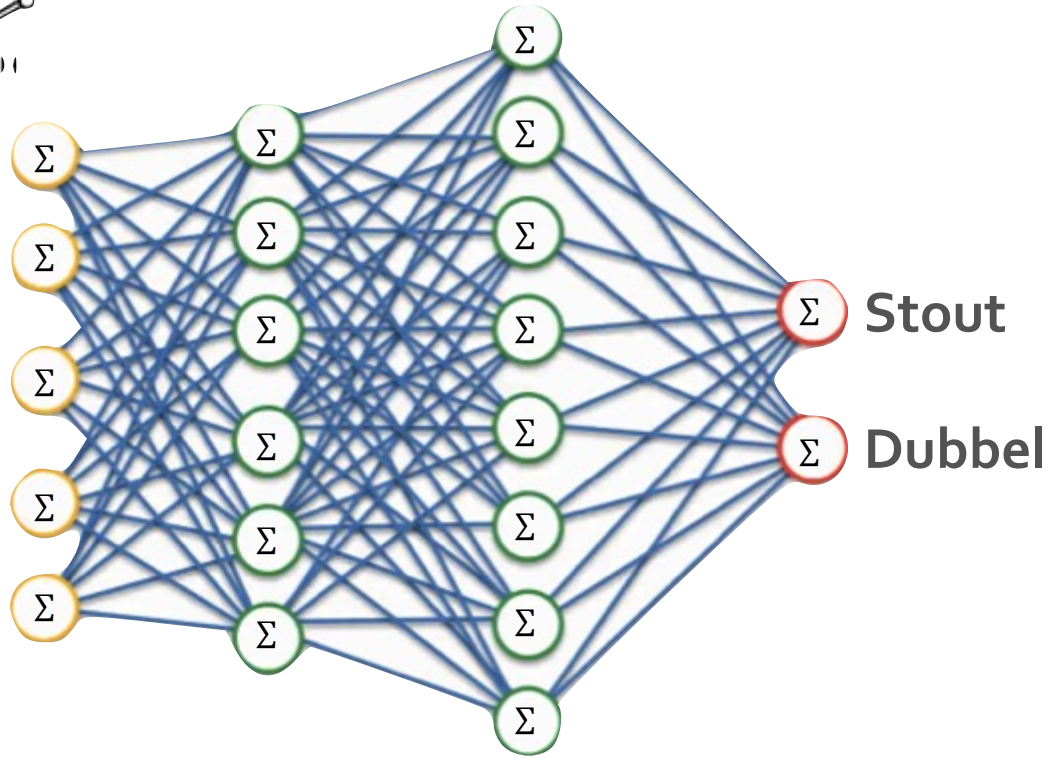
A review of the neurobiology of beer flavor and why it matters

Bjørn Gilbert Nielsen, Ph.D., M.Sc.Eng.

nielsen@calaverabeer.com

MASTER BREWERS
EST! 1887
ASSOCIATION OF THE AMERICAS
UNITED WE BREW





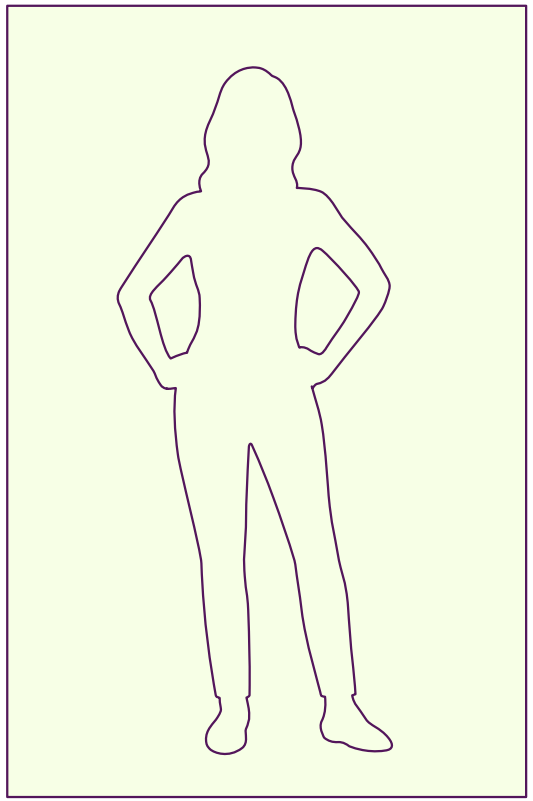
¿What constitutes the neural code for a percept?…

PERCEPT: The object as perceived by a subject.

René Magritte (1926)

The knowledge argument

¿How do we know that we know?



Merriam-Webster SINCE 1828

quale noun

Save Word

qua·le | \ ˈkwä-lē, -ˌlā \

plural **qualia** \ ˈkwä-lē-ə \

Definition of *quale*

1 : a property (such as redness) considered apart from things having the property : UNIVERSAL

2 : a property as it is experienced as distinct from any source it might have in a physical object

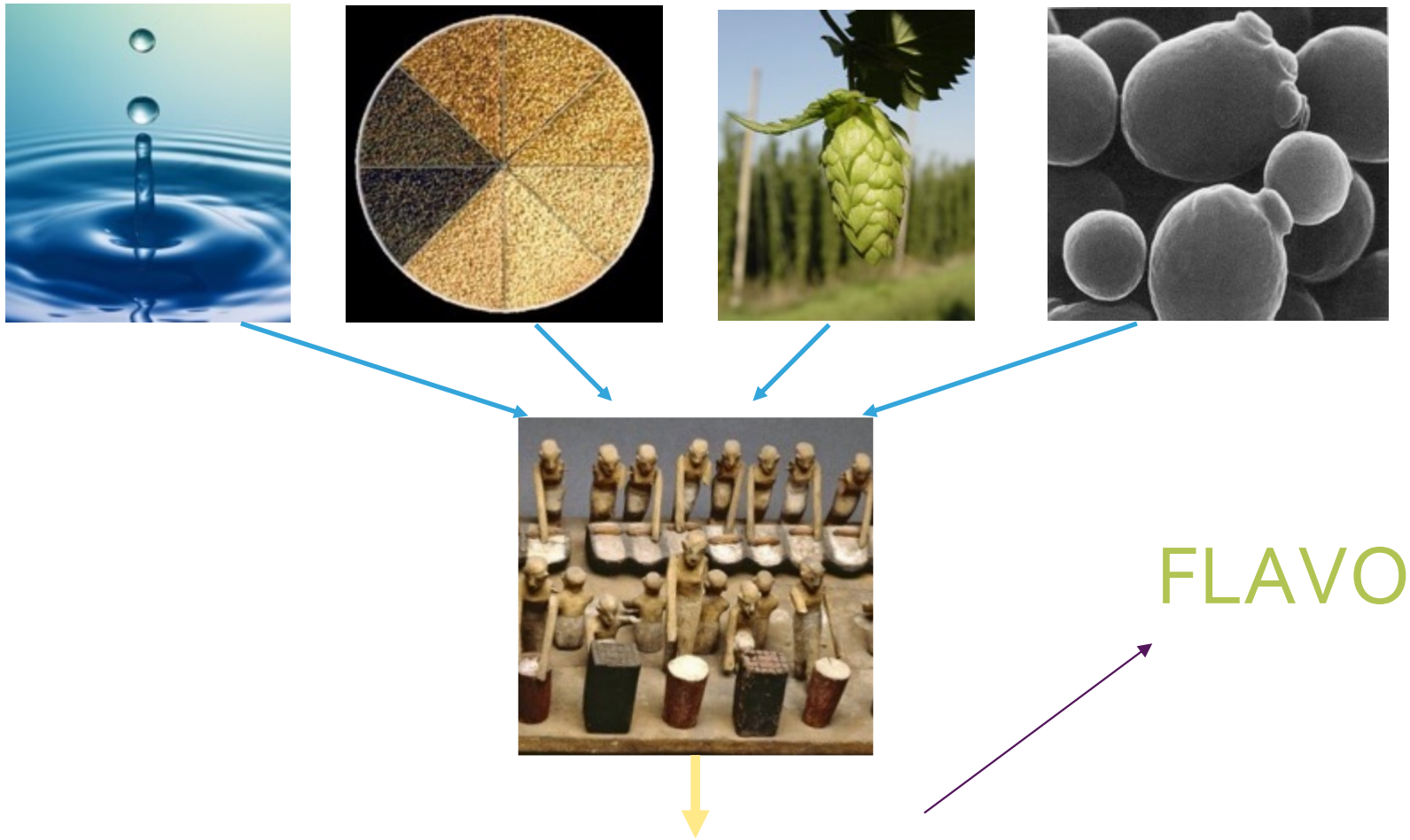
First Known Use of *quale*

1675, in the meaning defined at sense 1

Frank Jackson (1982), Epiphenomenal qualia

Flavor depends on the chemical compounds contained in beer.

- Water
- Malts
- Hops
- Yeast
- Processing



FLAVOR!!

Mixture of over +700 chemical substances

THE CHEMISTRY OF FLAVOR

TABLE I.
Recommended Descriptors O = Odour T = Taste M = Mouthfeel W = Warming Af = Afterflavour

Class term	First tier	Second tier	Relevance	Comments, synonyms, definitions
Class I—Aromatic, Fragrant, Fruity, Floral				
	0110 Alcoholic		OTW	The general effect of ethanol and higher alcohols.
		0111 Spicy	OTW	Allspice, nutmeg, peppery, eugenol. See also 1003 Vanilla.
		0112 Vinous	OTW	Bouquet, fusely, wine-like.
	0120 Solvent-like		OT	Like chemical solvents.
		0121 Plastics	OT	Plasticizers.
		0122 Can-liner	OT	Lacquer-like.
		0123 Acetone	OT	
	0130 Estery		OT	Like aliphatic esters.
		0131 Isoamyl acetate	OT	Banana, peardrop.
		0132 Ethyl hexanoate	OT	Apple-like with note of aniseed. See also 0142 Apple.
		0133 Ethyl acetate	OT	Light fruity, solvent-like. See also 0120 Solvent-like.

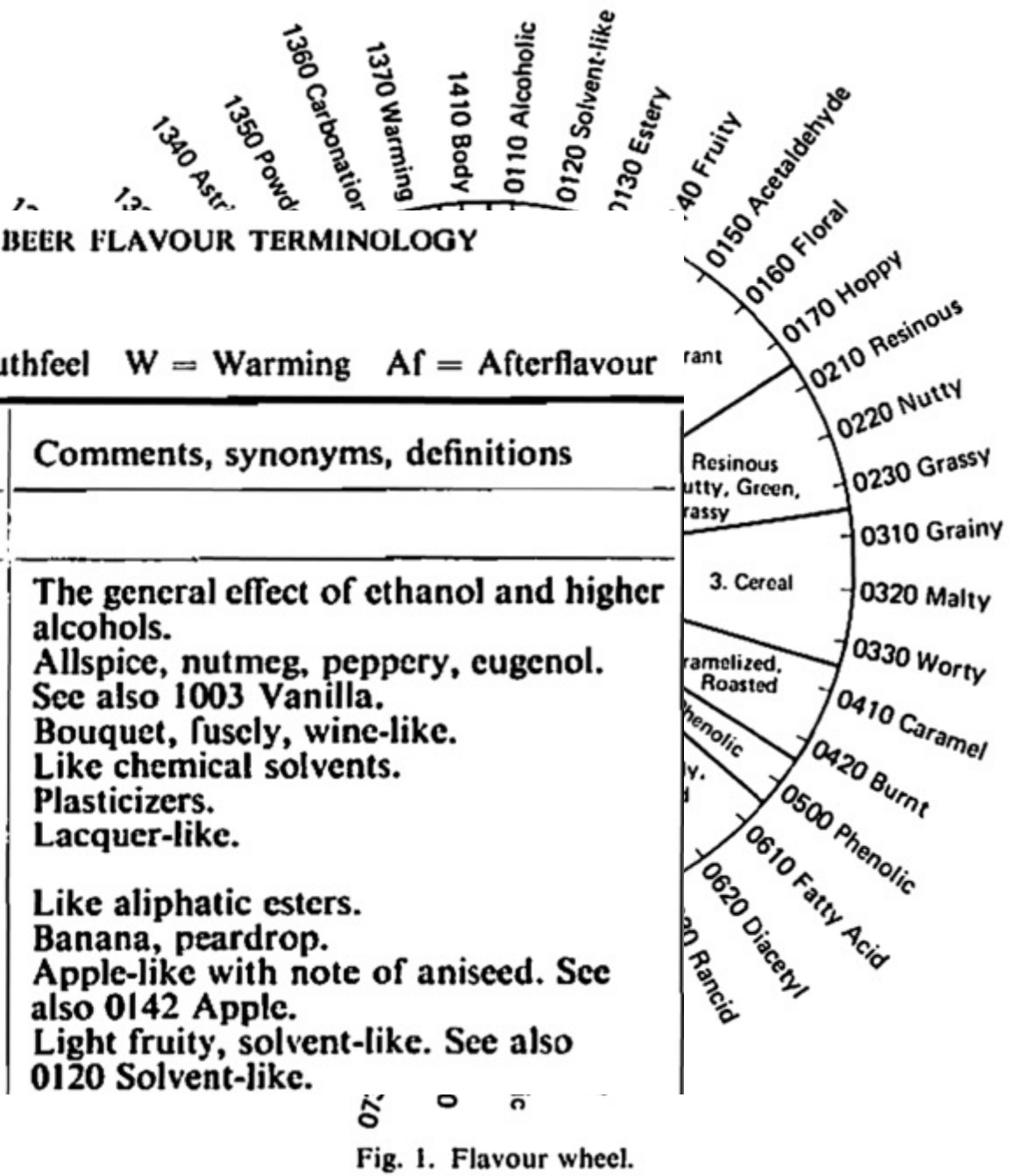
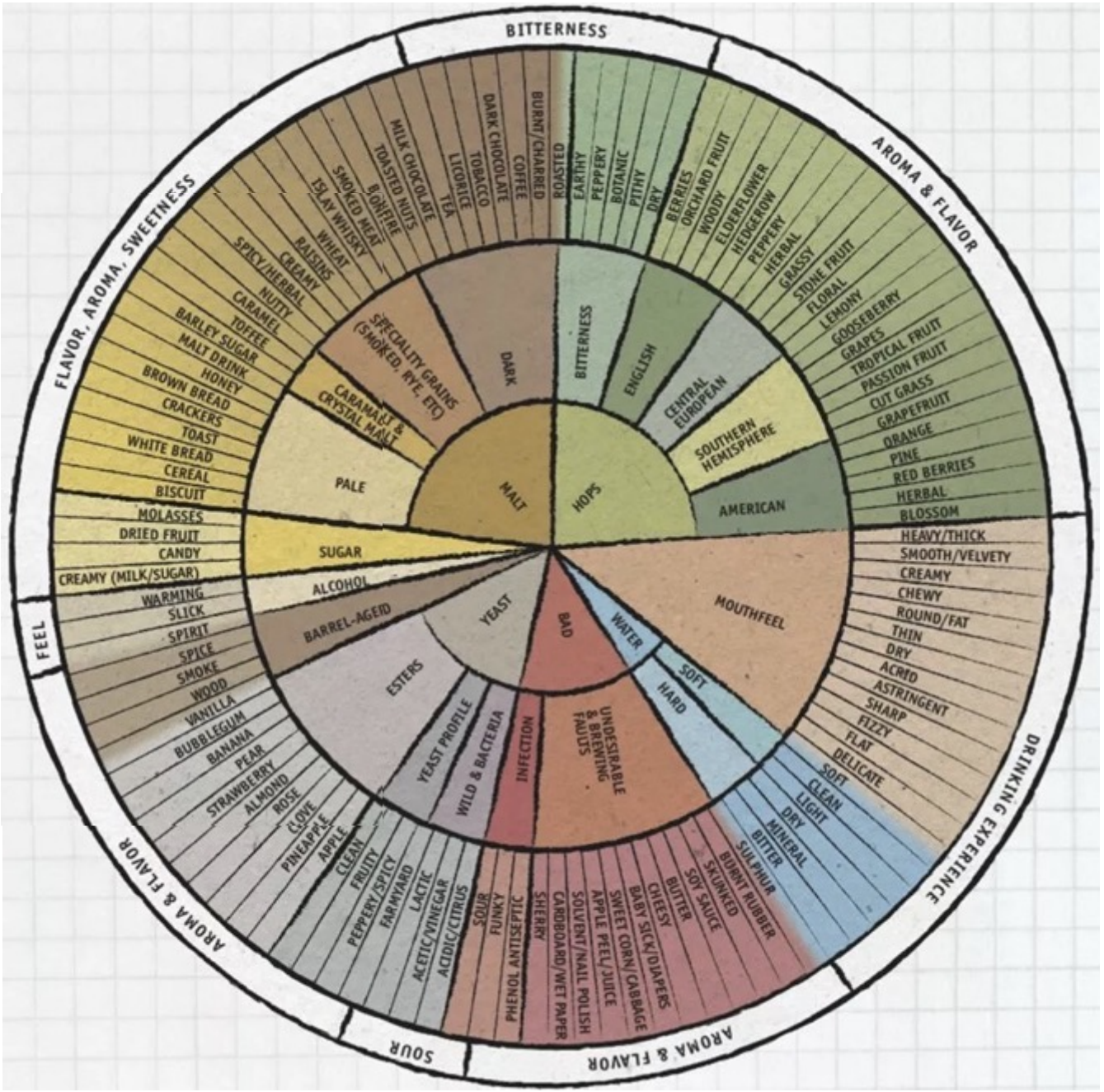


Fig. 1. Flavour wheel.

Morten Meilgaard *et al* (1979)

Flavor wheel

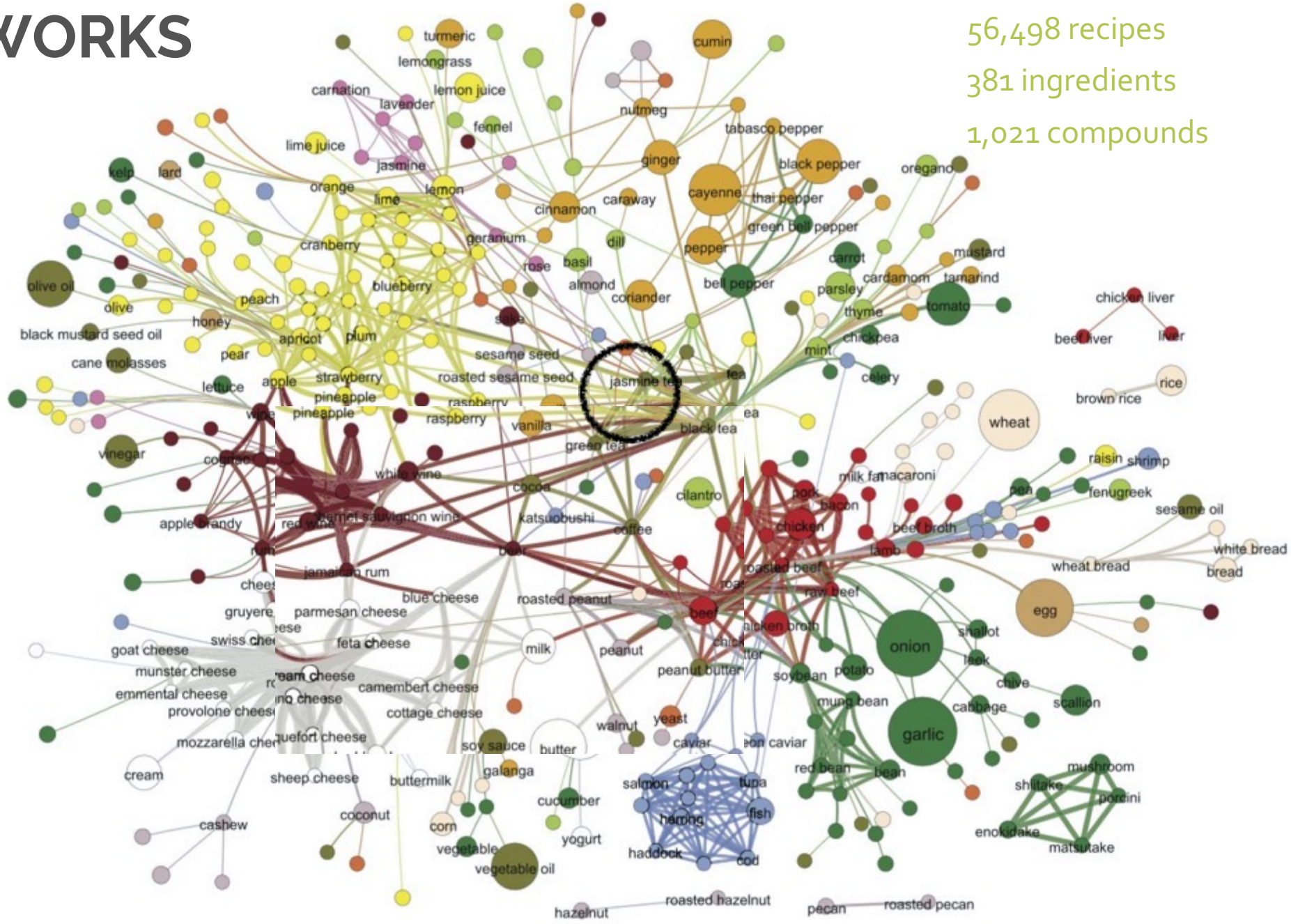


Beer Version

FLAVOR NETWORKS

BEER linked to:

- Meat
- Coffee
- Katsuobushi
- Cocoa
- Sake
- Wines/Liqours
- Cheese
- Cereals
- Milk products



56,498 recipes

381 ingredients

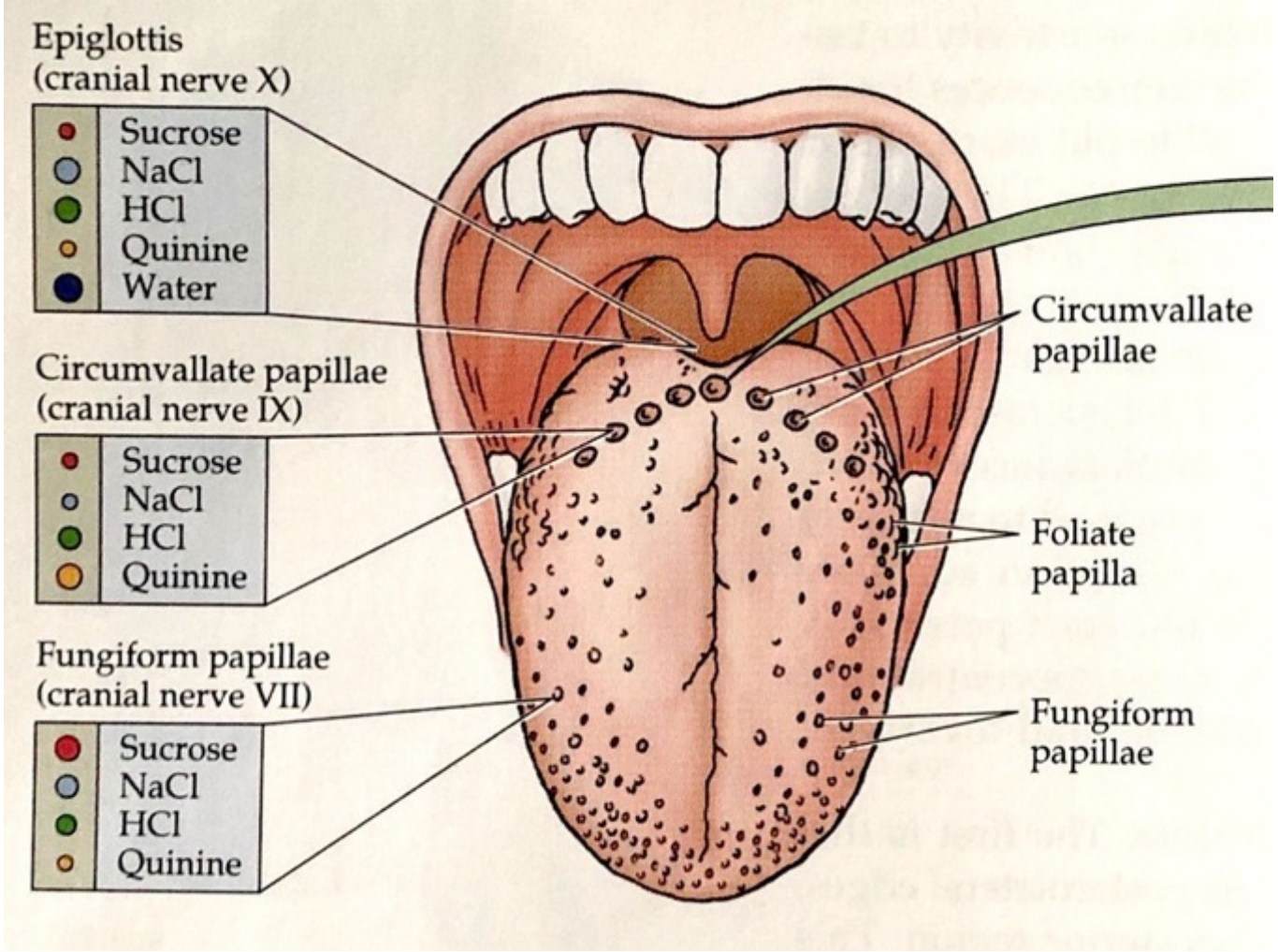
1,021 compounds

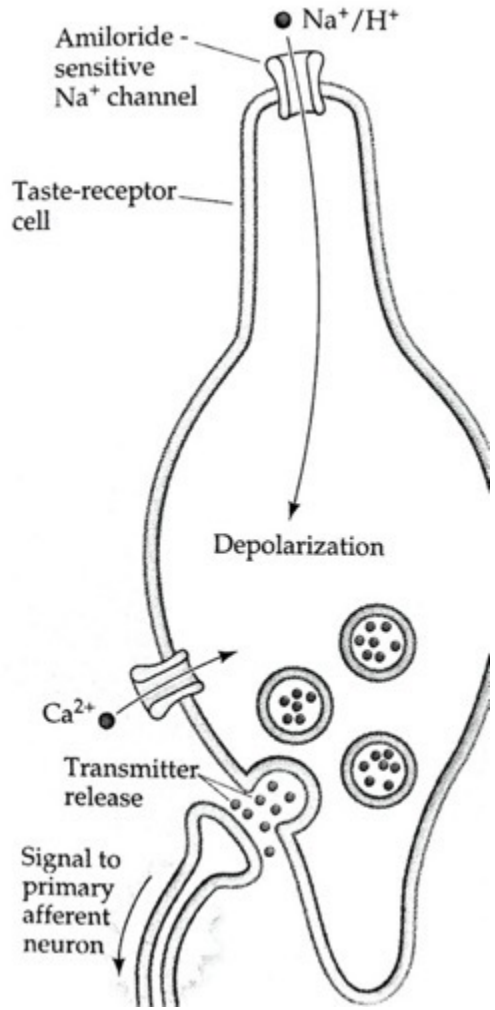
Ahn et al (Scientific Reports 2011)

SENSORY RECEPTION OF FLAVORS

Our papillae contain many different sensory receptors that specialize in specific substances

- Sweet
- Bitter
- Sour
- Salty
- Umami
- Heat (capsaicin)
- Cold (mentol)
- Astringency
- Metallic
- Calcium/mineral
- Fatty
- Starchy
- Water (!)





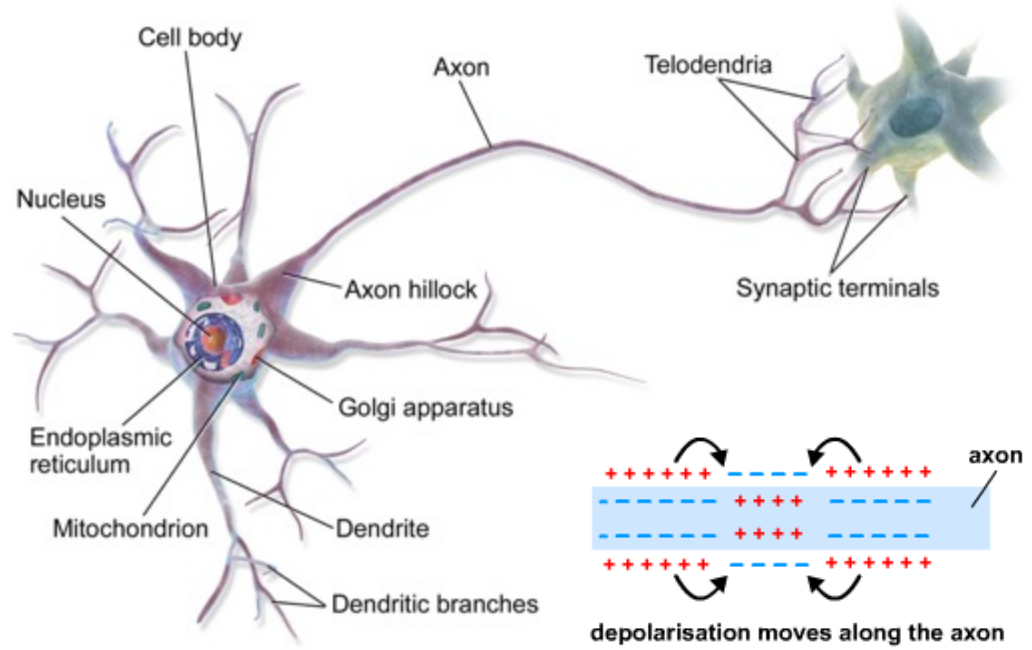
SENSORY RECEPTION OF FLAVORS

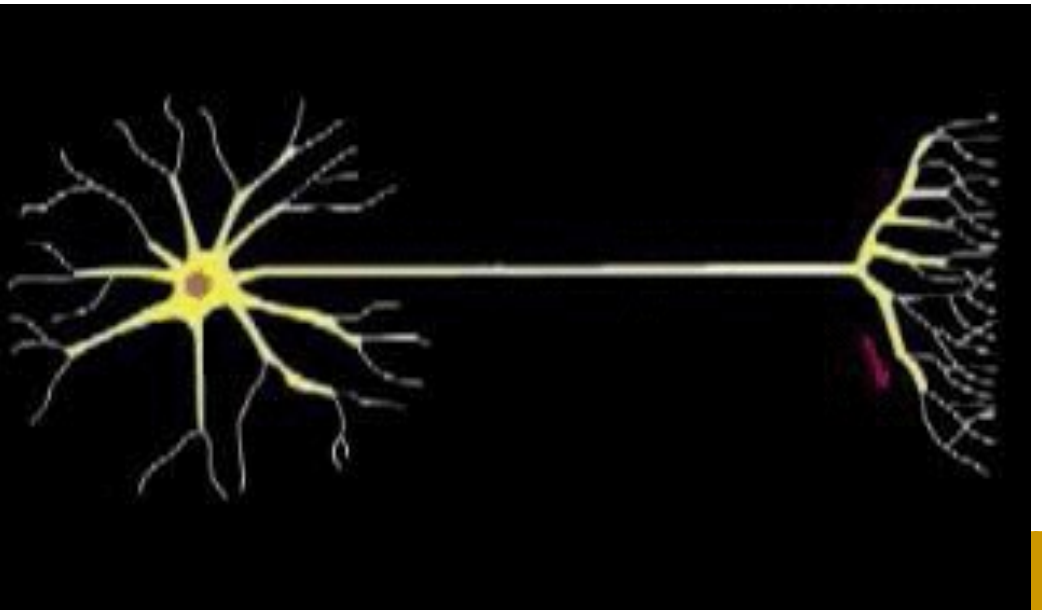
We have *many* more receptors coding for SMELL

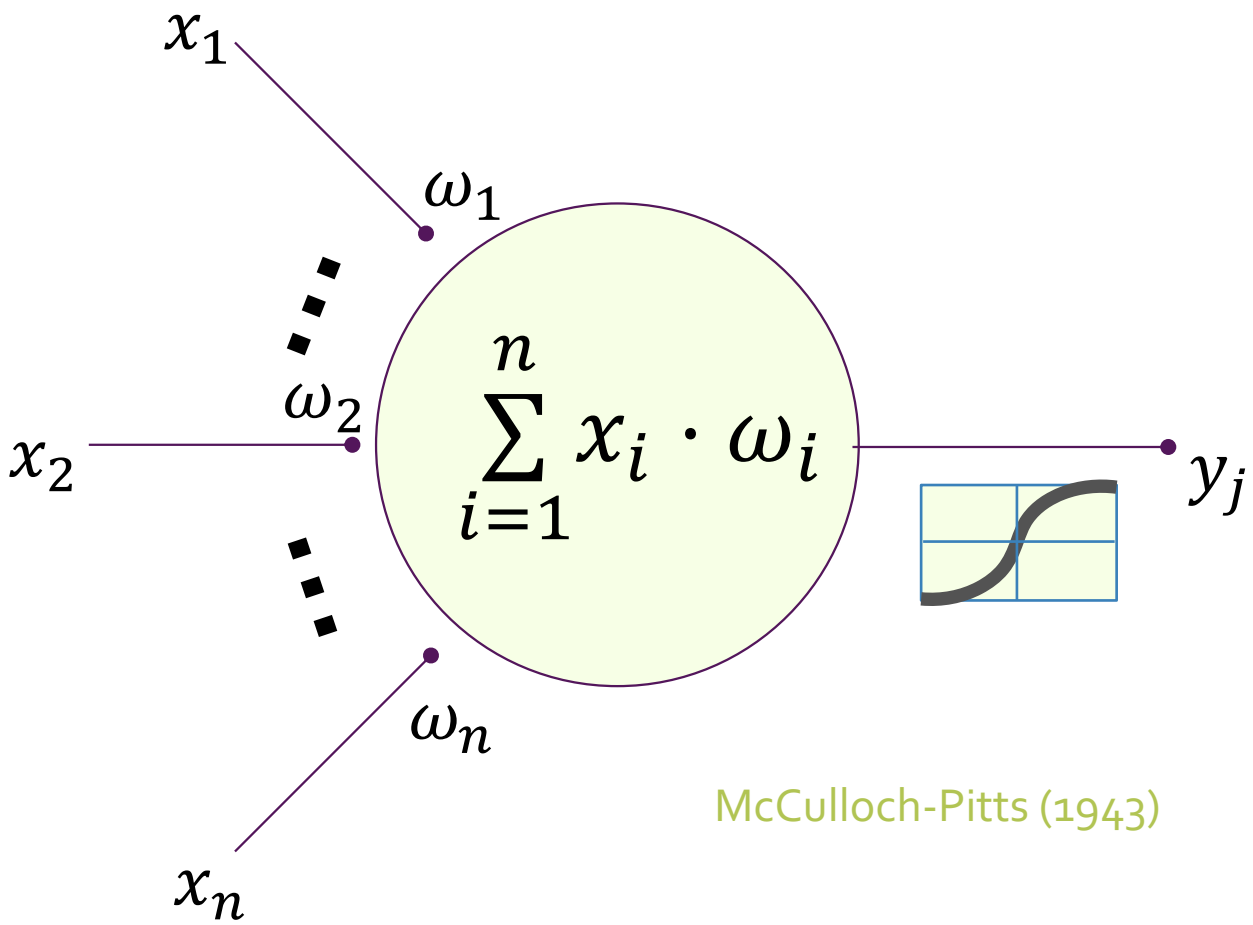
Odorant receptors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Description
A					●										rancid, sour, goat-like
B		●				●									sweet, herbal, woody
C	●			●	●		●			●	●				rancid, sour, sweaty
D		●			●	●									violet, sweet, woody
E	●			●	●		●	●		●	●	●			rancid, sour, repulsive
F				●	●		●			●					sweet, orange, rose
G	●			●	●		●	●		●		●		●	waxy, cheese, nut-like
H				●	●		●			●		●			fresh, rose, oily floral

MODIFIED AFTER LINDA BUCK AND COLLEAGUES IN CELL VOL 96, MARCH 5, 1999

CELLULAR MESSENGERS – THE COMPUTATIONAL NEURON





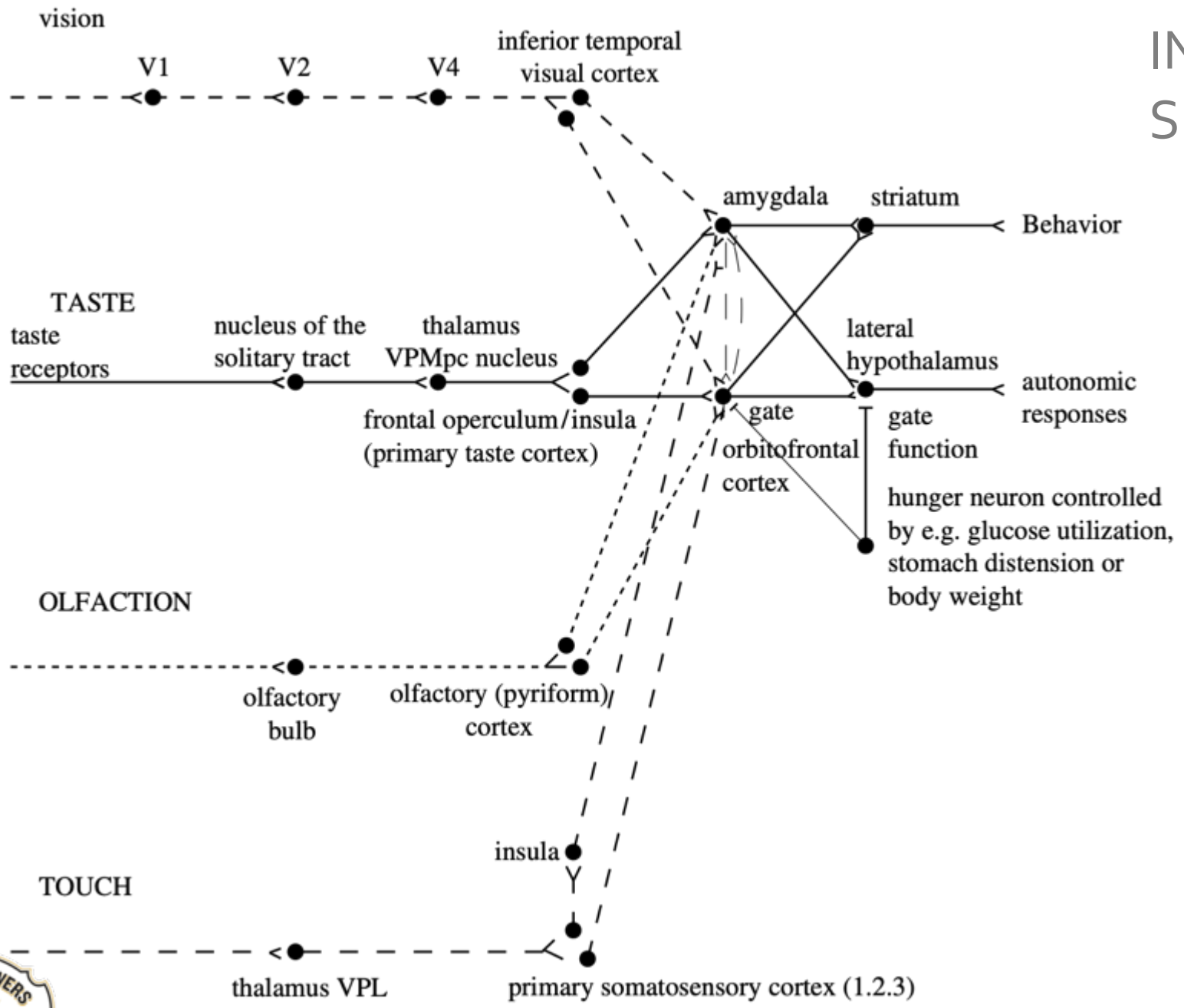


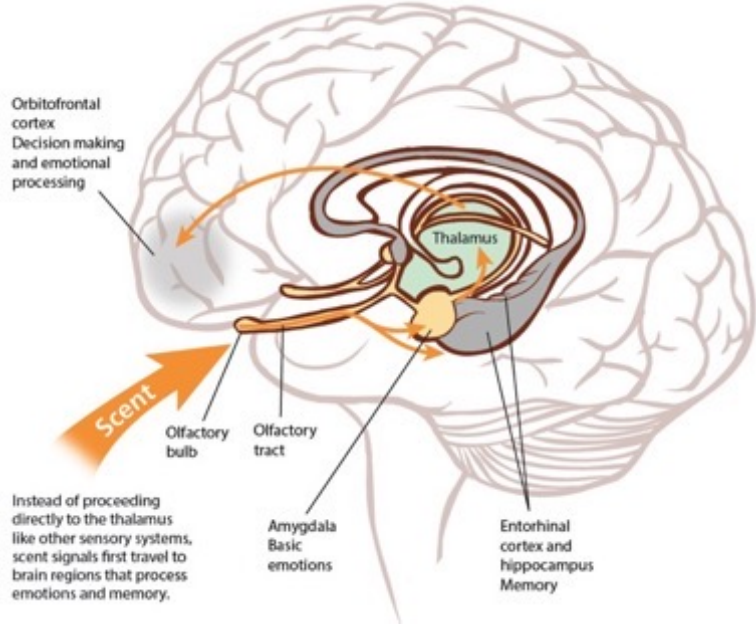
McCulloch-Pitts (1943)

Hebb's Mechanism (1949): When an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased.

Neurons that fire together wire together!!

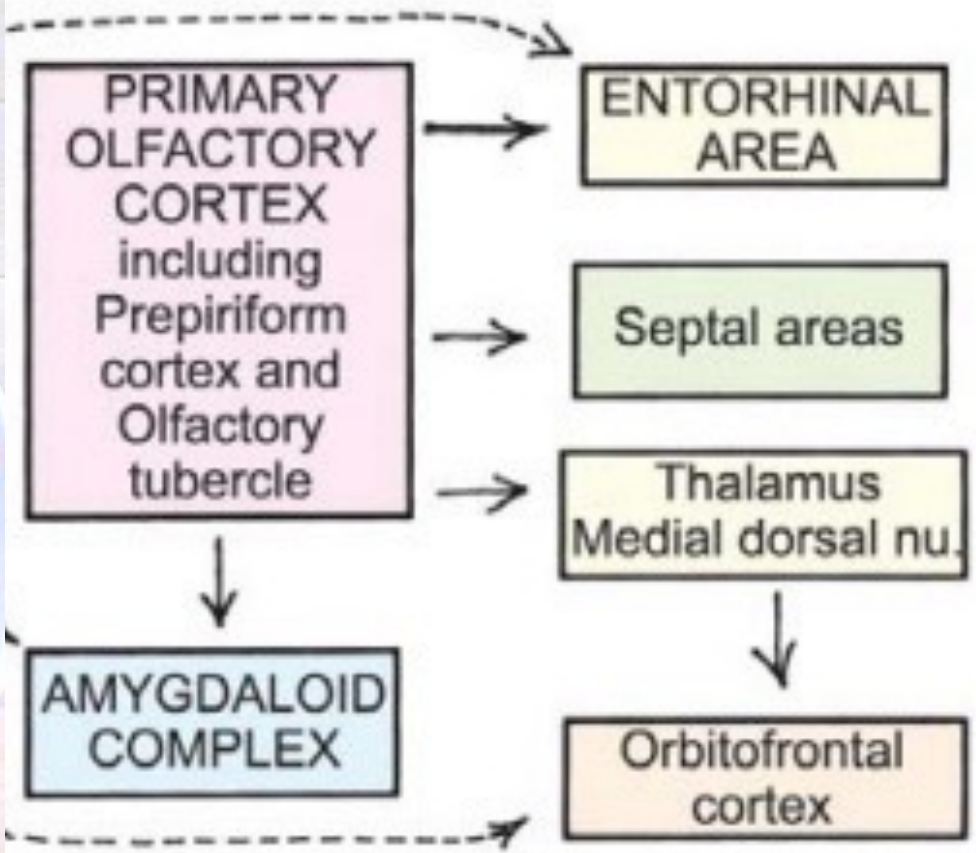
INTEGRATION OF THE SENSES





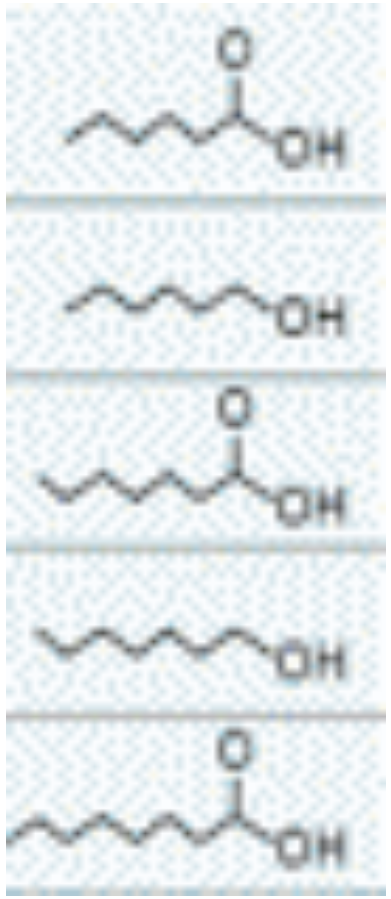
Edmund T. Rolls (2006)

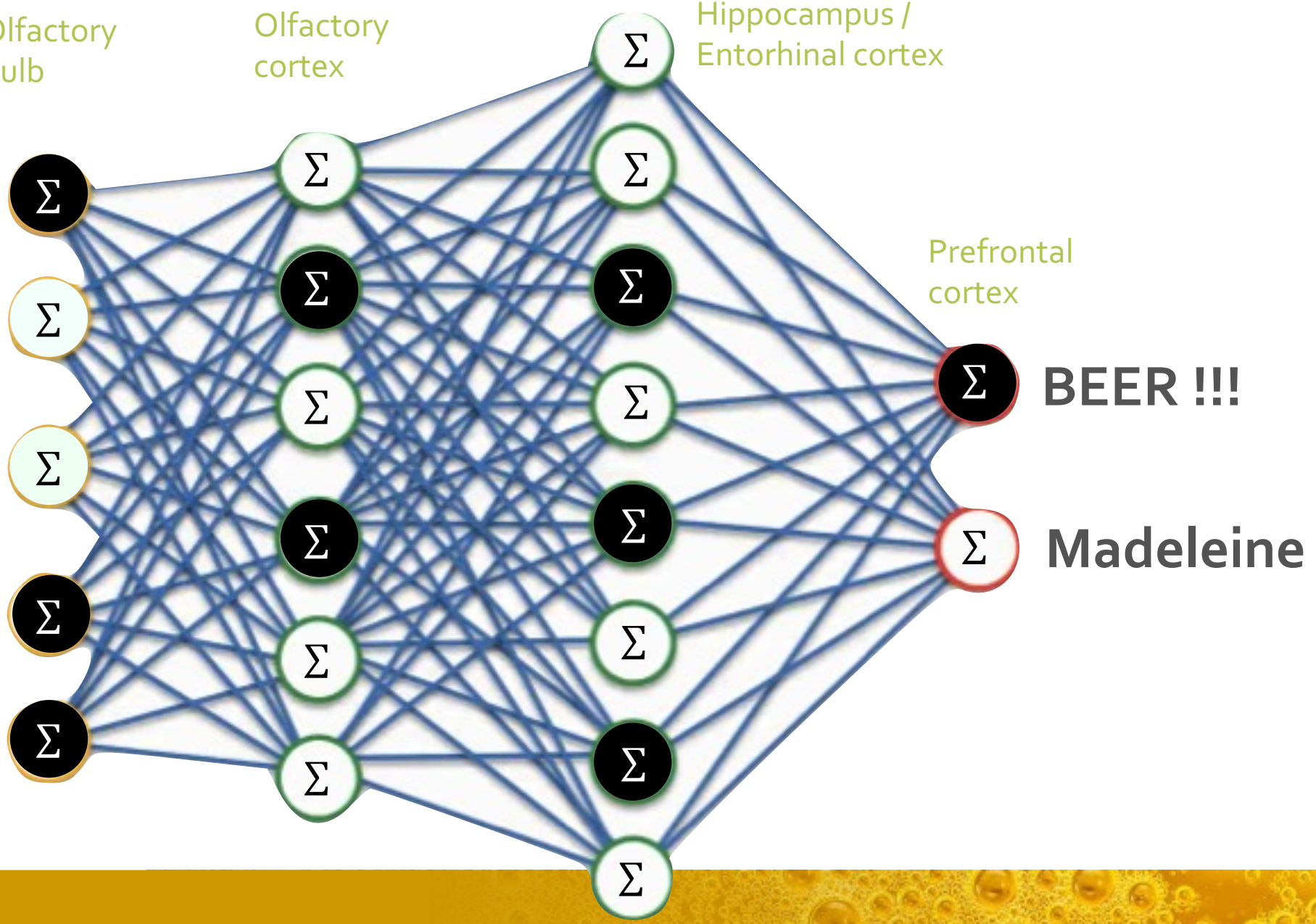
The "Madeleine" moment – or “Proust effect"



Marcel Proust (1871 - 1922) “À la recherche du temps perdu”

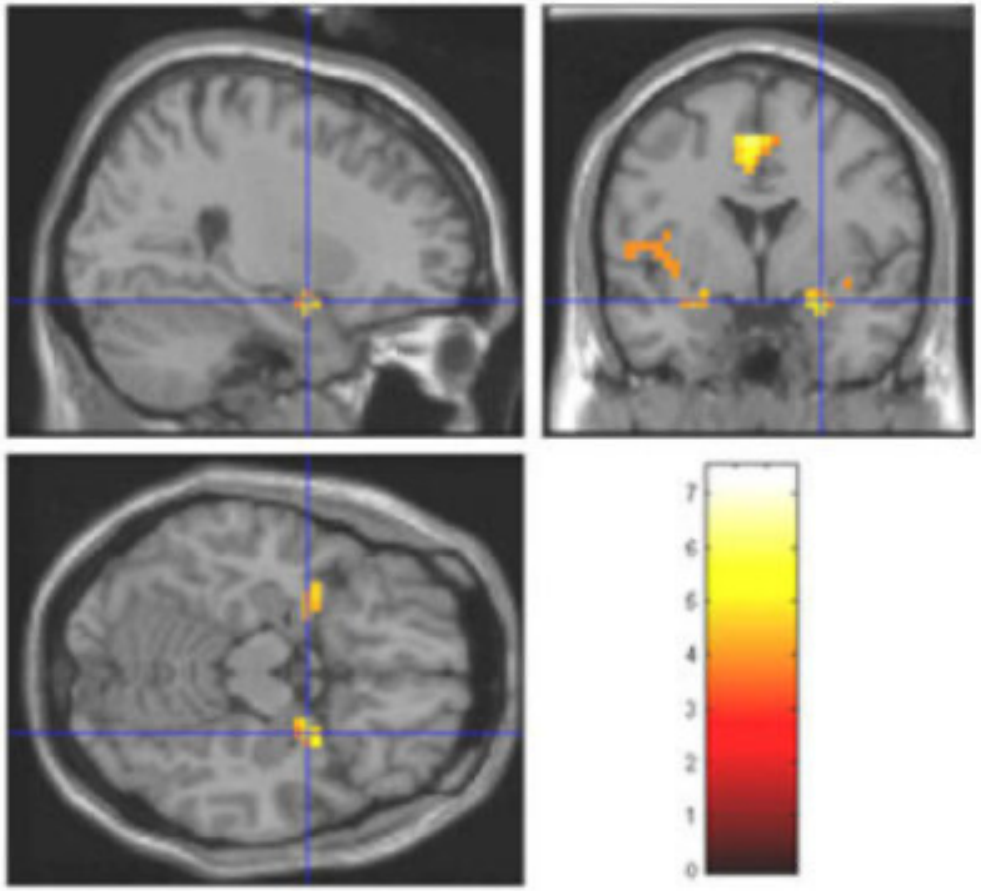
The "Madeleine" moment – or "Proust effect"

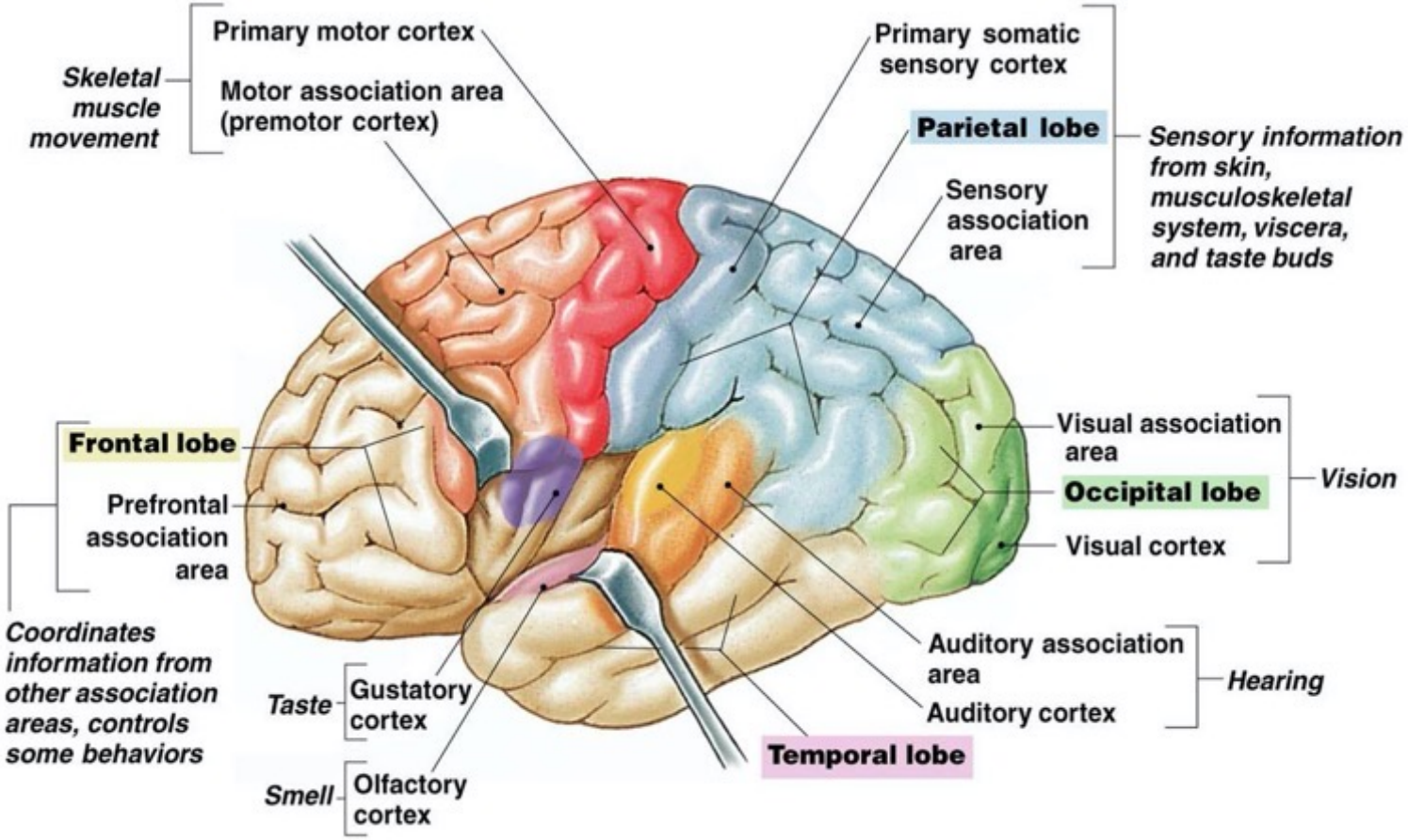


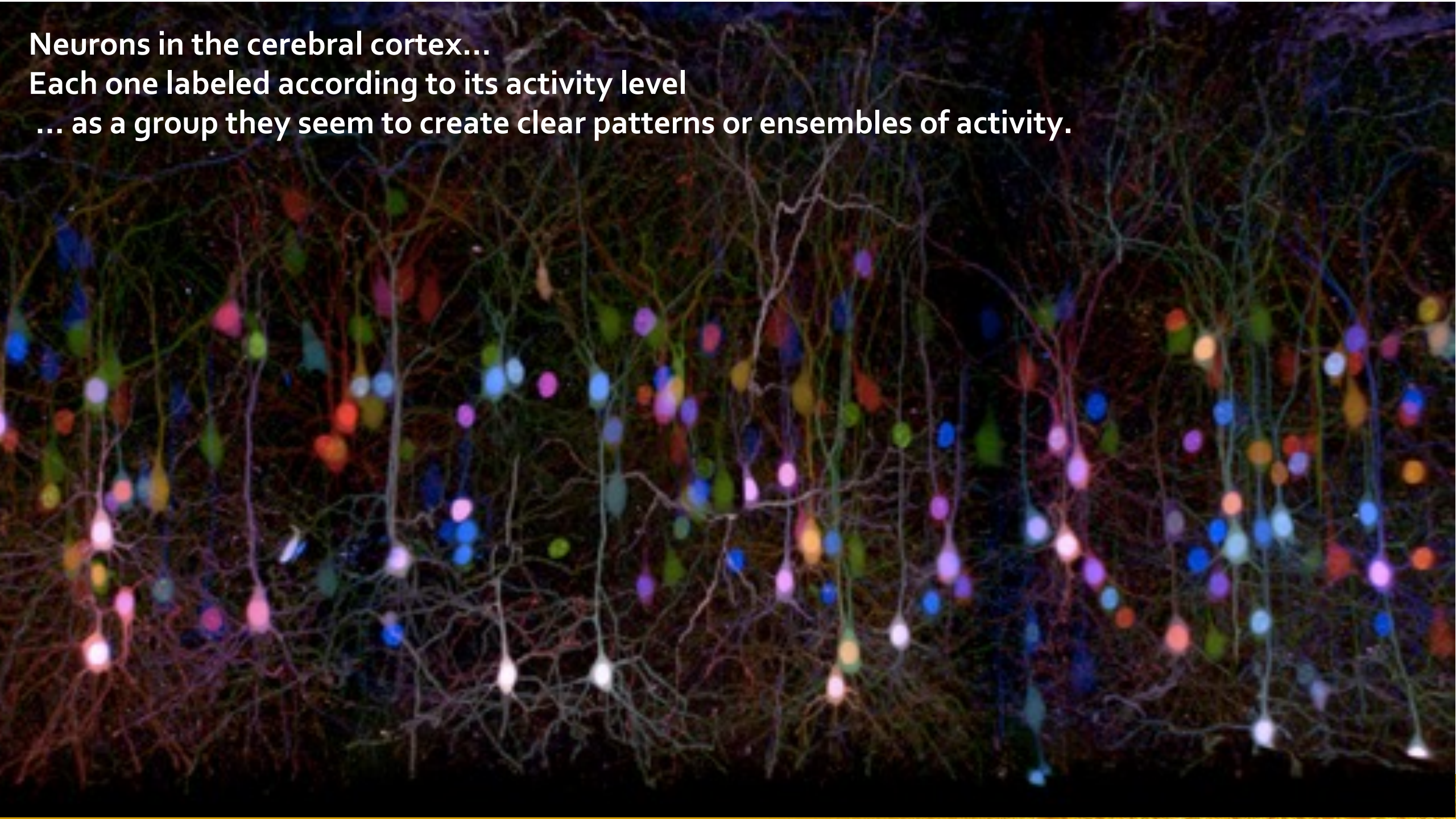


NEURONAL ECONOMY

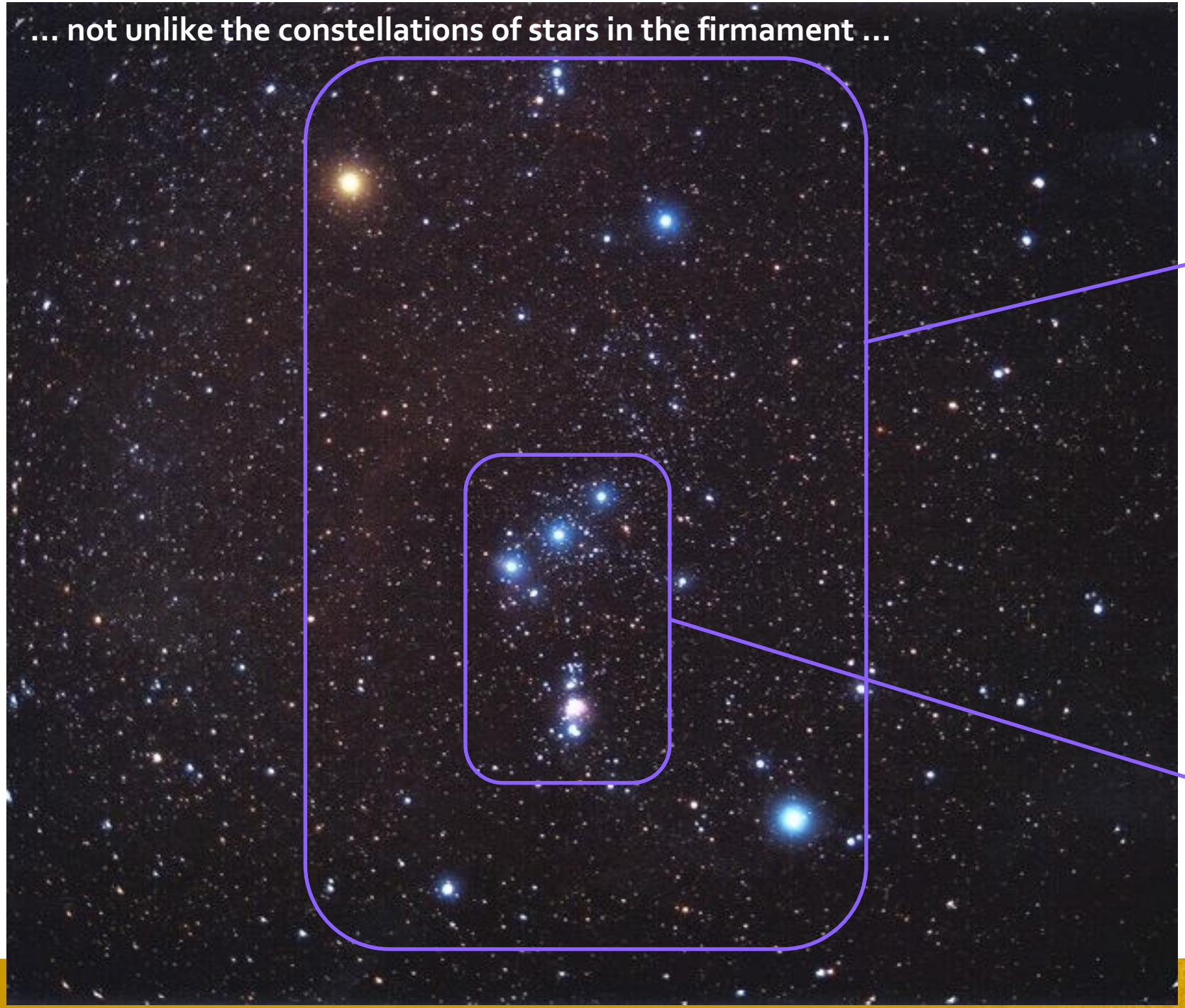
The same areas of the brain become active when we **perceive** an aroma as when we **think** about that aroma!!

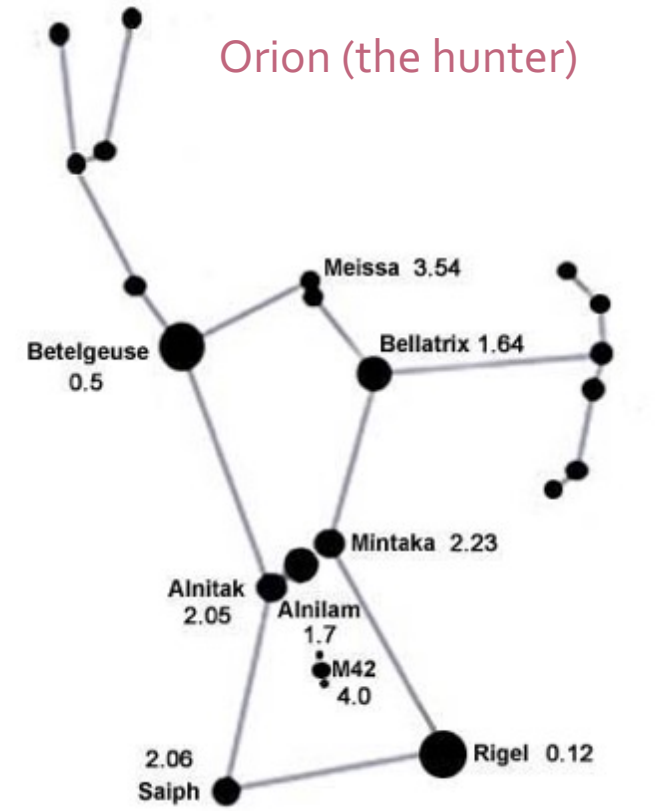


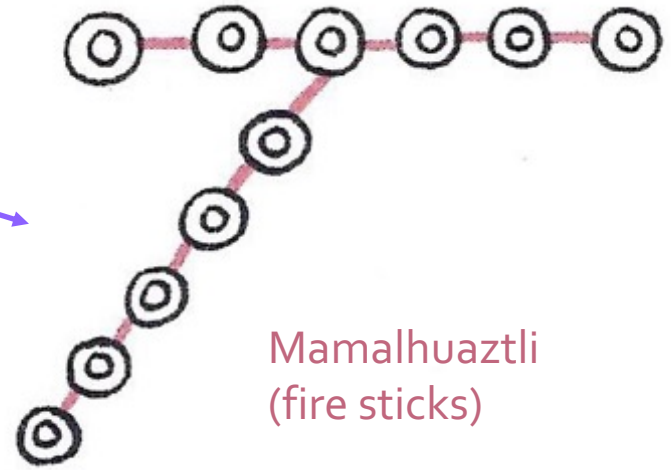



Neurons in the cerebral cortex…
Each one labeled according to its activity level
… as a group they seem to create clear patterns or ensembles of activity.

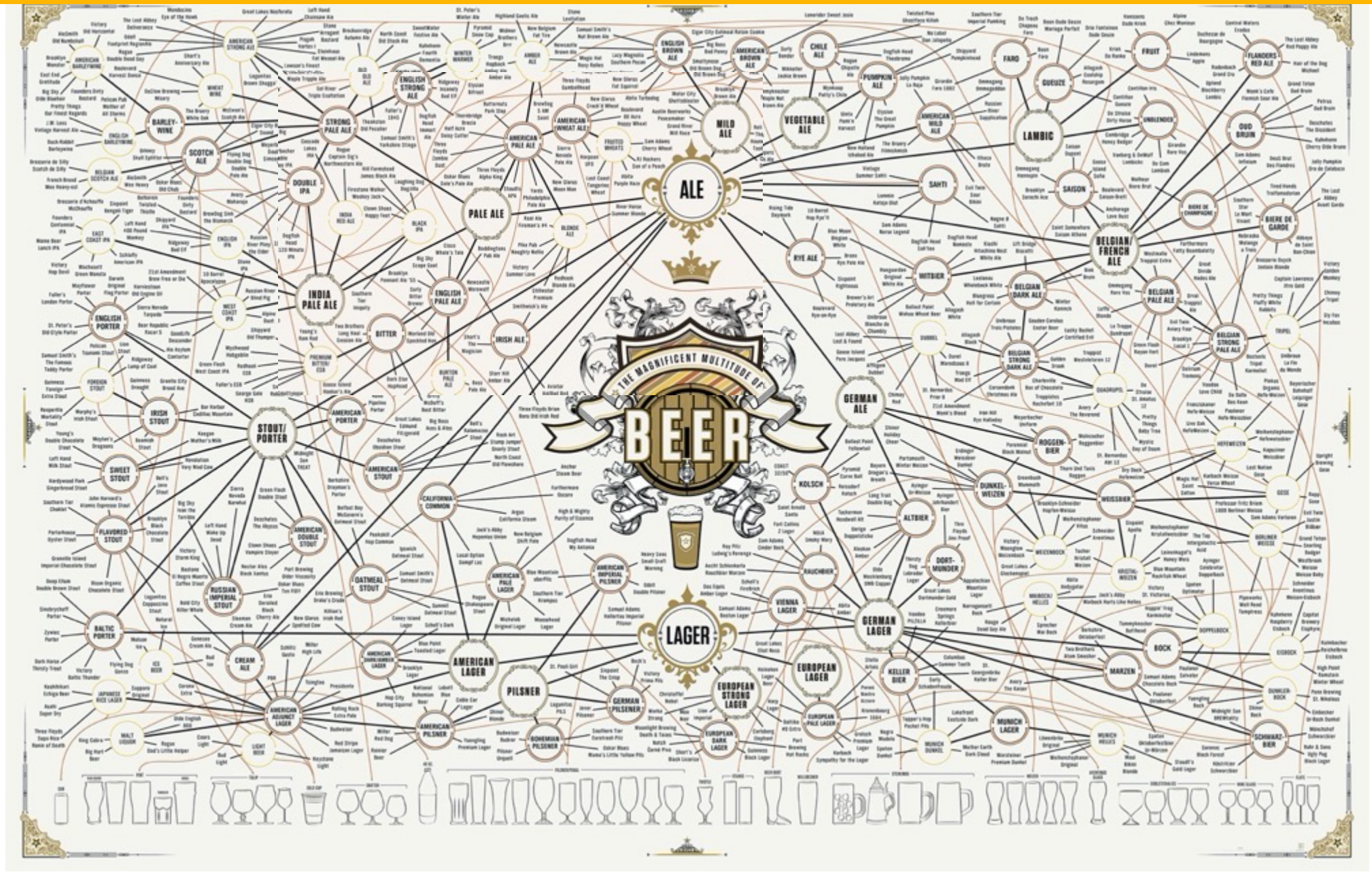
… not unlike the constellations of stars in the firmament …

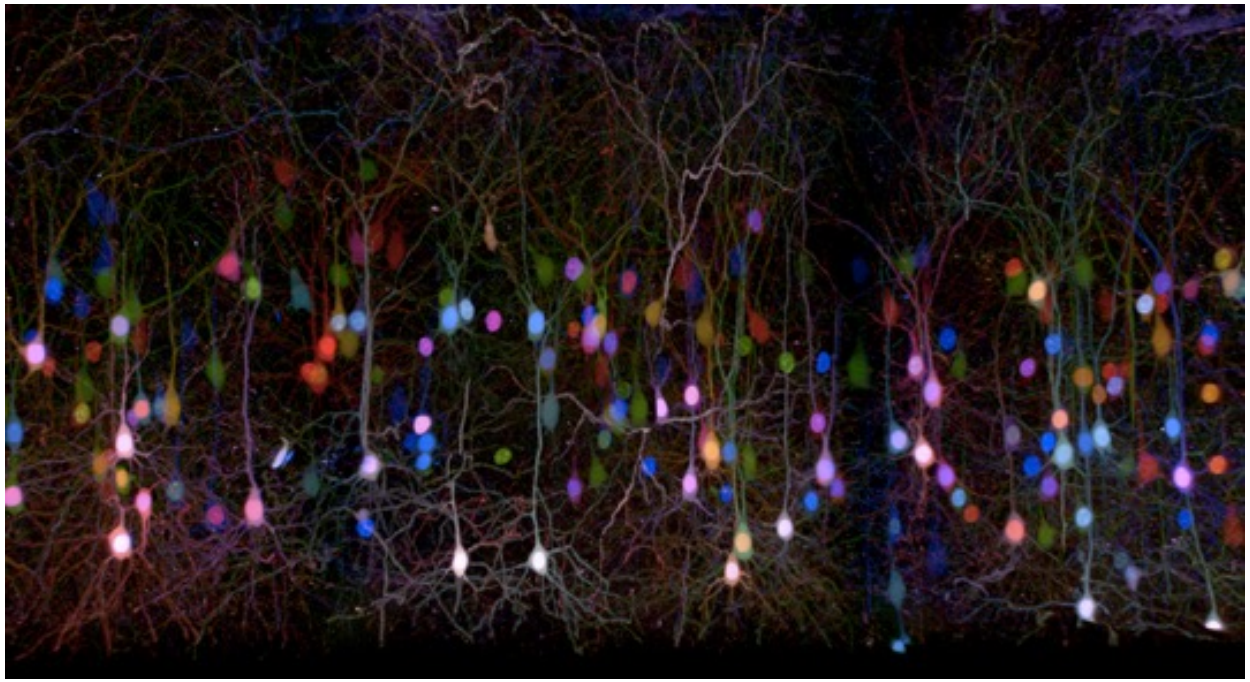




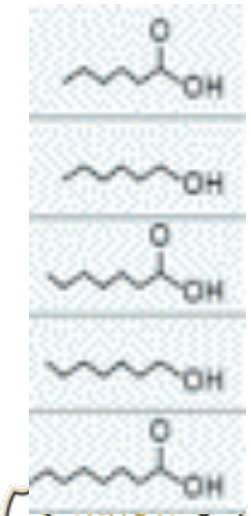


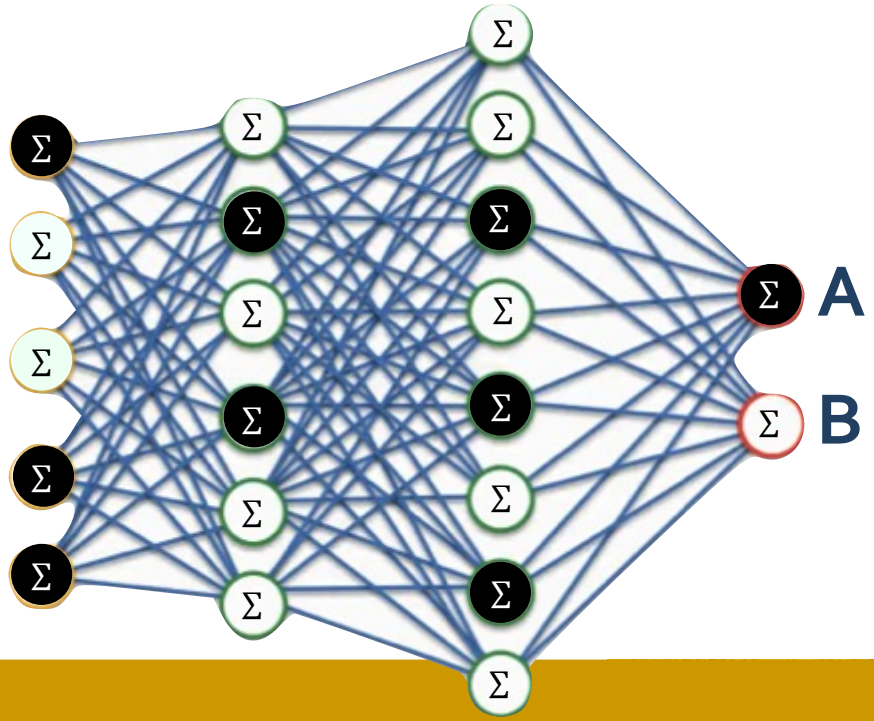
It is these “patterns” of neuronal activity forming constellations that we interpret as individual beer “styles”!!





- ★ However, neurons never remain static
- ★ Their patterns emerge, change and disappear continuously as a response to small changes in stimuli.
- ★ Hence the nervous system is a very dynamic system not well described by fixed patterns





So, rather than a "fixed" pattern of the type

A vs. B

we should try to identify a "trajectory" of varying patterns through a phase space of neuronal activity.

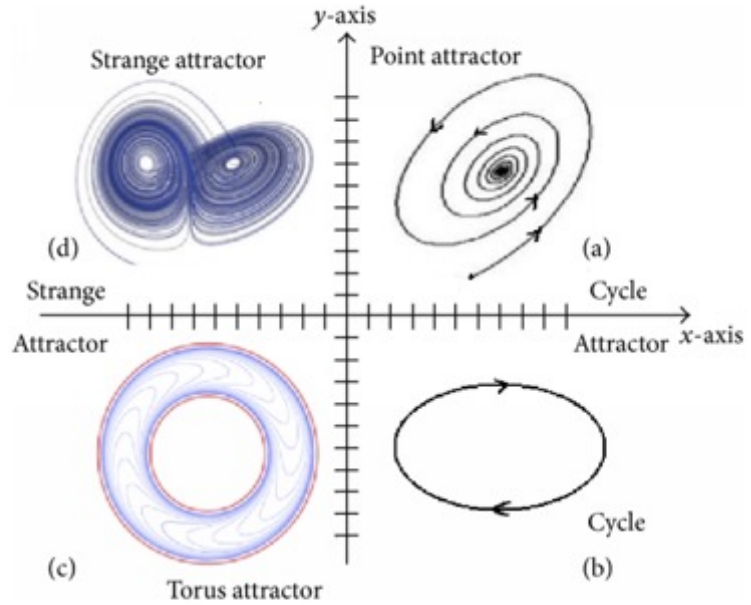
Lorenz attractor

$$\frac{dx}{dt} = a(y - x)$$

$$\frac{dy}{dt} = x(b - z) - y$$

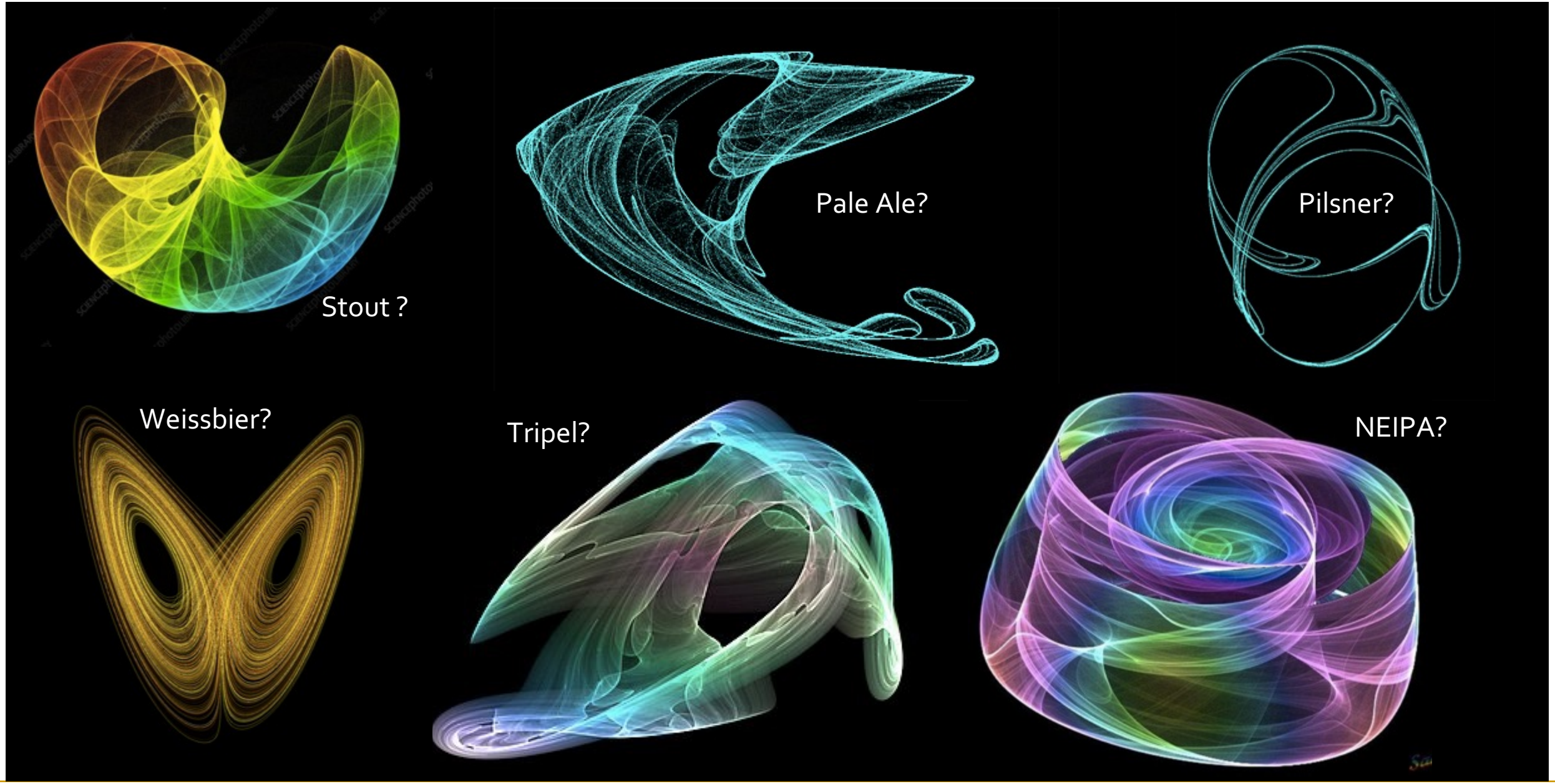
$$\frac{dz}{dt} = xy - cz$$

a = 10, b = 28, c = 8 / 3



The trajectory of a "strange attractor" never repeats (it is *ergodic*)

… however, the pattern drawn by the trajectory may be very recognizable and is always the same.



As an intrinsically dynamic system, a network of neurons can in principle represent PERCEPTS as what mathematically may be construed as "strange attractors". This would allow for an infinite variation of patterns that are highly sensitive to variations in stimuli.


CHEERS!
And of course… apart from yielding some very colourful and complex graphs…
… now we have yet another excuse or talking science while enjoying a good beer!

Resources

- Frank Jackson (1982). Epiphenomenal Qualia. *The Philosophical Quarterly*, **32**(127):127-136.
- M.C.Meilgaard, C.E. Dalgliesh, J.F. Clapperton (1979). Beer Flavour Terminology. *Journal of the Institute of Brewing*, **85**(1):38-42.
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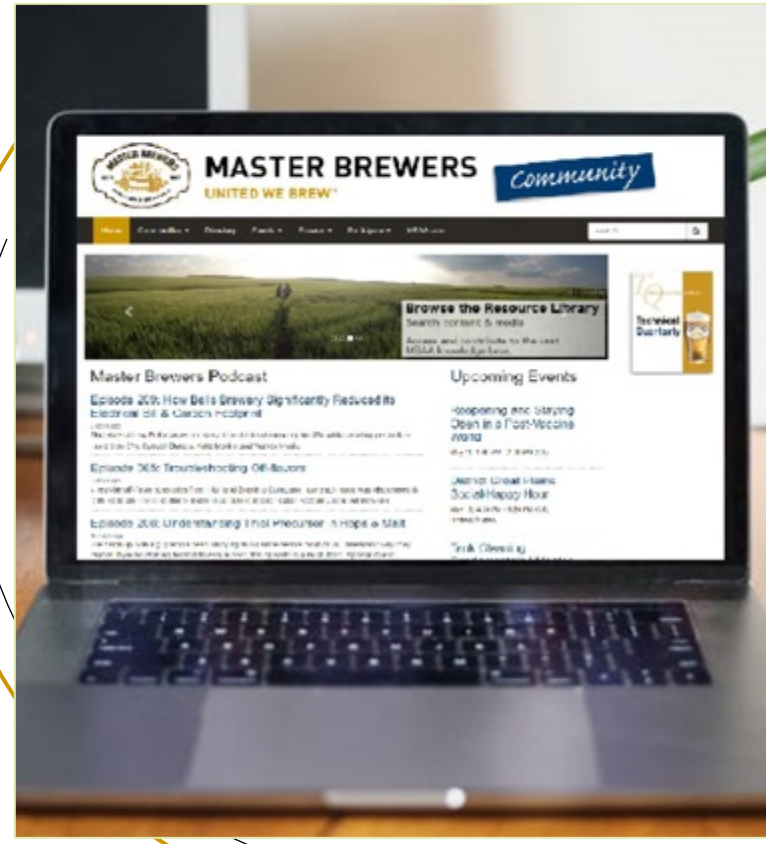


Q&A