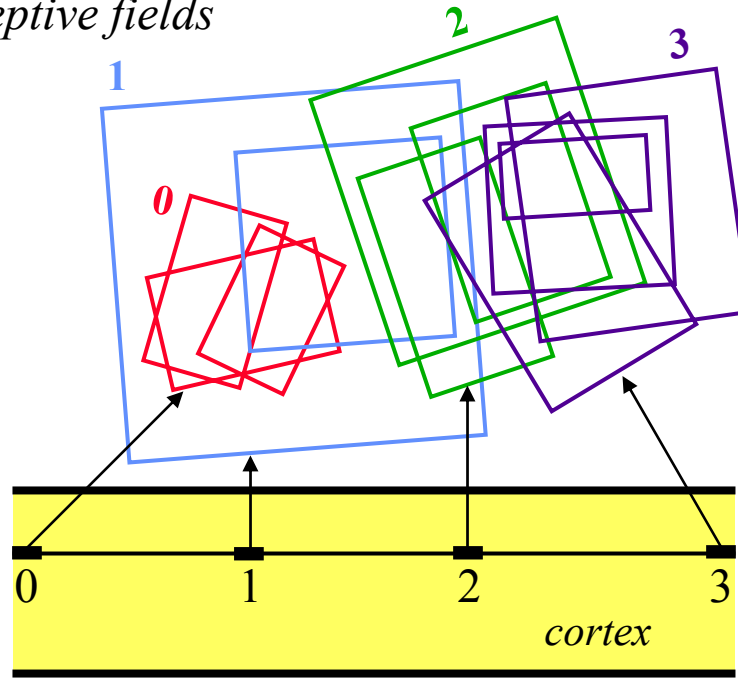


	Motor	Somato-sensory	Frontal	Temporal	Parietal	Visual	Mean of means
Mouse	109.2 ± 6.7	111.9 ± 6.9	110.8 ± 7.1	110.5 ± 6.5	104.7 ± 7.2	112.2 ± 6.0	109.9 ± 6.8
Rat	108.2 ± 5.8	107.0 ± 6.7	104.3 ± 7.2	107.7 ± 9.2	105.2 ± 6.8	107.8 ± 7.9	106.7 ± 7.4
Cat	103.9 ± 7.6	106.6 ± 7.2	108.0 ± 6.2	113.8 ± 7.3	110.6 ± 7.4	109.8 ± 9.9	108.8 ± 7.7
Monkey	110.2 ± 9.4	109.4 ± 9.4	112.0 ± 11.1	109.8 ± 10.3	114.6 ± 9.9		----
Man	102.3 ± 9.5	103.7 ± 5.8	103.3 ± 8.6	107.7 ± 7.5	104.1 ± 12.5		----

mean ± s.d.

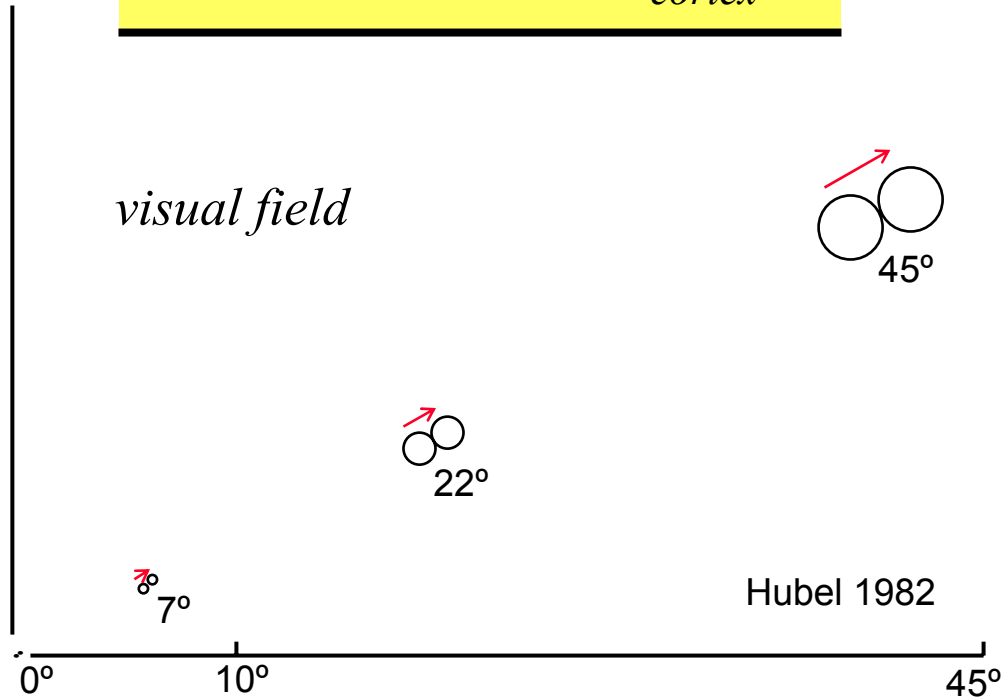
Rockel AJ, Hiorns RW & Powell TP (1980) "The basic uniformity in structure of the neocortex," *Brain* **103**:221-44.

receptive fields

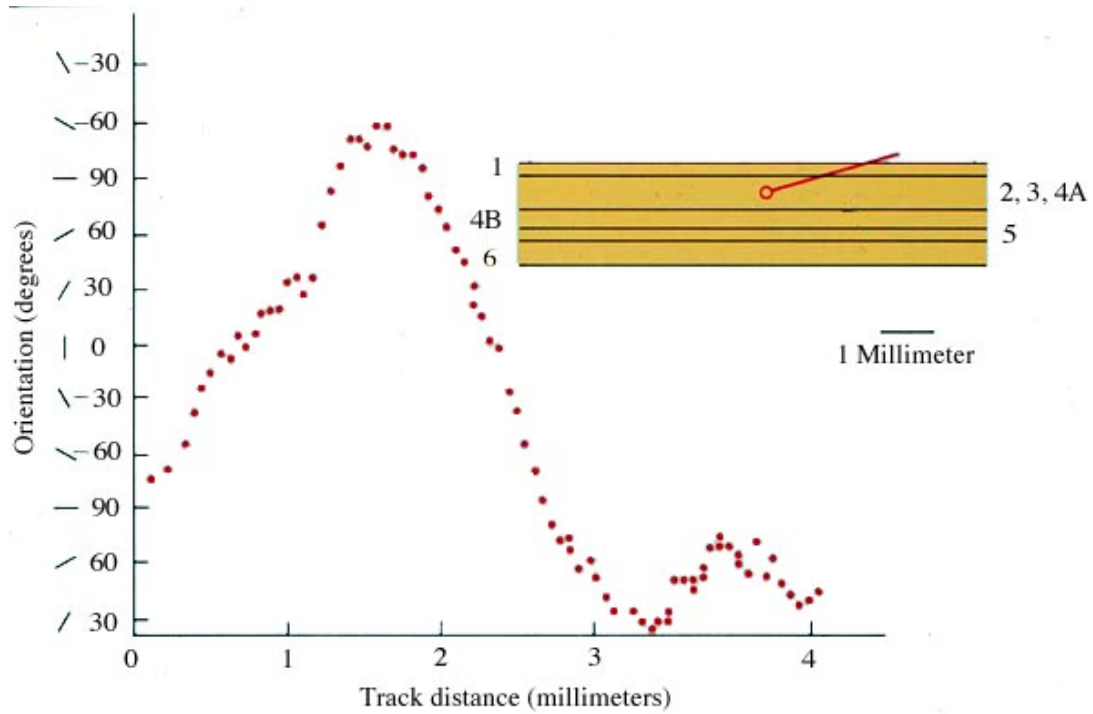


Hubel & Wiesel 1974

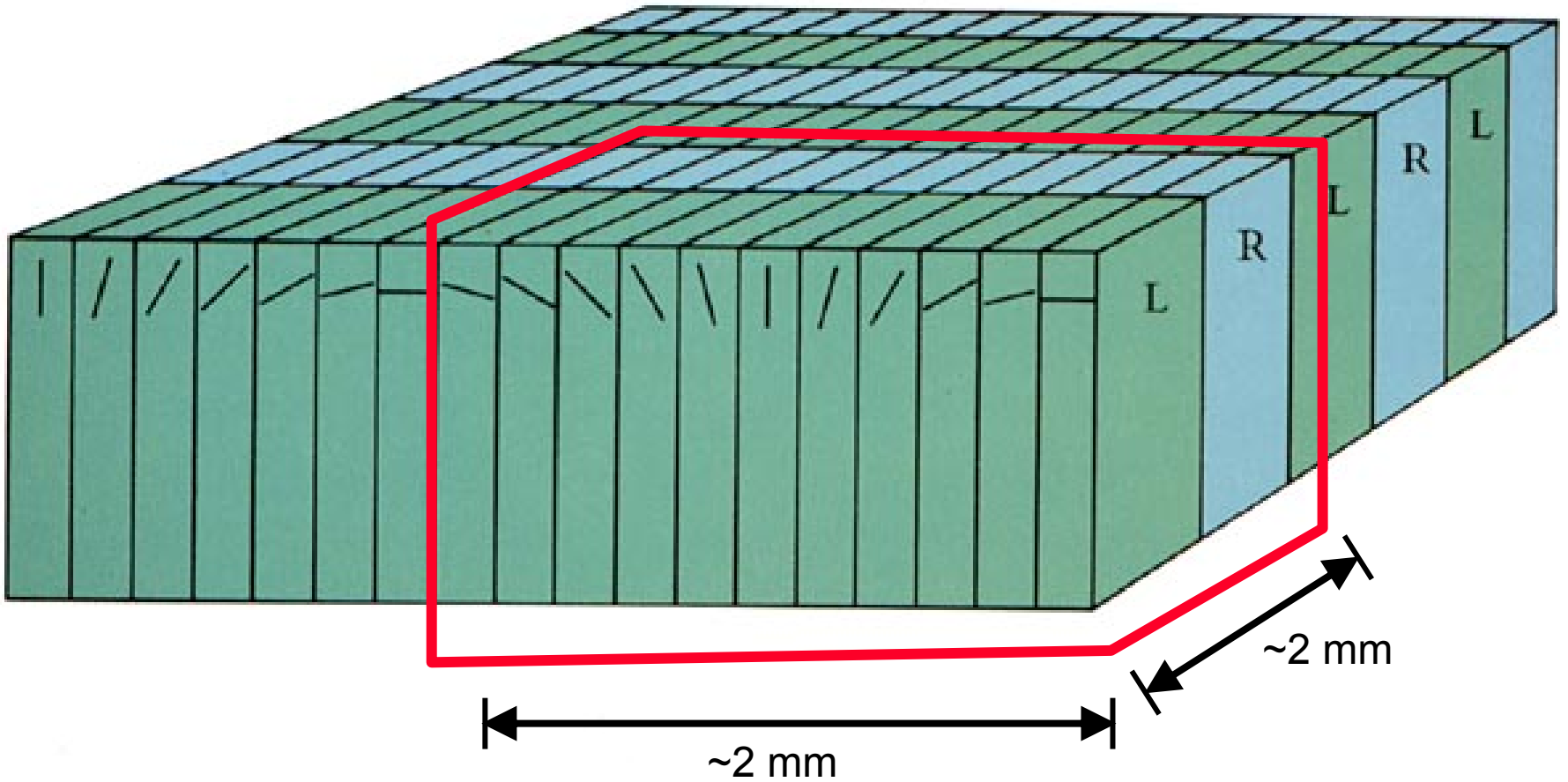
visual field



Hubel 1982

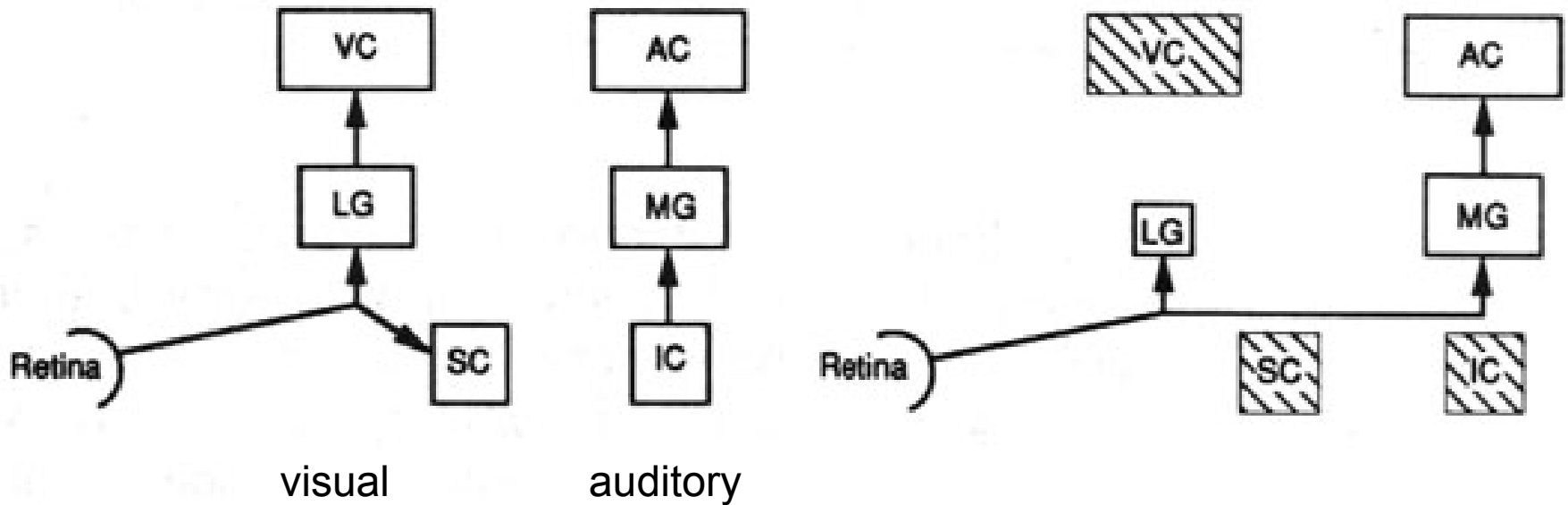


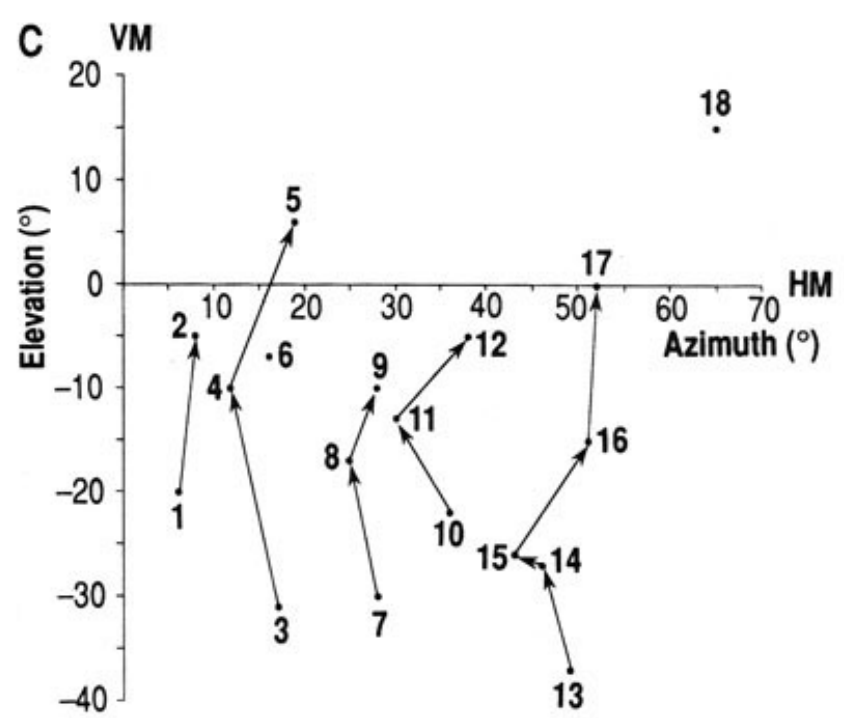
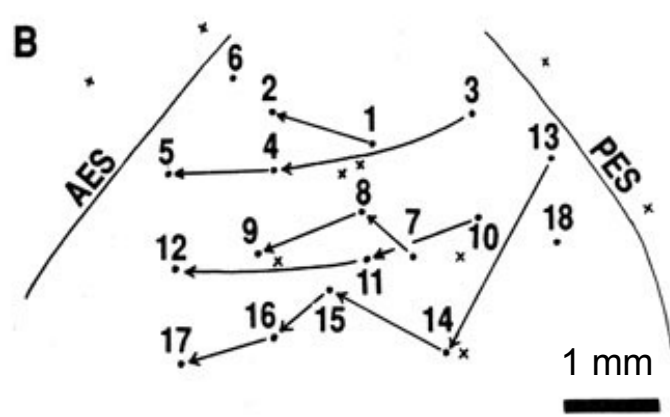
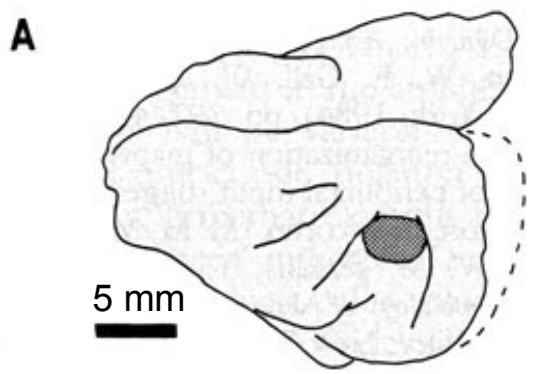
“Hypercolumn”

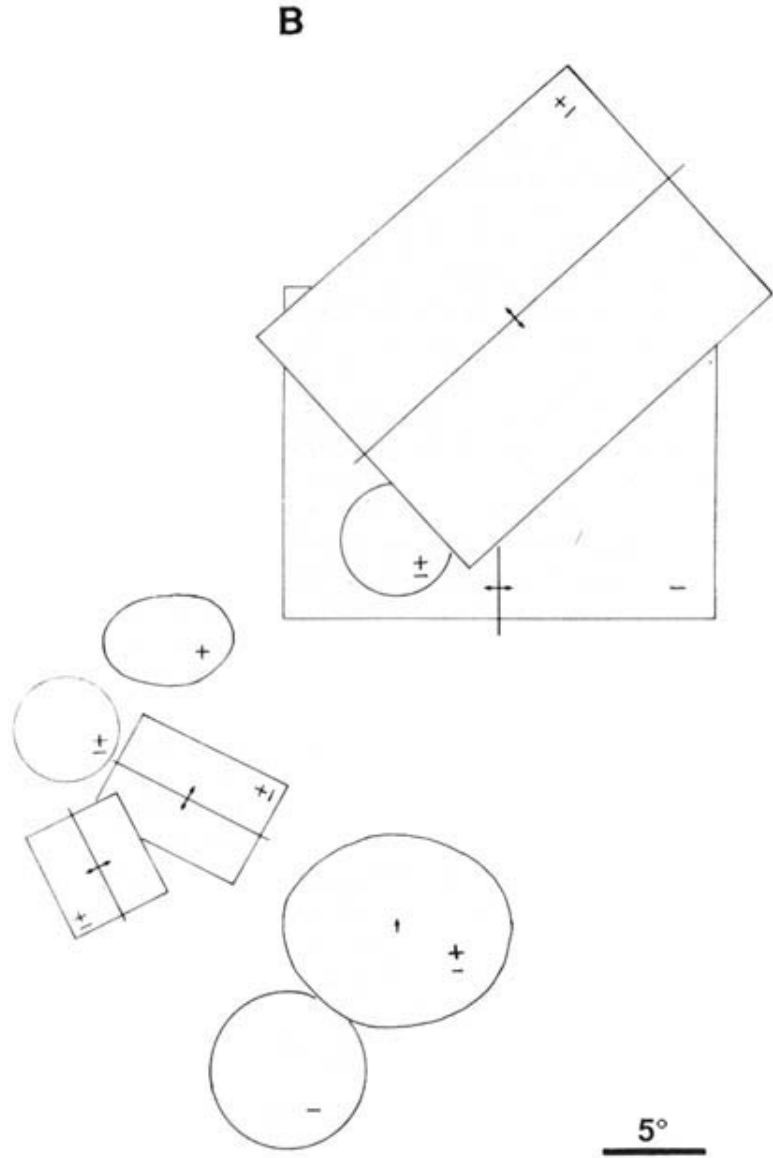
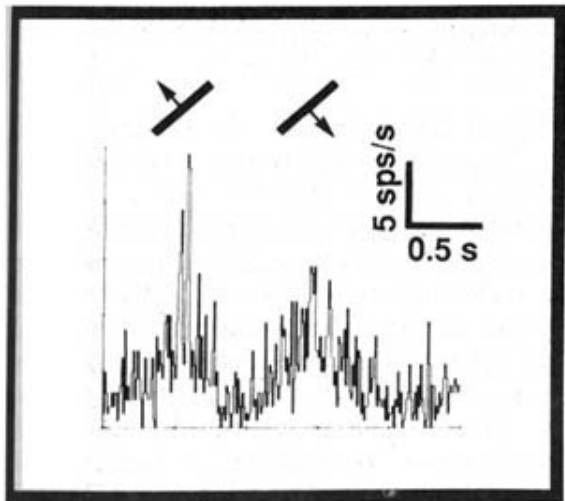
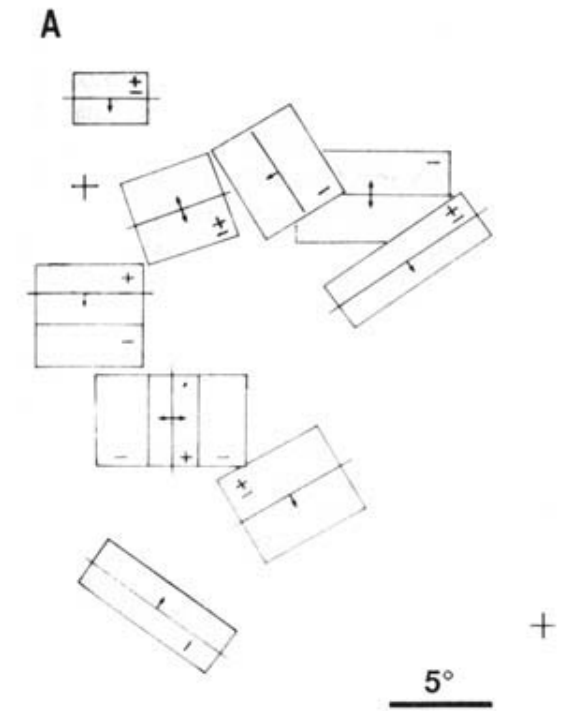


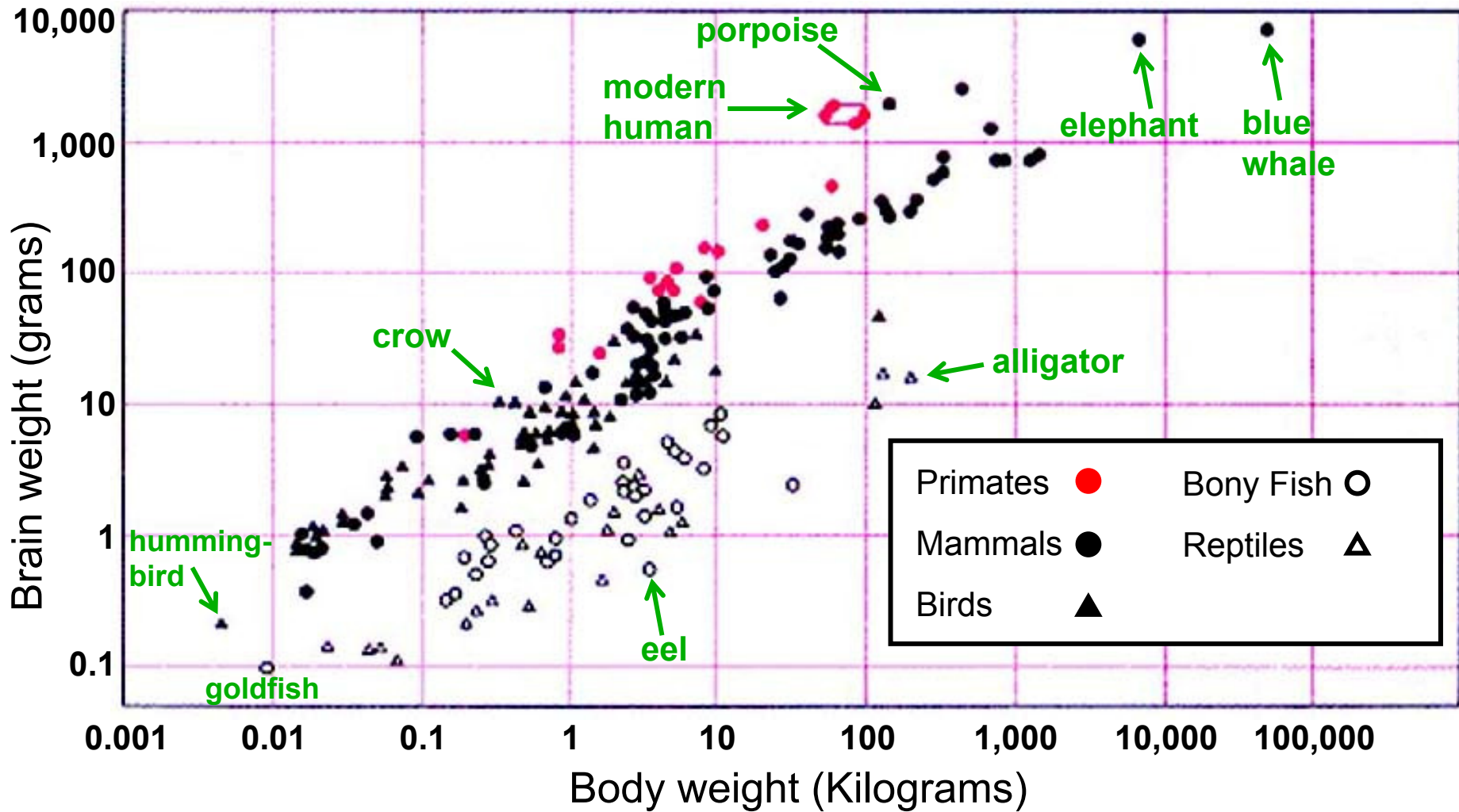
after Hubel & Wiesel 1962

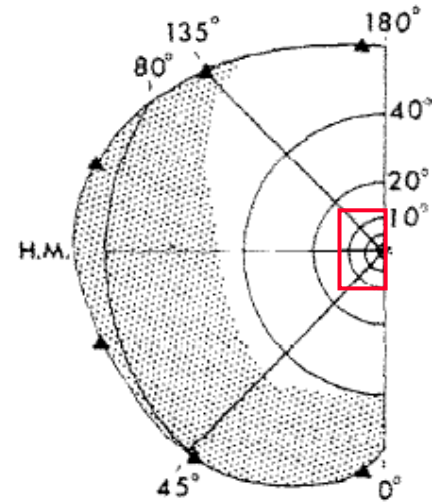
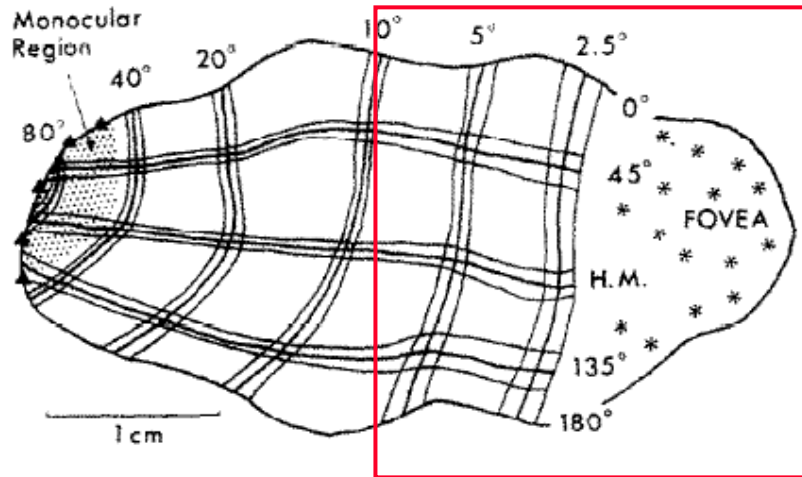
Re-routing experiments (ferret)



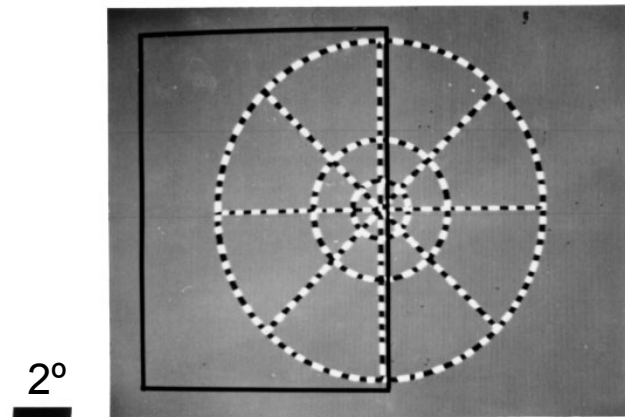
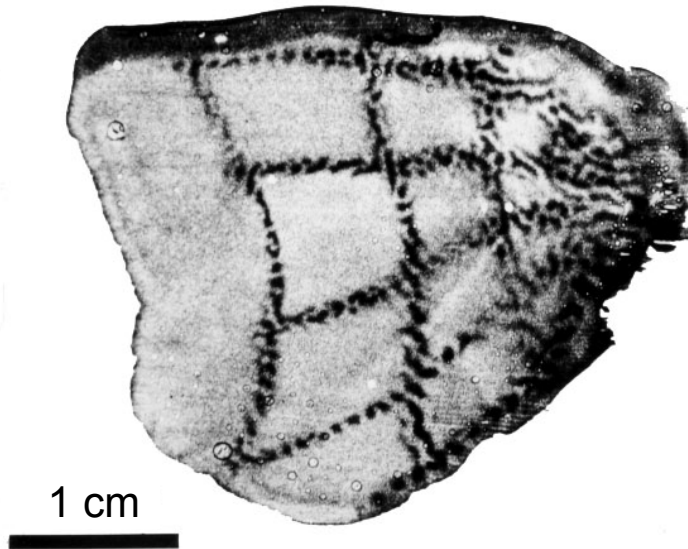






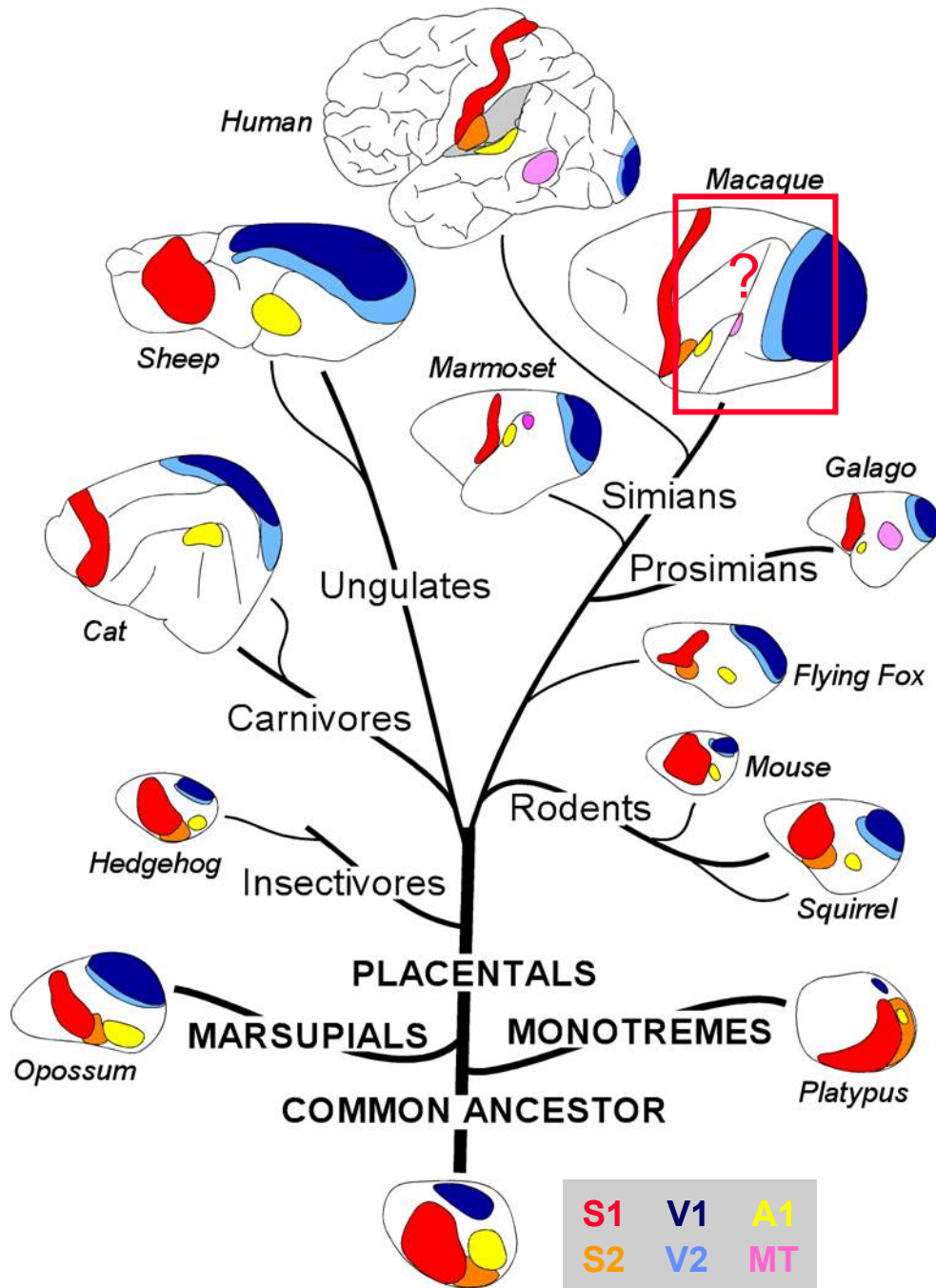


Van Essen et al. 1984



Tootell et al. 1982

Half of area V1 represents the central 10° (2% of the visual field)

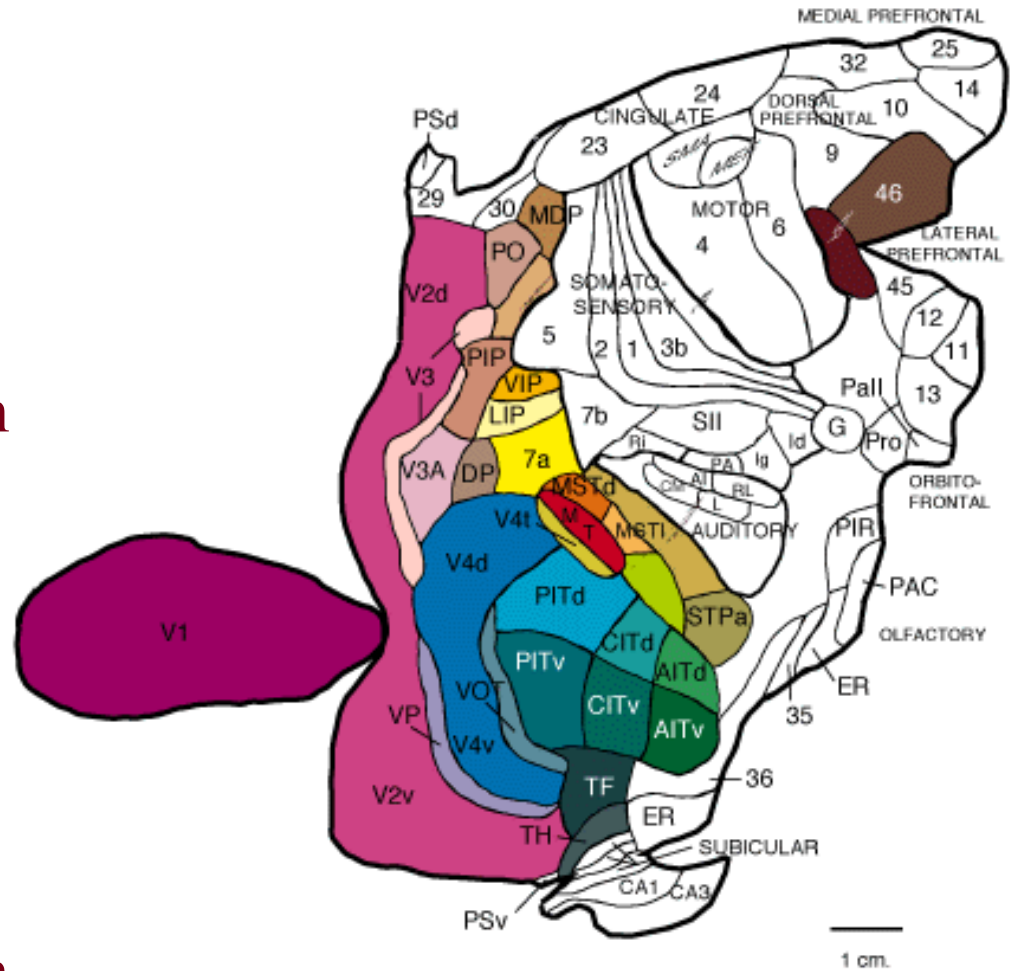




Lateral view of monkey brain



Medial view of monkey brain



Cortex unfolded



"Thus the hypothesis is that the cerebral cortex confers skill in **deriving useful knowledge** about the material and social world from the uncertain evidence of our senses, it **stores this knowledge**, and **gives access to it when required.**"

Finding New Associations in Sensory Data

1. Remove evidence of associations you *already know about* . . .

. . . to facilitate detecting new ones.
($1/f^2$ and center-surround)

2. Make available the *probabilities* of the features currently present . . .

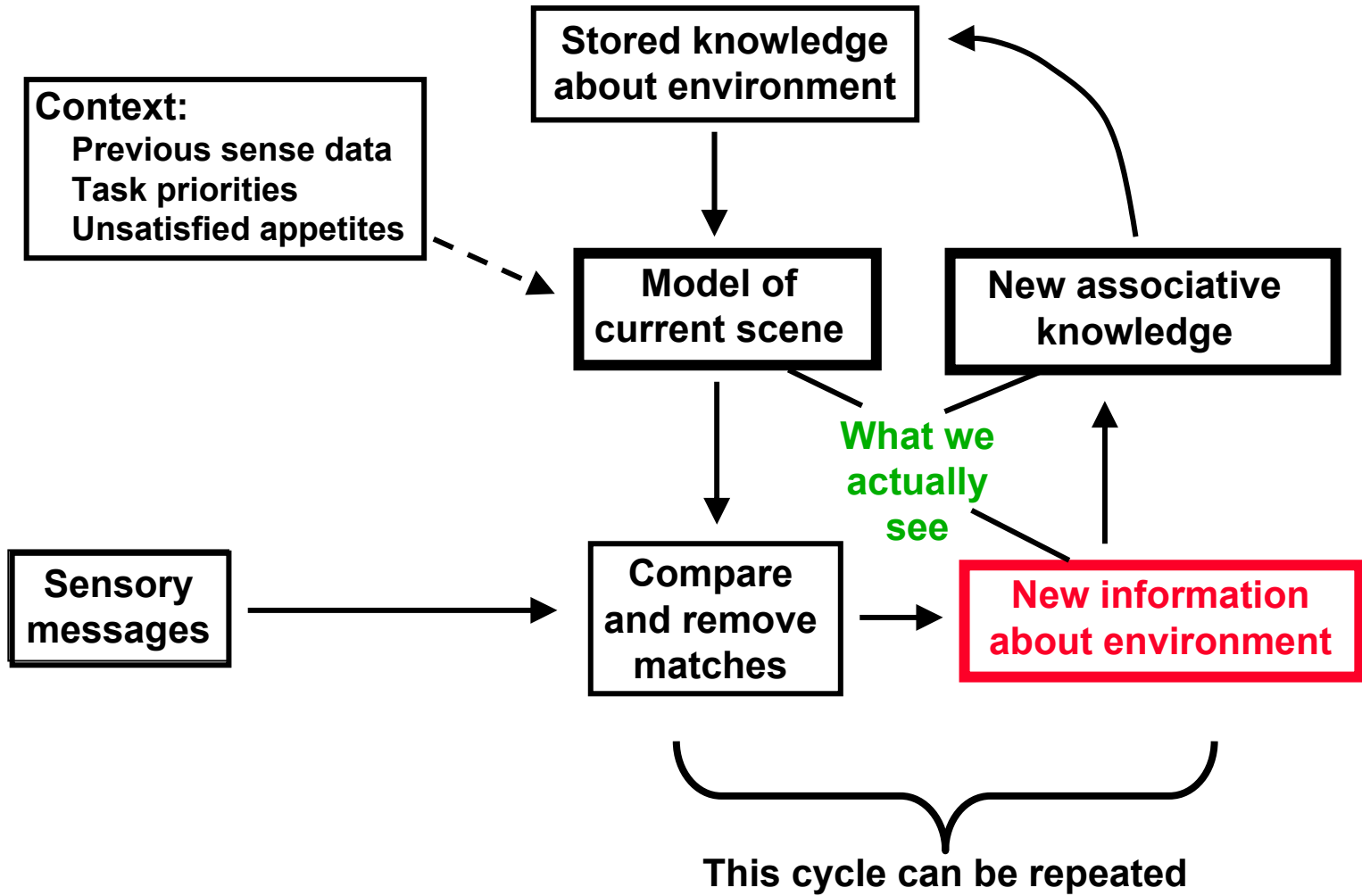
. . . to determine chance expectations.
($-\log p$, adaptation)

3. Choose features that occur *independently* of each other in the normal environment . . .

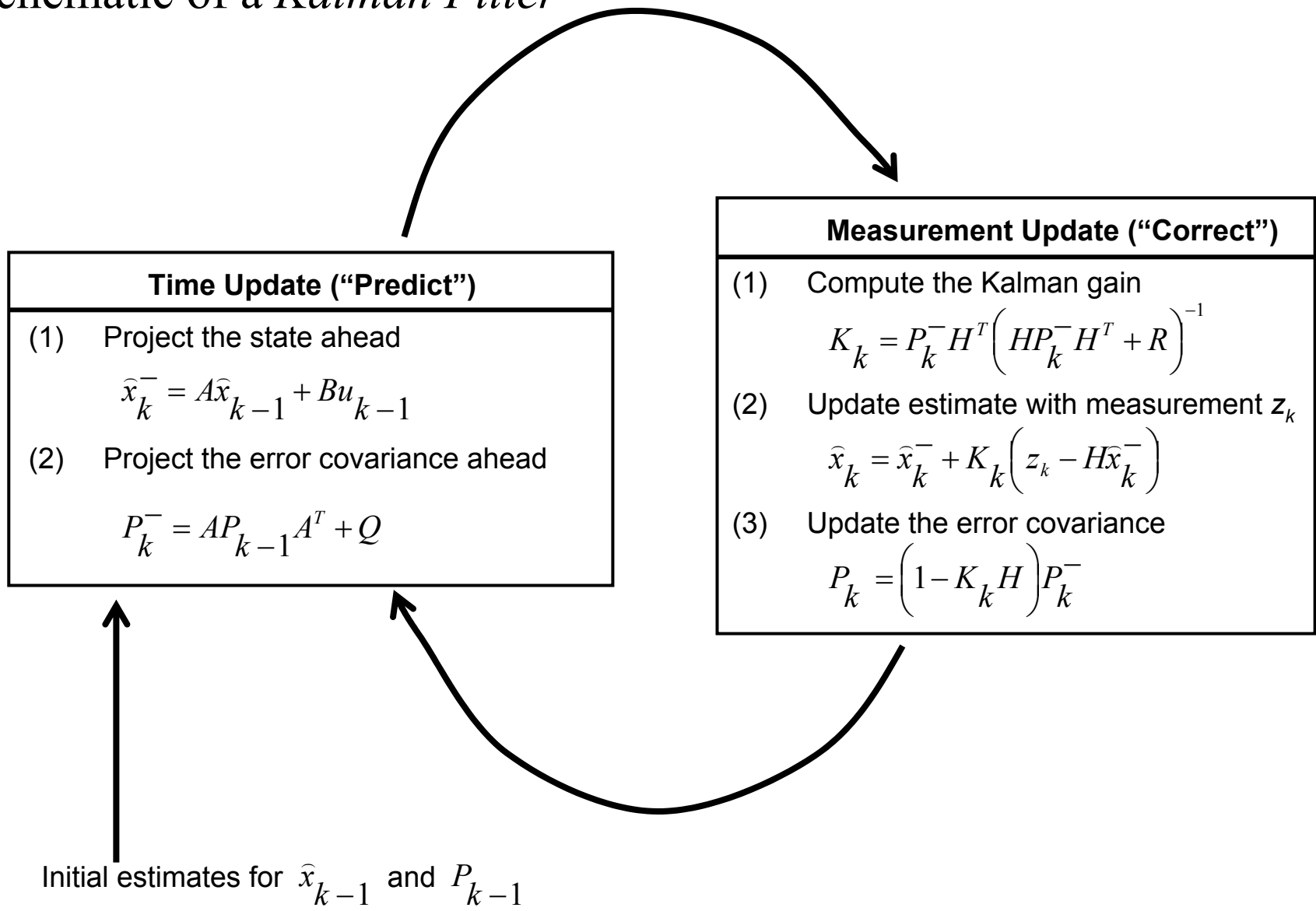
. . . to determine chance expectations or combinations of them.
(lateral inhibition)

4. Choose “*suspicious coincidences*” as features . . .

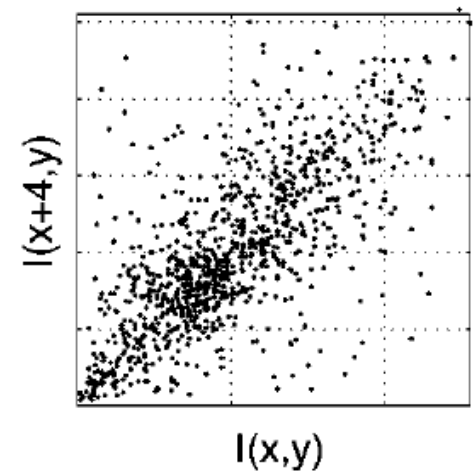
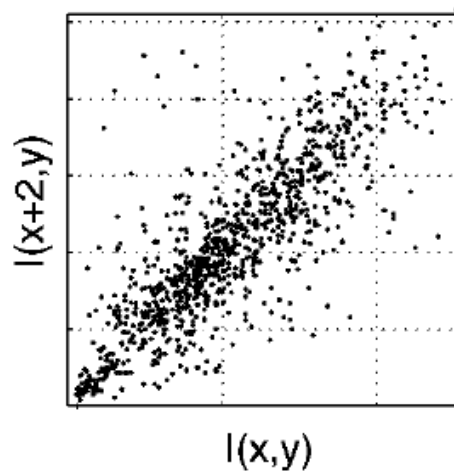
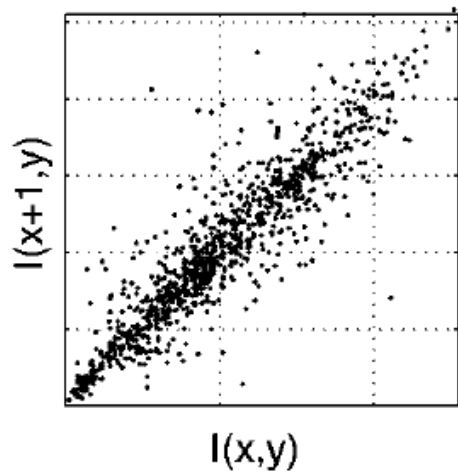
. . . to reduce redundancy and ensure appropriate generalization.
(orientation selectivity)



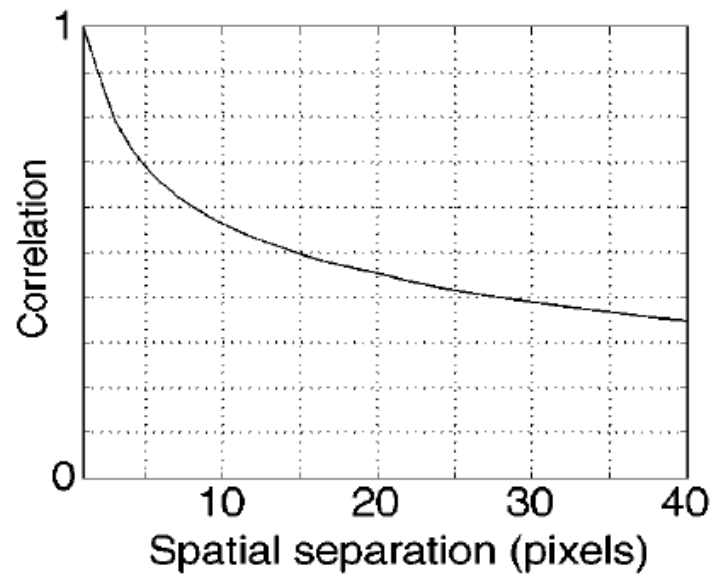
Schematic of a *Kalman Filter*



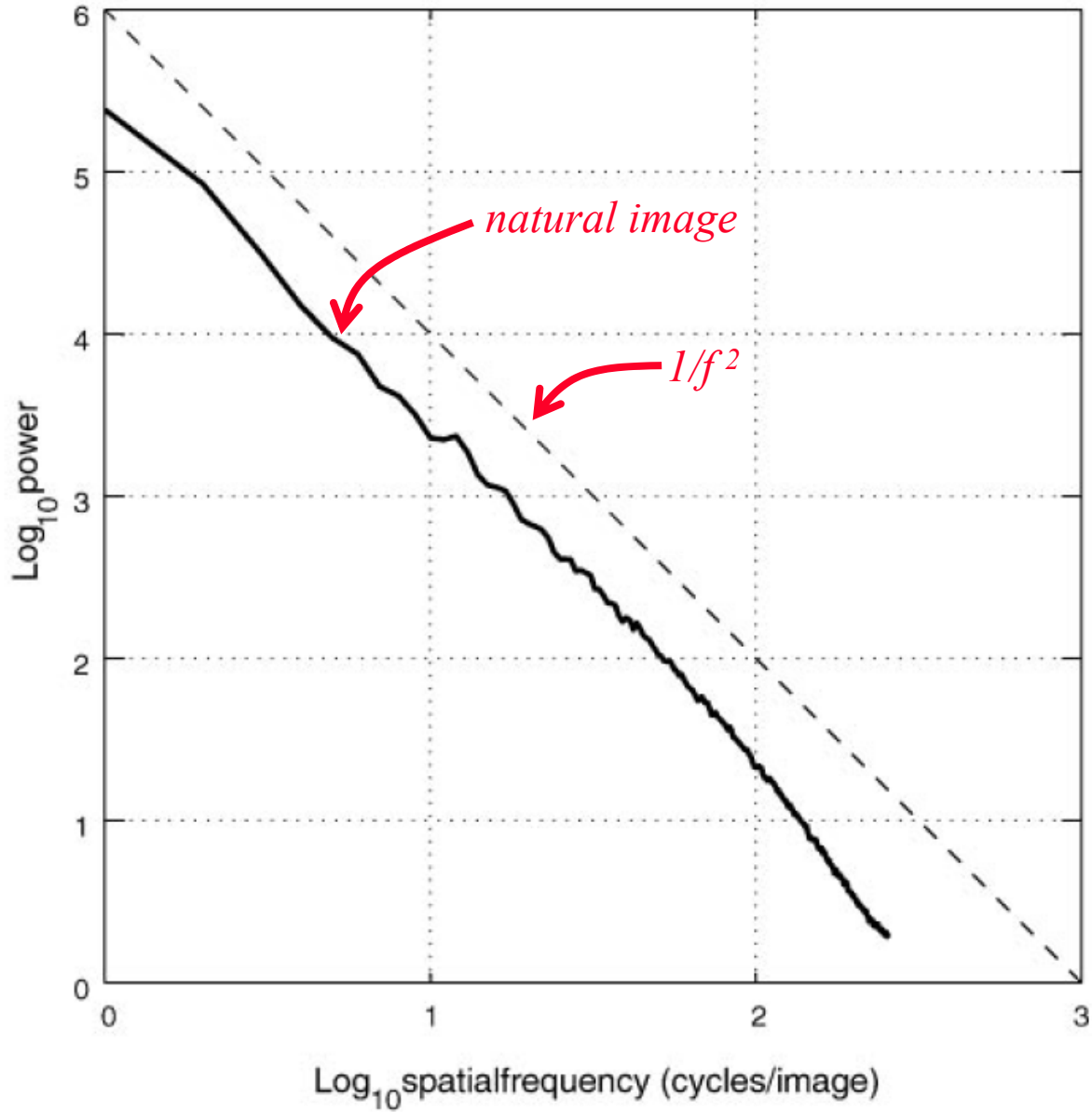
Neighboring pixels tend to have similar values



b.



Neighboring pixels tend to have similar values



Sophie in the Arctic



“Whitened”: $\nabla^2 \cdot G$ or what ctr-sur does



Finding New Associations in Sensory Data (The yellow Volkswagen problem)

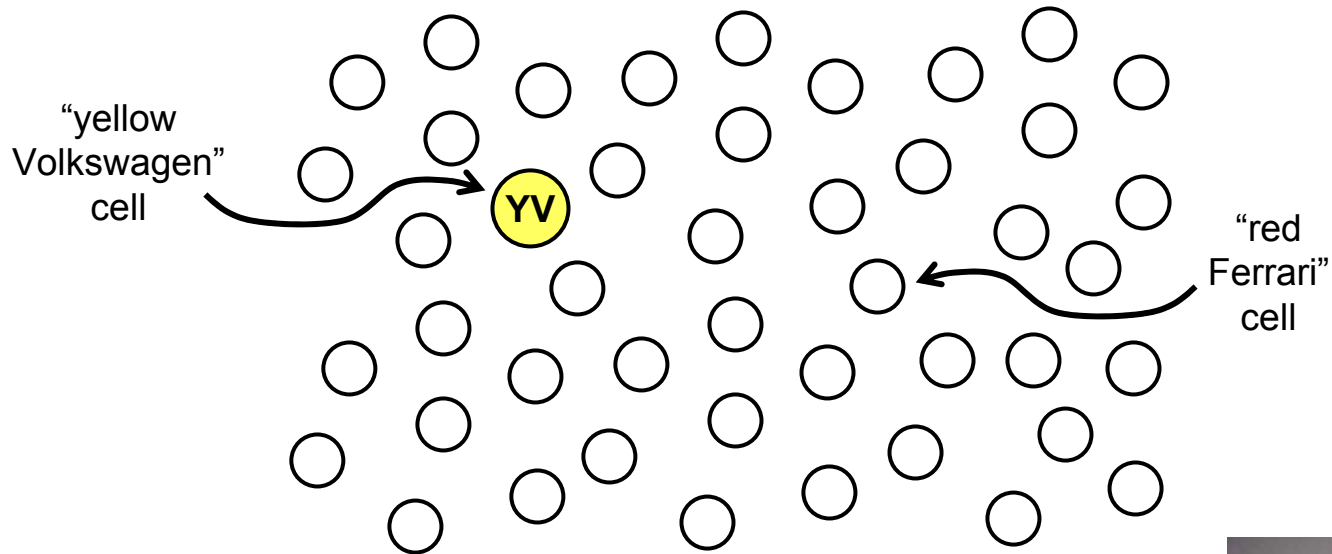


		Reward?	
		Yes	No
Yellow Volkswagen?	Yes		
	No		

Finding New Associations in Sensory Data (The yellow Volkswagen problem)

sparse

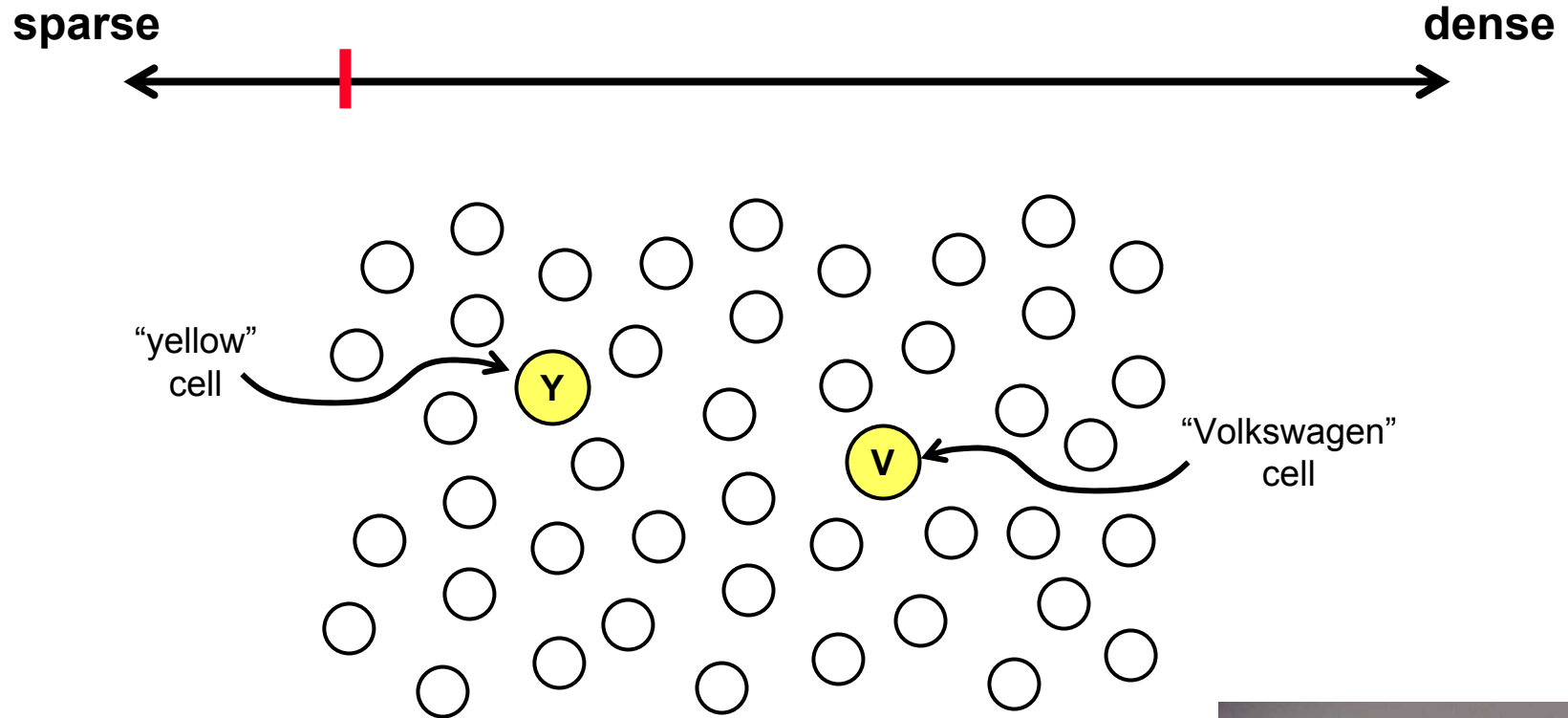
dense



“combinatorial explosion”



Finding New Associations in Sensory Data (The yellow Volkswagen problem)



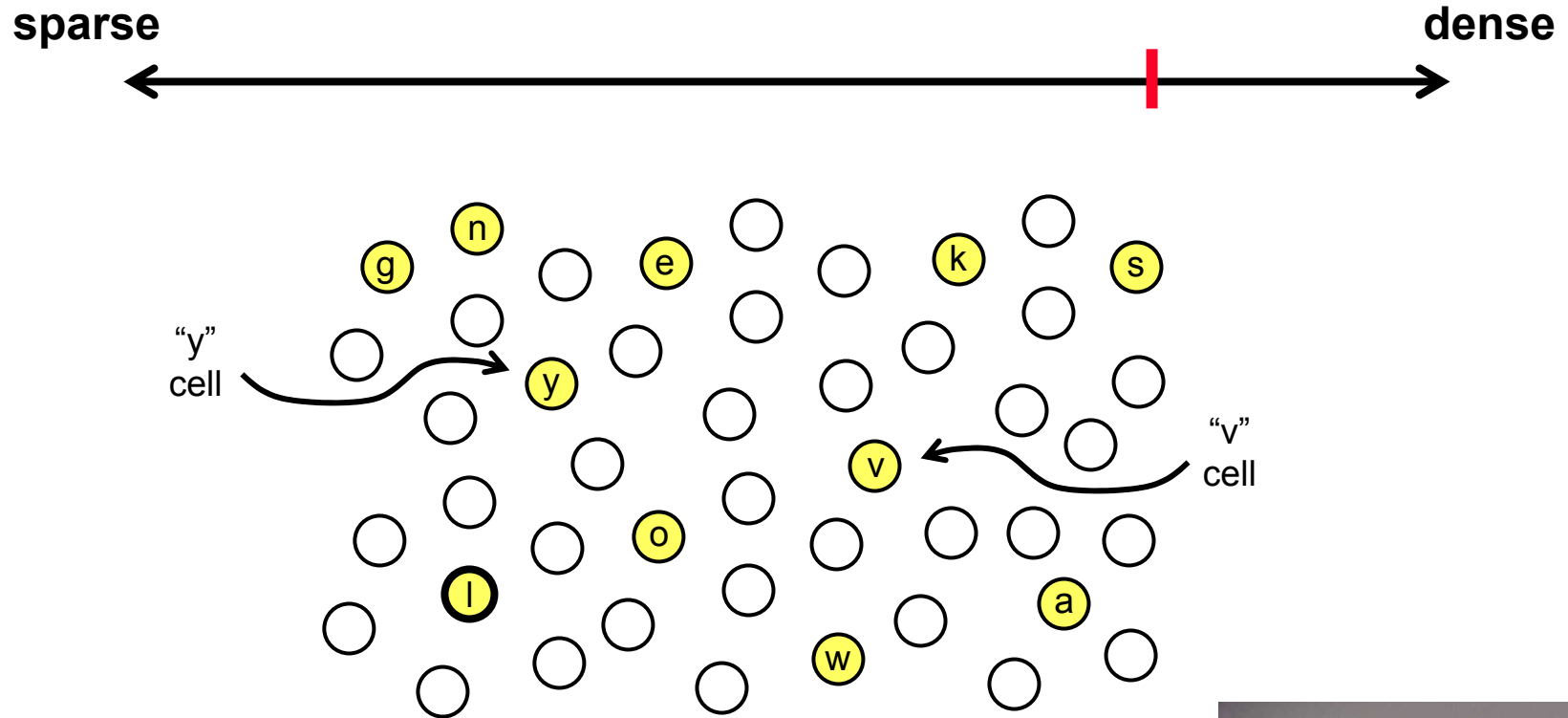
Finding New Associations in Sensory Data (The yellow Volkswagen problem)

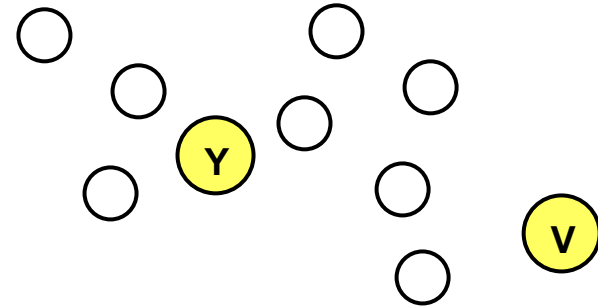
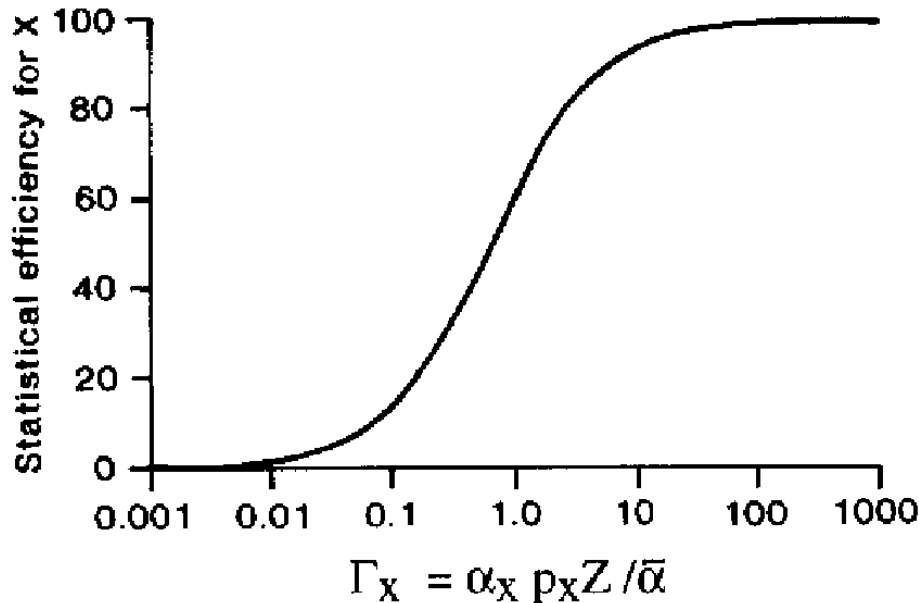


		Reward?	
		Yes	No
Yellow?	Yes		
	No		

		Reward?	
		Yes	No
Volkswagen?	Yes		
	No		

Finding New Associations in Sensory Data (The yellow Volkswagen problem)





The curve shows how statistical efficiency for detecting associations with a feature **X** varies with the value of a parameter defined as follows:

$$\Gamma_x = \alpha_x p_x Z / \langle \alpha \rangle$$

“sparseness”

where α_x , $\langle \alpha \rangle$ are the activity ratio for feature **X** and the average activity ratio, p_x is the probability of **X**, and Z is the number of neurons in the subset under consideration. For instance, one could identify an association with any one of the 45 possible pairs of active neurons in a subset of 10 with an efficiency of 50% provided that the neurons were active independently, the pair caused two neurons to be active, the probability of the pair occurring was 0.1, and the average fraction active was 0.2. (From Gardner-Medwin and Barlow 1994)

What are the desirable properties of directly represented features?

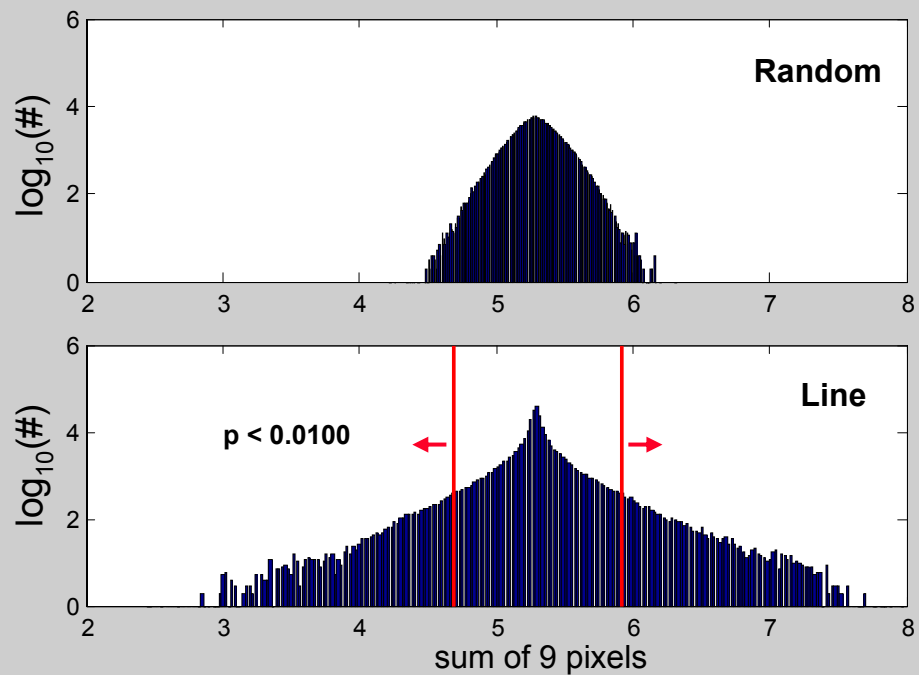
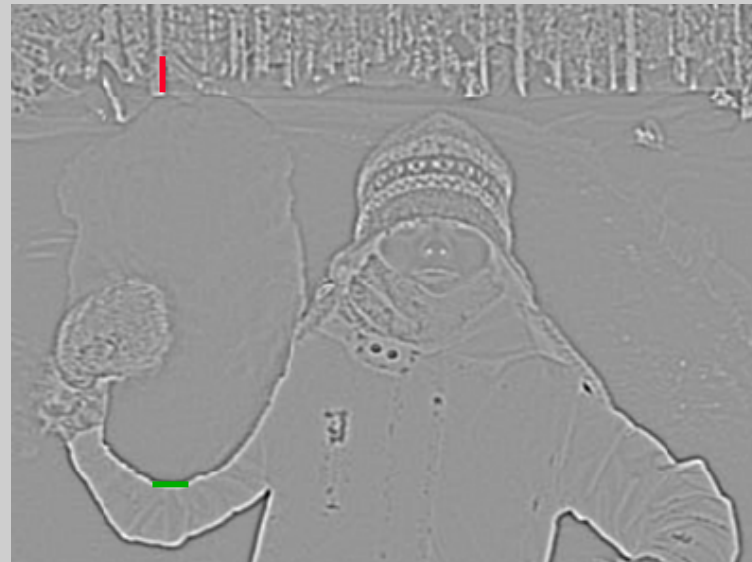
“. . . primitive conjunctions of active elements that actually occur often, but would be expected to occur only infrequently by chance,” that is,

“curious coincidences”

Sophie in the Arctic



“Whitened”: $\nabla^2 \cdot G$ or what ctr-sur does



Suspicious Coincidences



The perfect map?



12-5398 Boston, MA Medical Center, Brookline, Francis
AERIALS ONLY 508-295-5551 (c) (E)

A more useful map

11

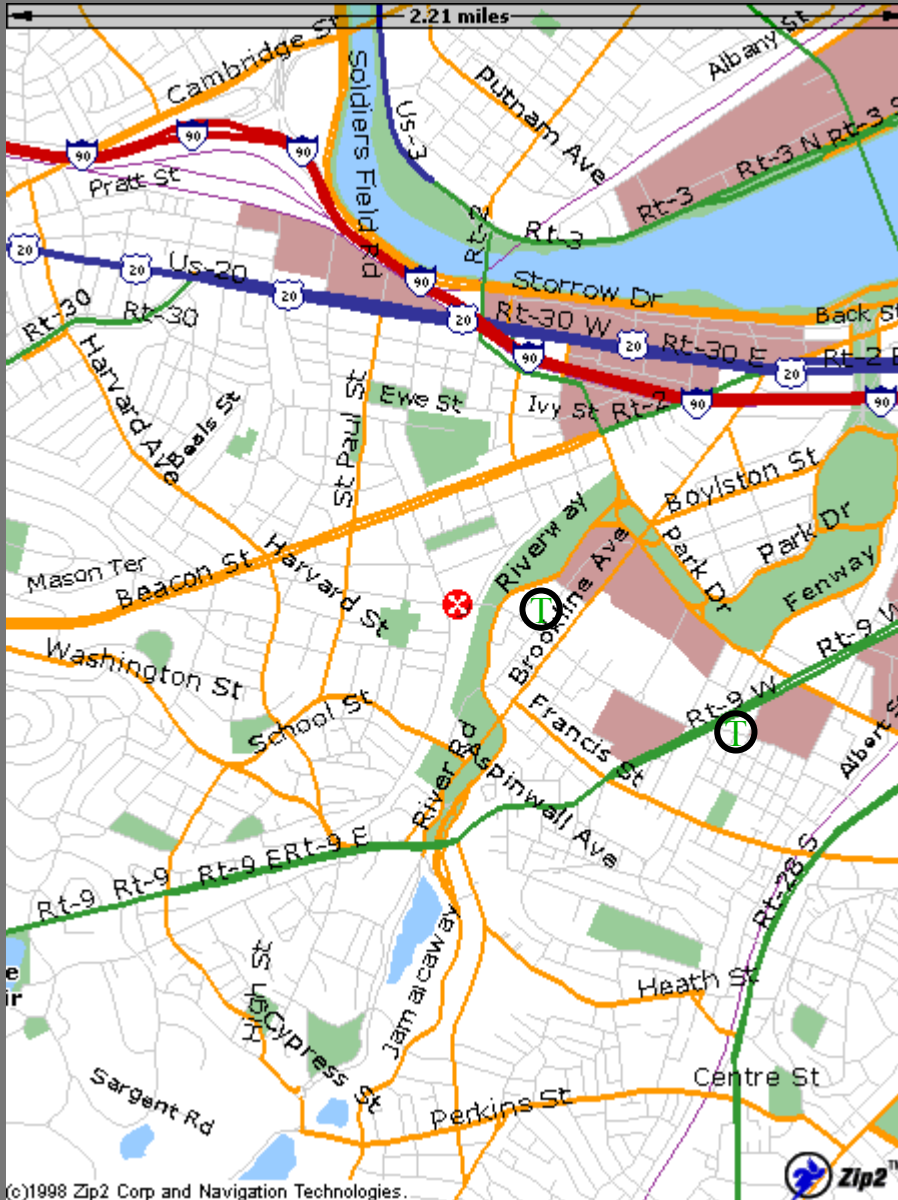
12

13

K

L

M



Streets

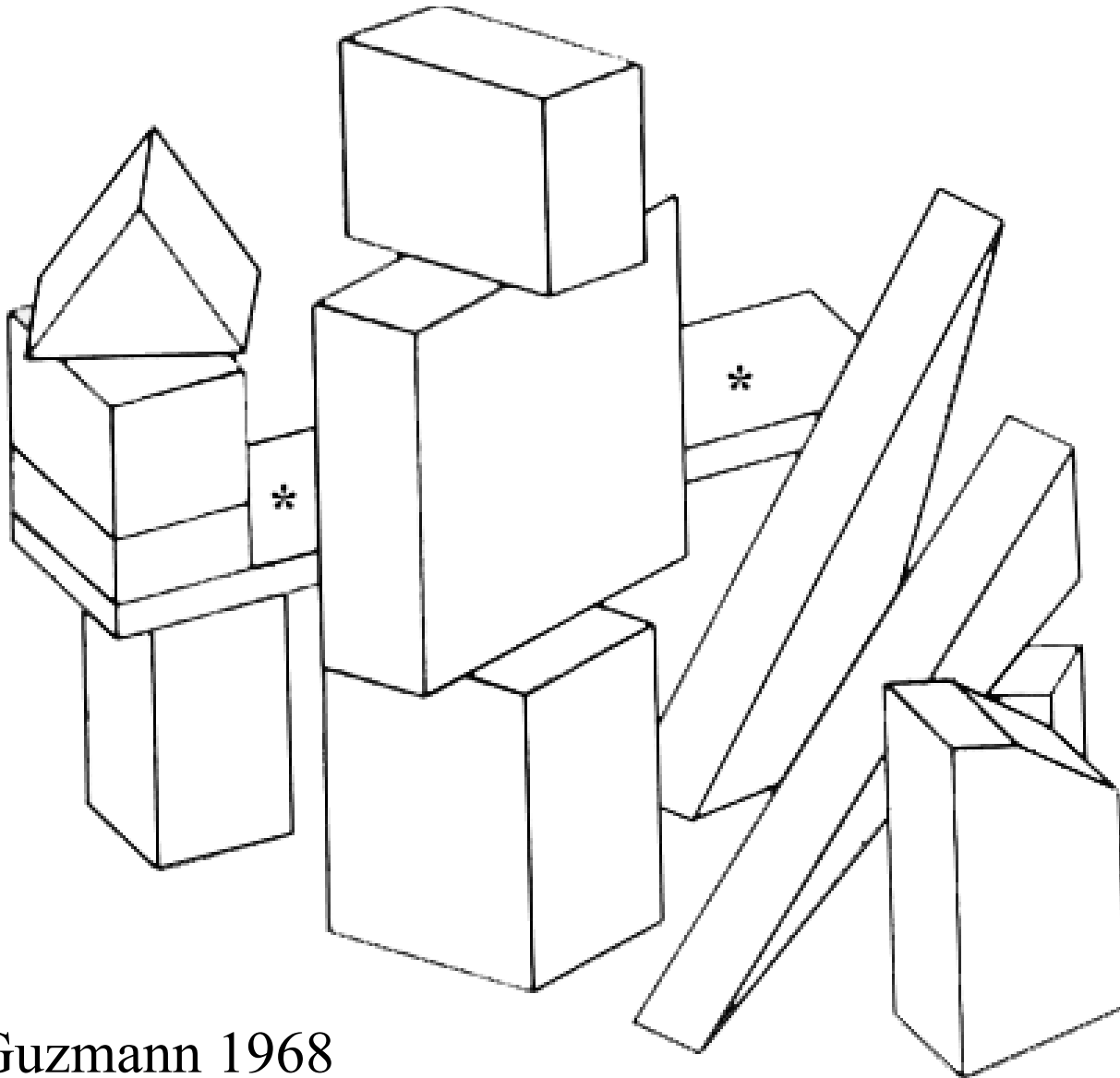
Aberdeen Rd	C7
Academy St	D9
Acorn Pk	F9
Acton St	C7
Adamian Pk	C9
Adams St	D9
Addison St	D9
Aerial St	C8
Albermarle St	D8
Alfred Rd	E9
Allen St	D9
Alpine St	C7

Longwood AveL12

MBTA map

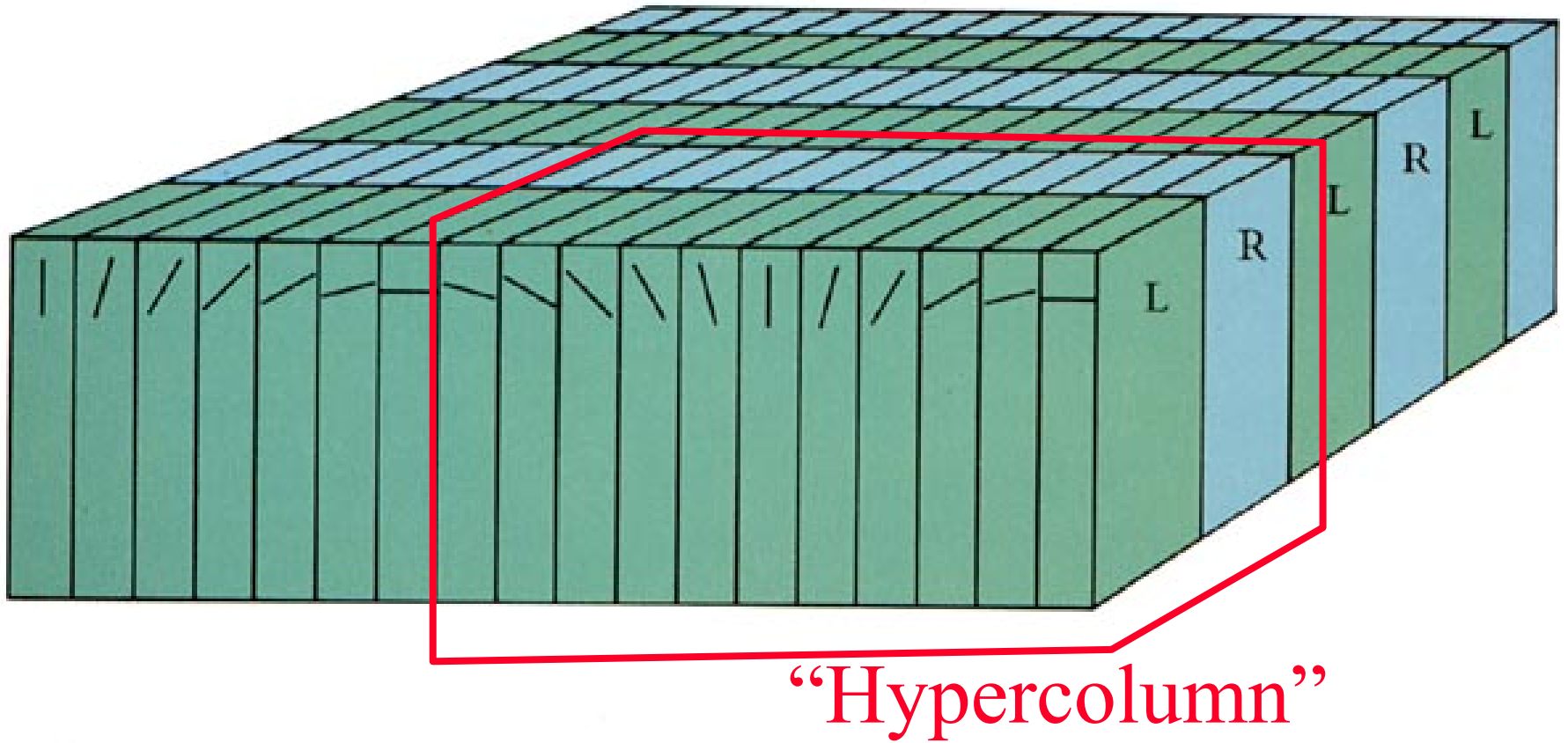


Linking Features: Orientation

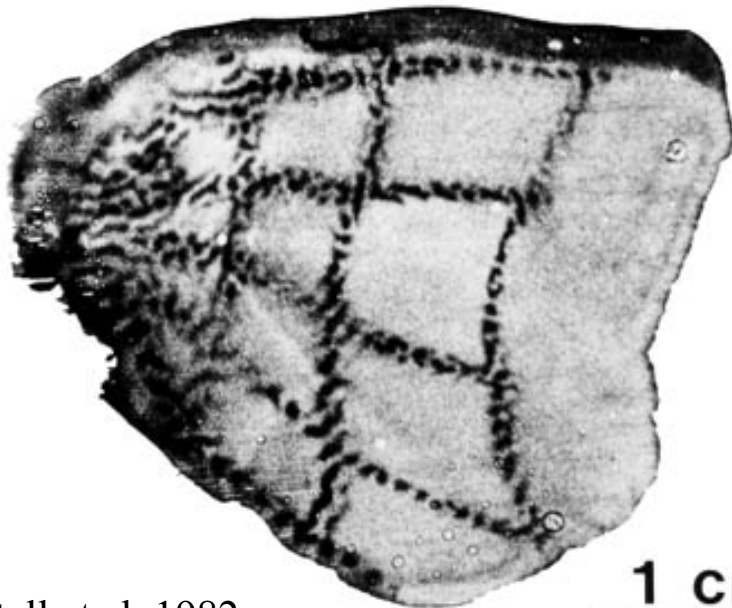
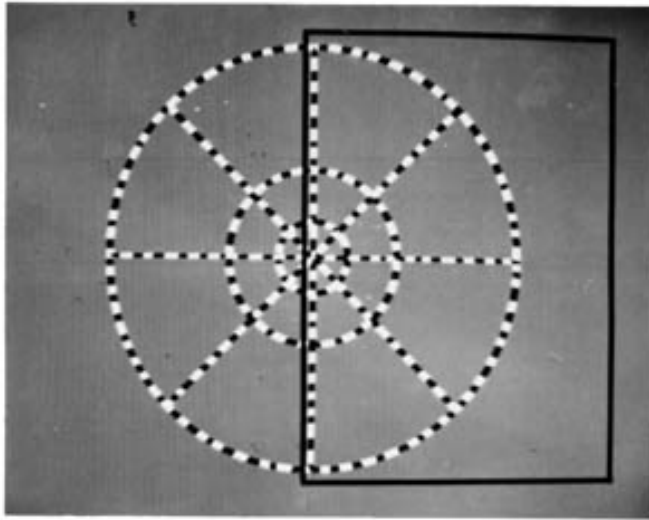


Guzmann 1968

Striate cortex contains a map of orientation.

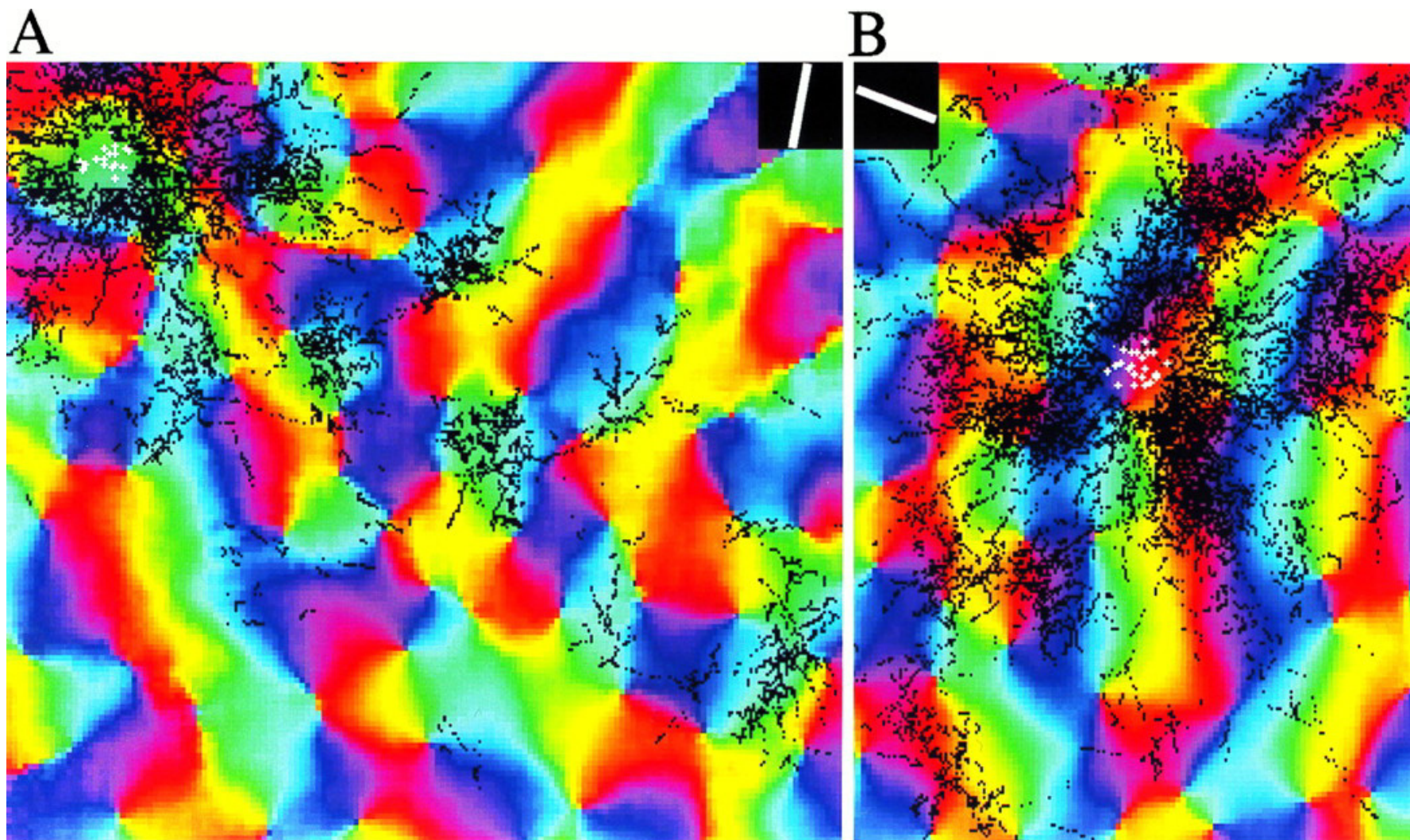


“Space”

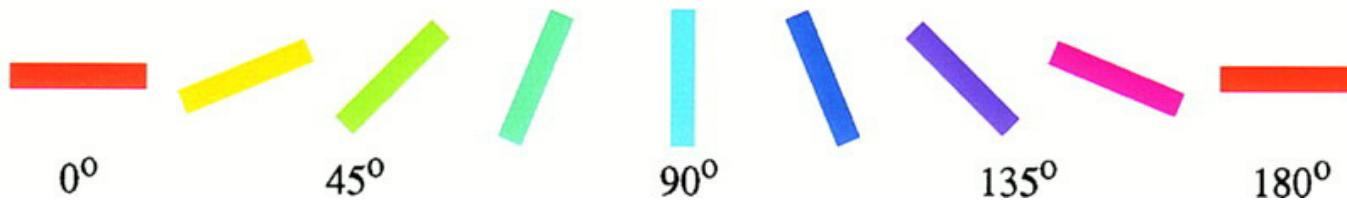


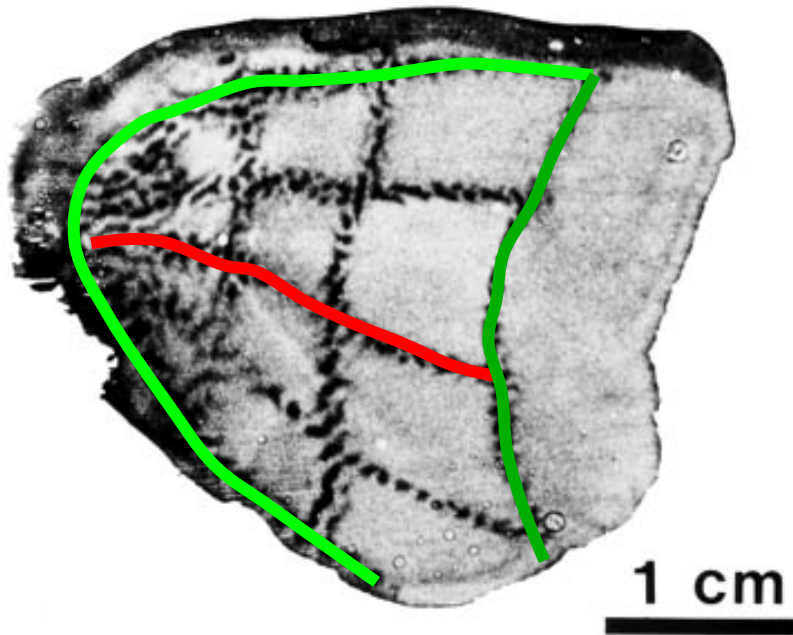
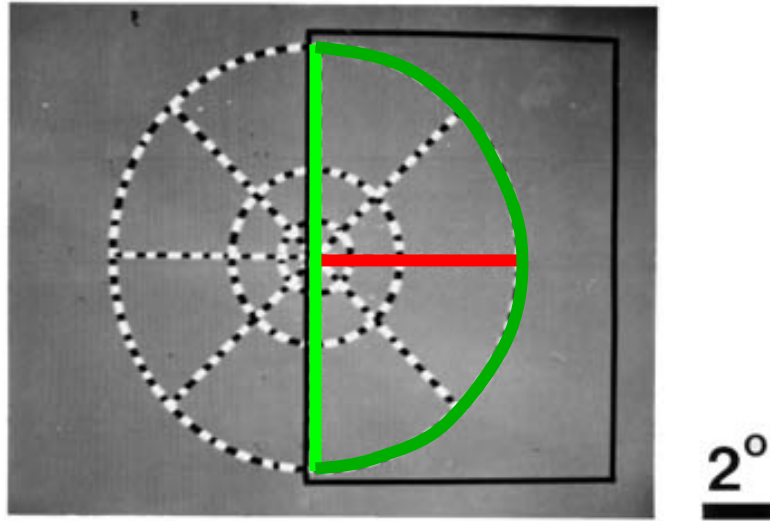
“Feature”

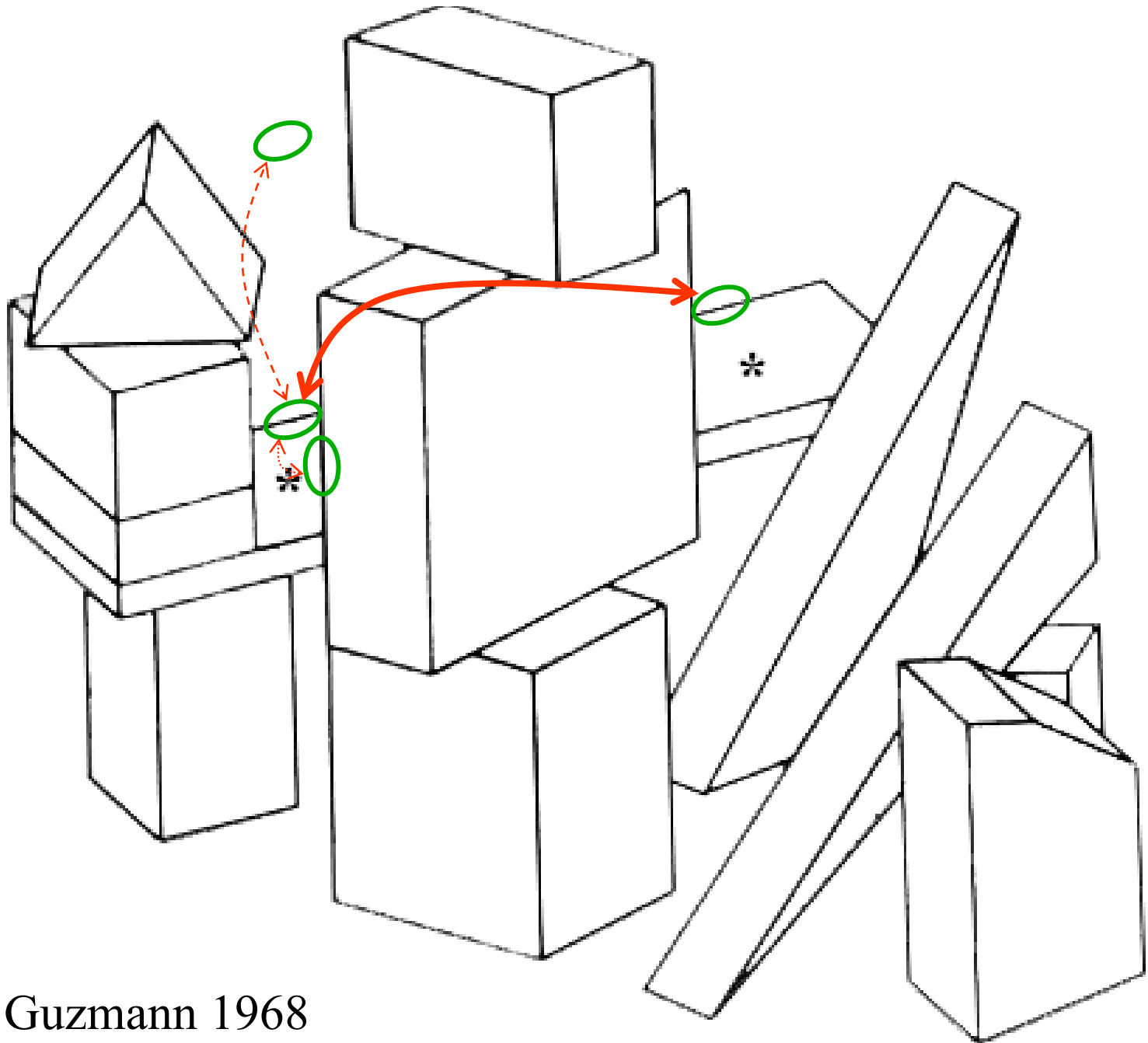




500 μm

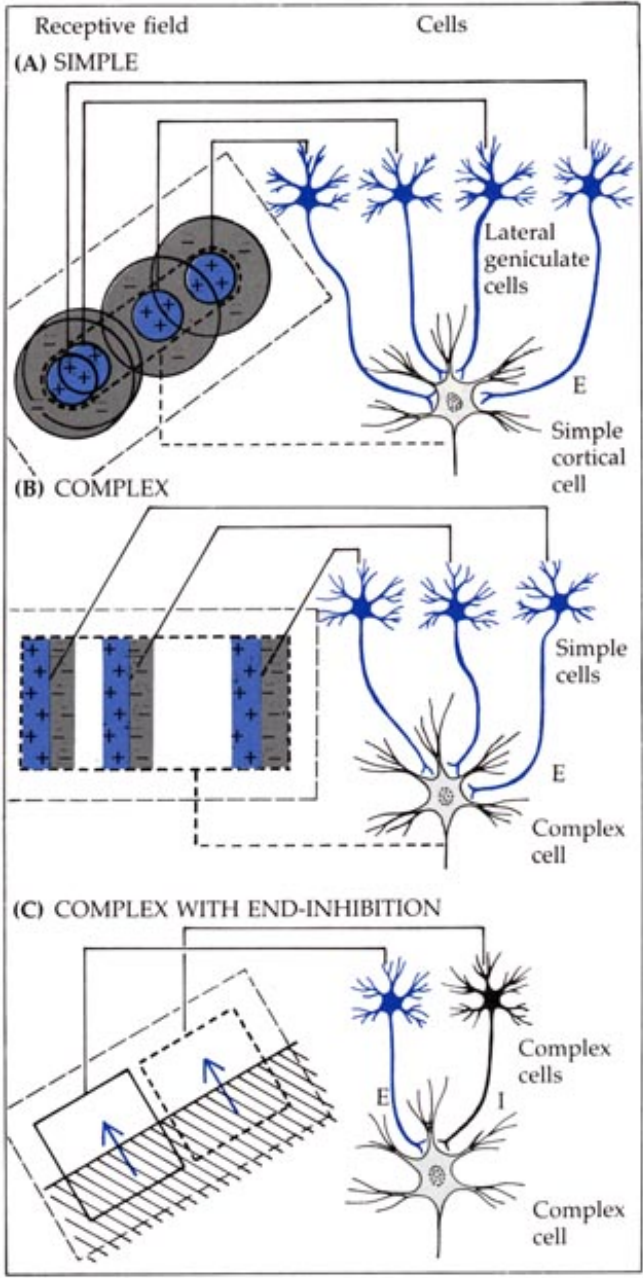






Guzmann 1968

hierarchy



gain adjustment



edge detection



invariance

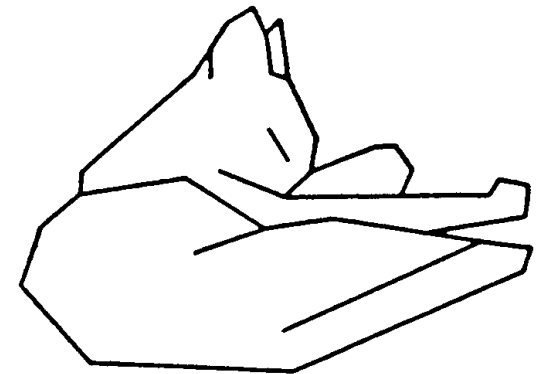
a) position
b) sign of contrast



curvature



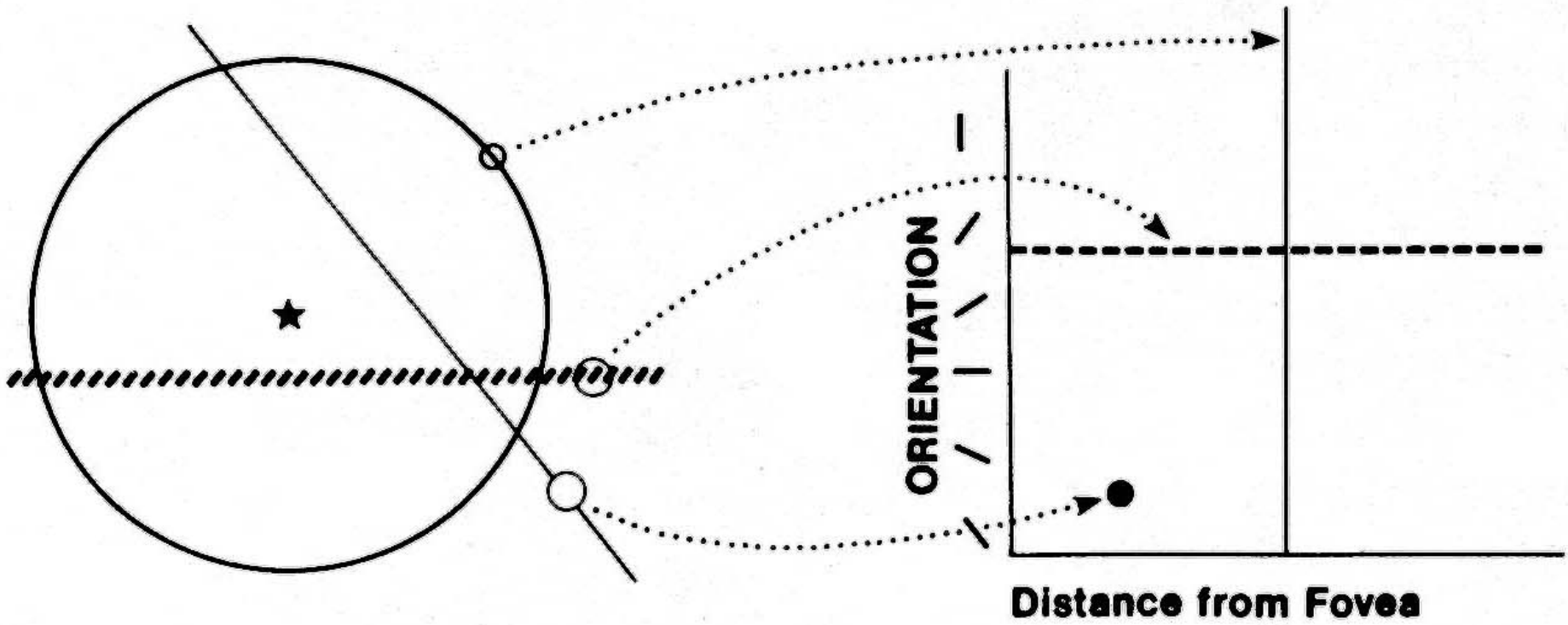
$(1024 * 768)\text{pixels} * 24 \text{ bits/pixel} = 18,874,368 \text{ bits}$



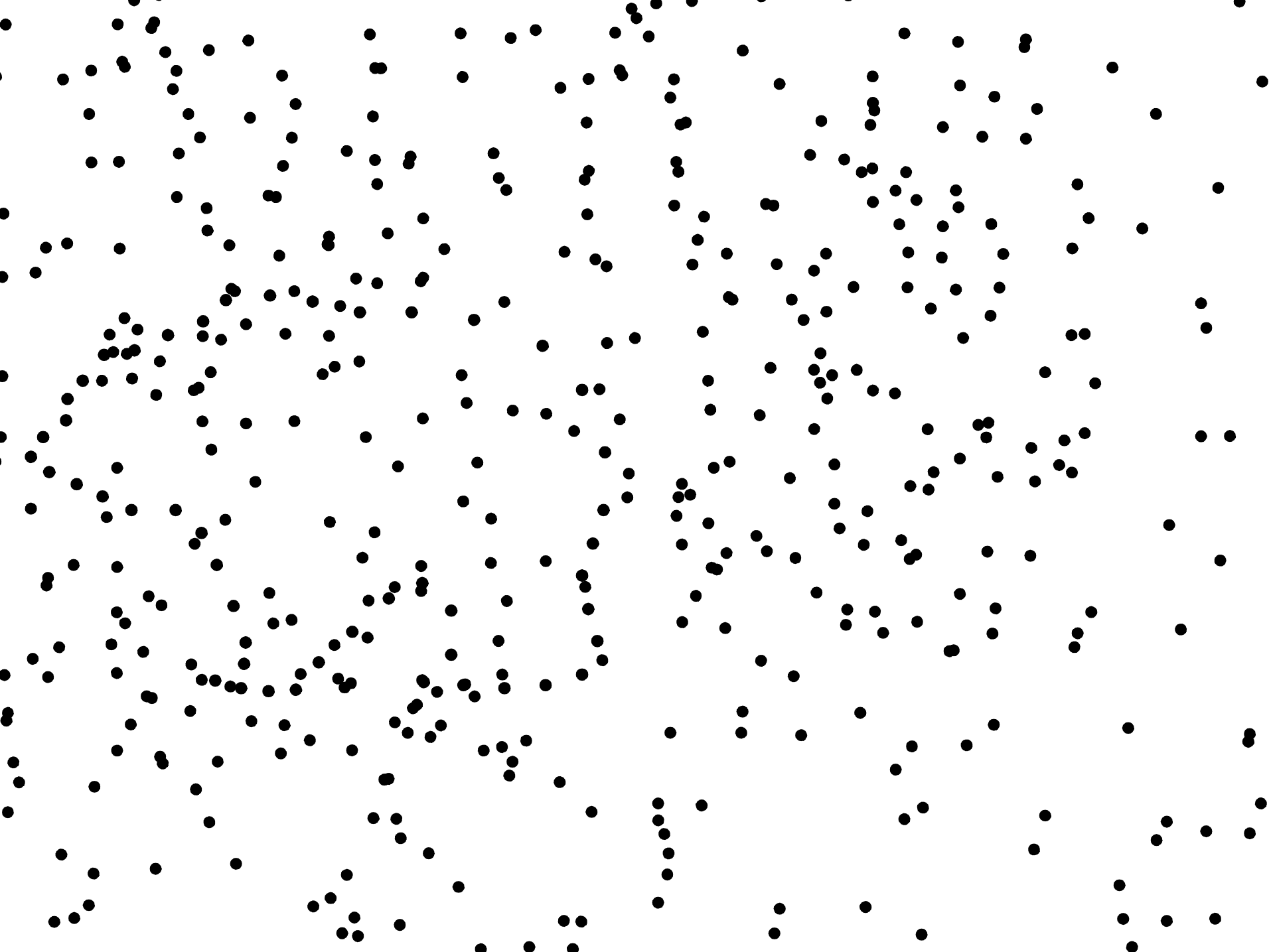
$38 \text{ points} * 2 \text{ words/point} * 16 \text{ bits/word} = 1,216 \text{ bits}$
 compression ratio = 15,522

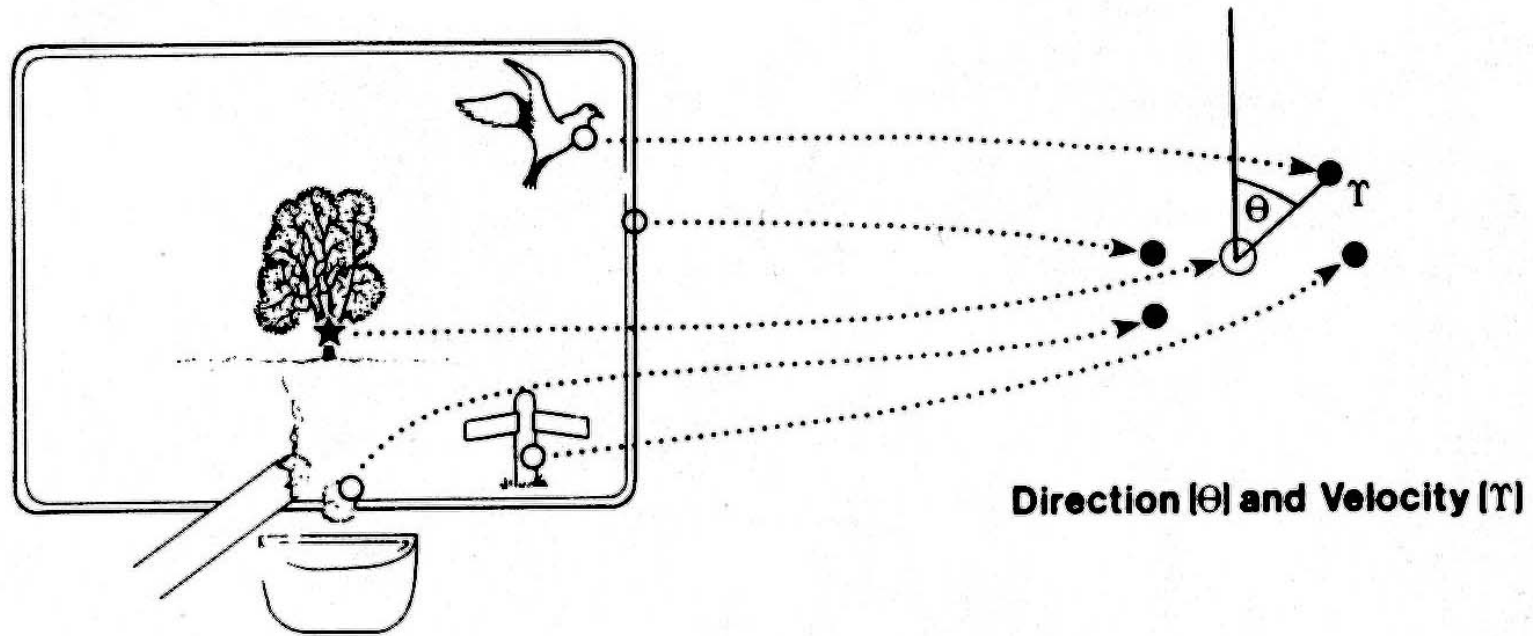
VISUAL FIELD

NON-TOPOGRAPHIC MAPS



ORIENTATION

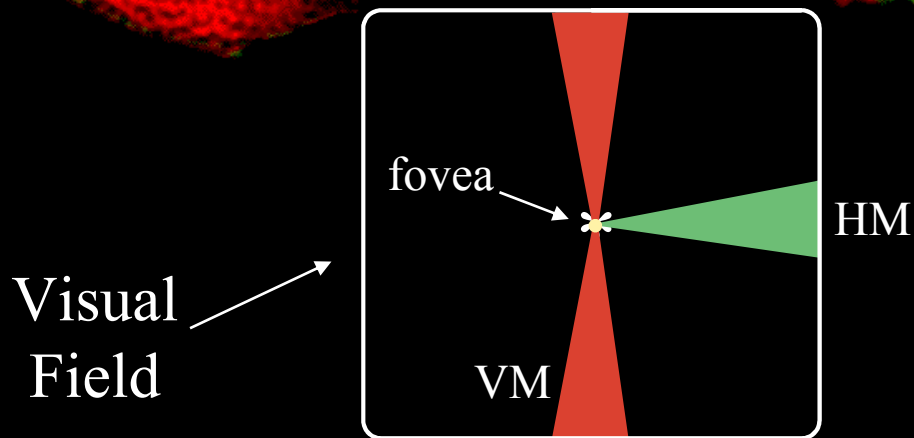
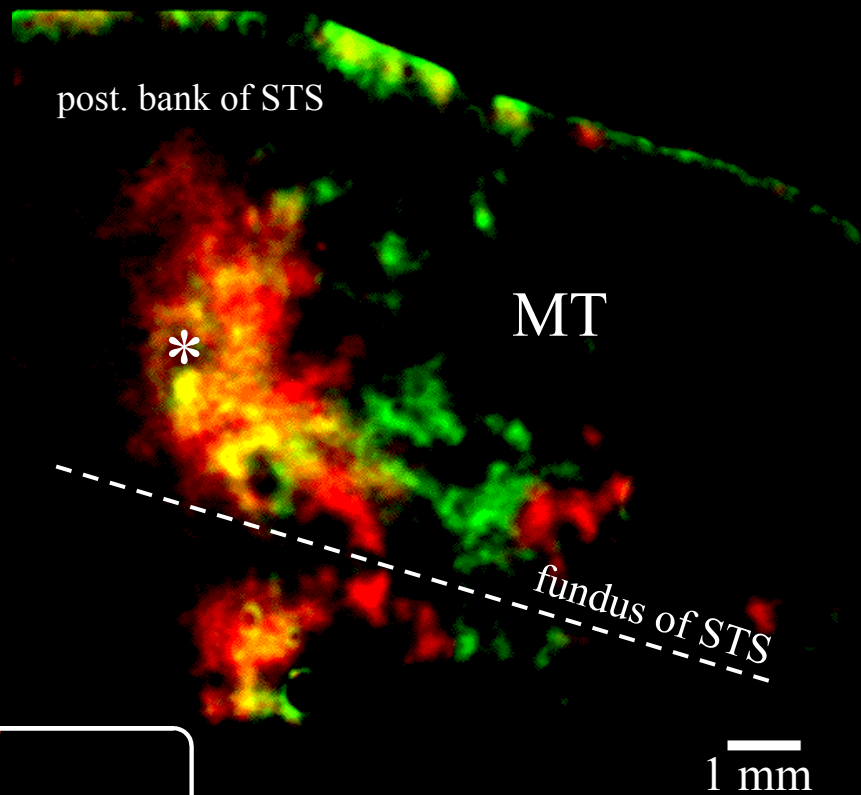
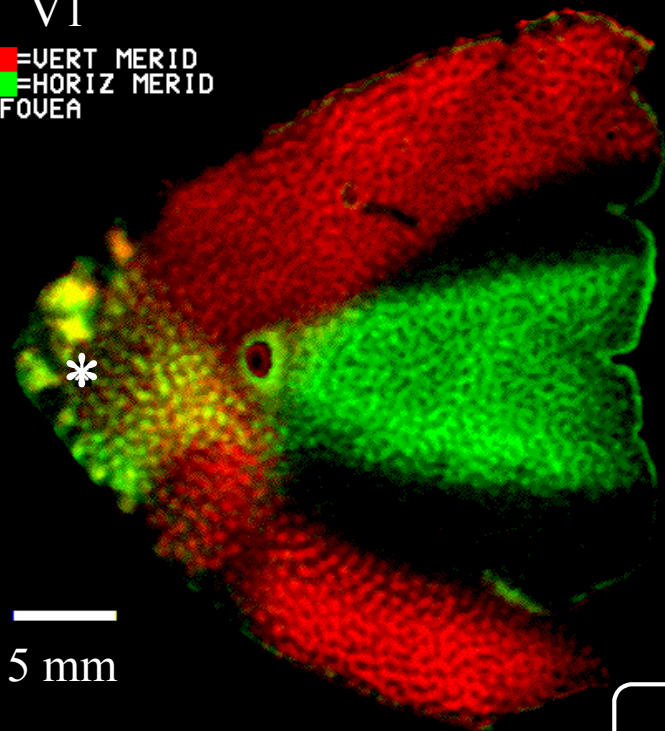




MOTION

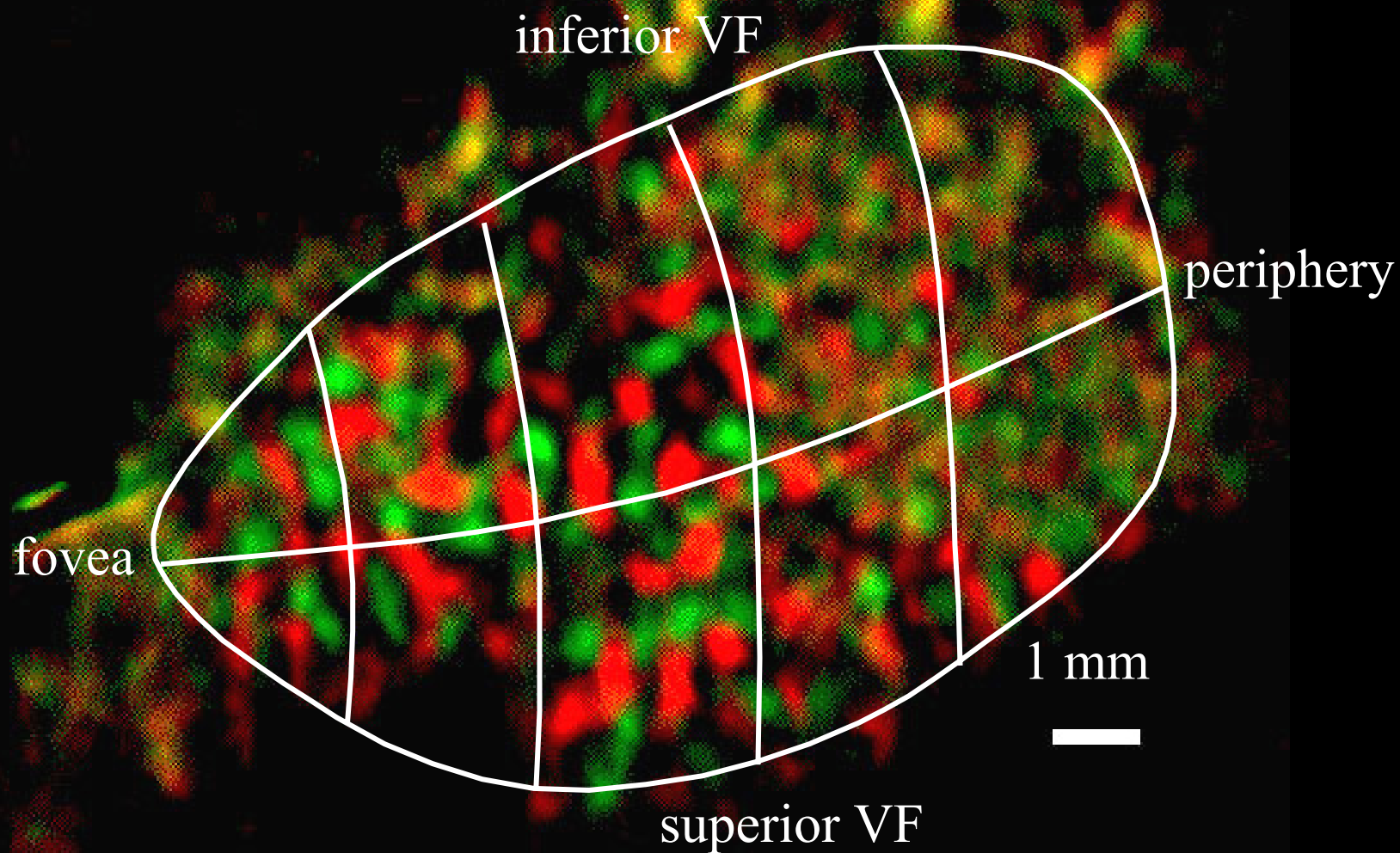
Direction θ and Velocity r

V1
= VERT MERID
= HORIZ MERID
*= FOVEA



● **Up**
● **Down**

d
└─ m



1 mm
—