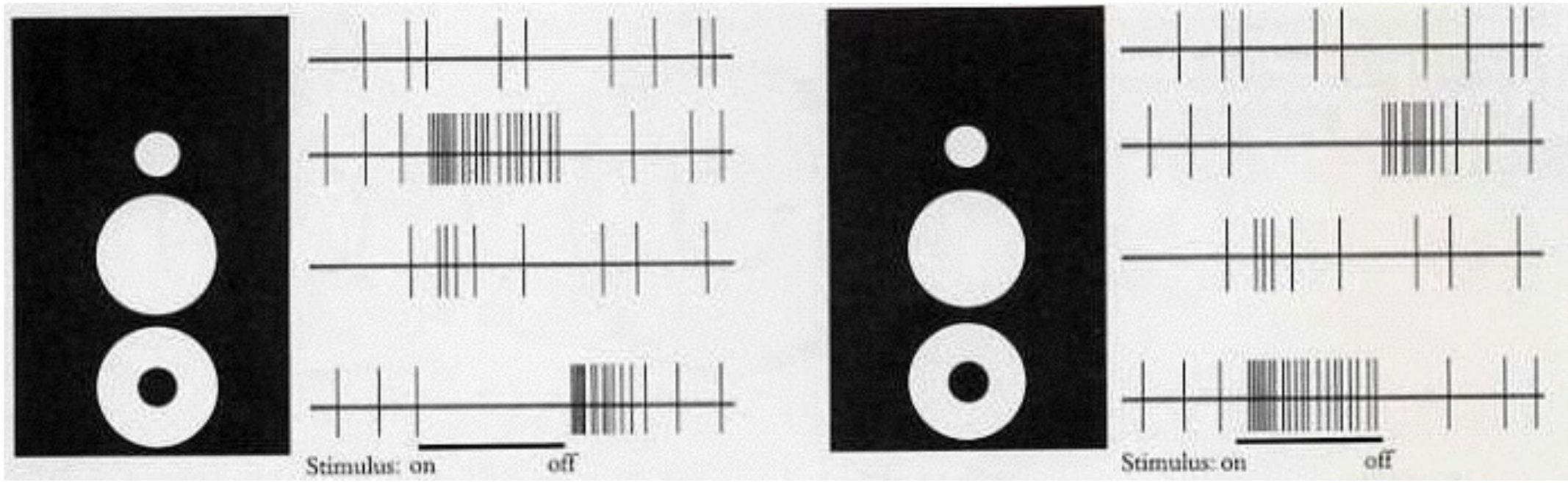
Foundations

- Fundamentals of primate vision cont’d

RF organization in LGN



RF organization in LGN

Summation at the soma

$$y = f\left(\sum w_i x_i\right)$$

Synaptic efficacies

Afferent activity from neuron i

source: webvision

photoreceptors

Retinal output (ganglion cells)

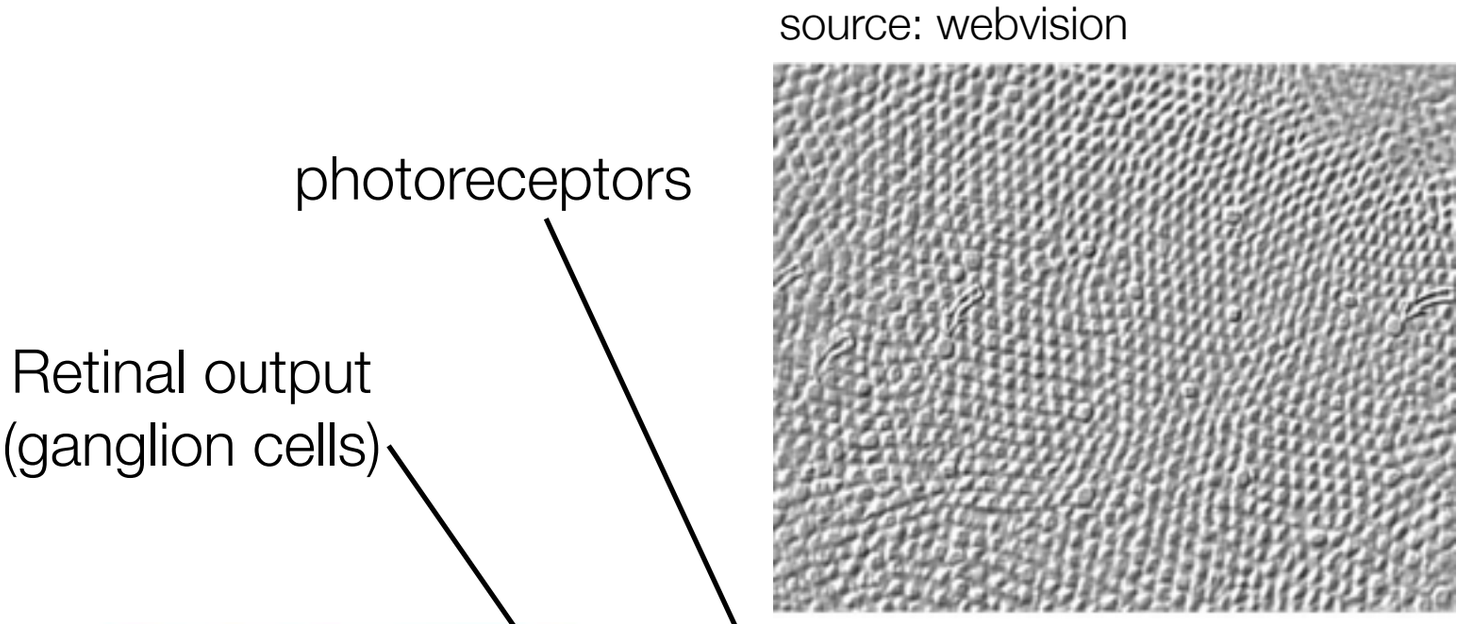
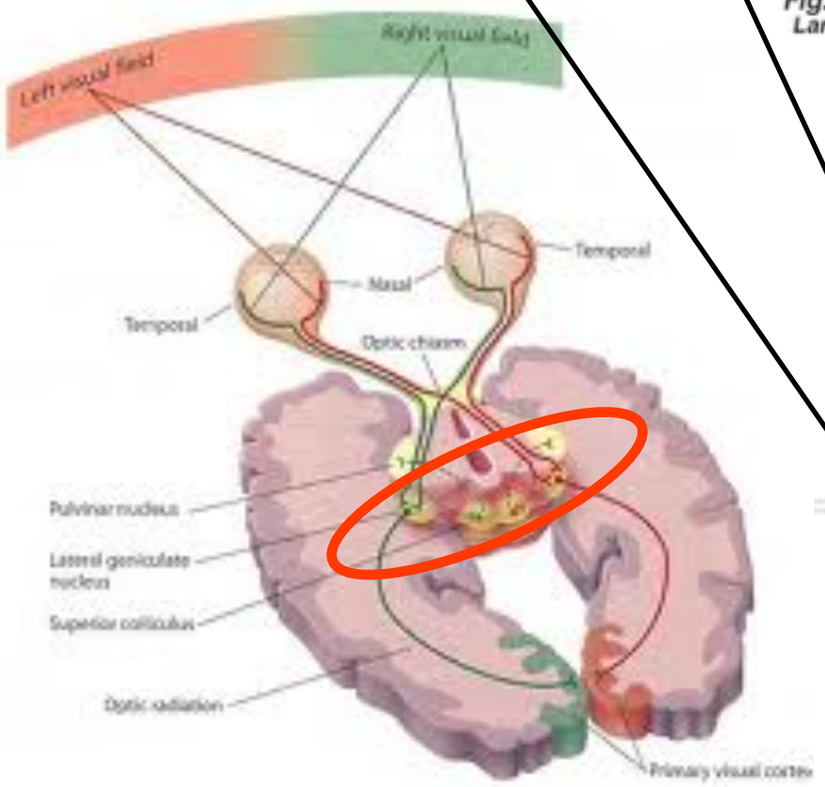
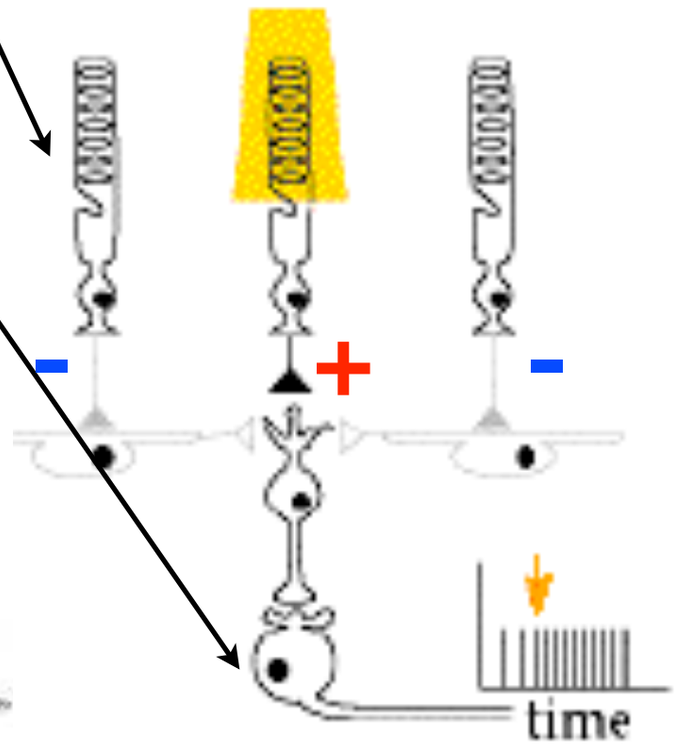
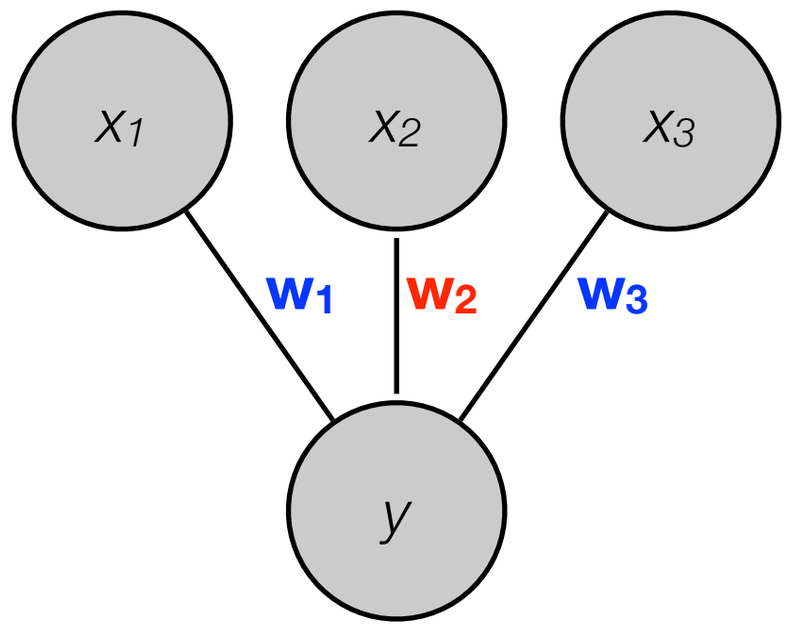


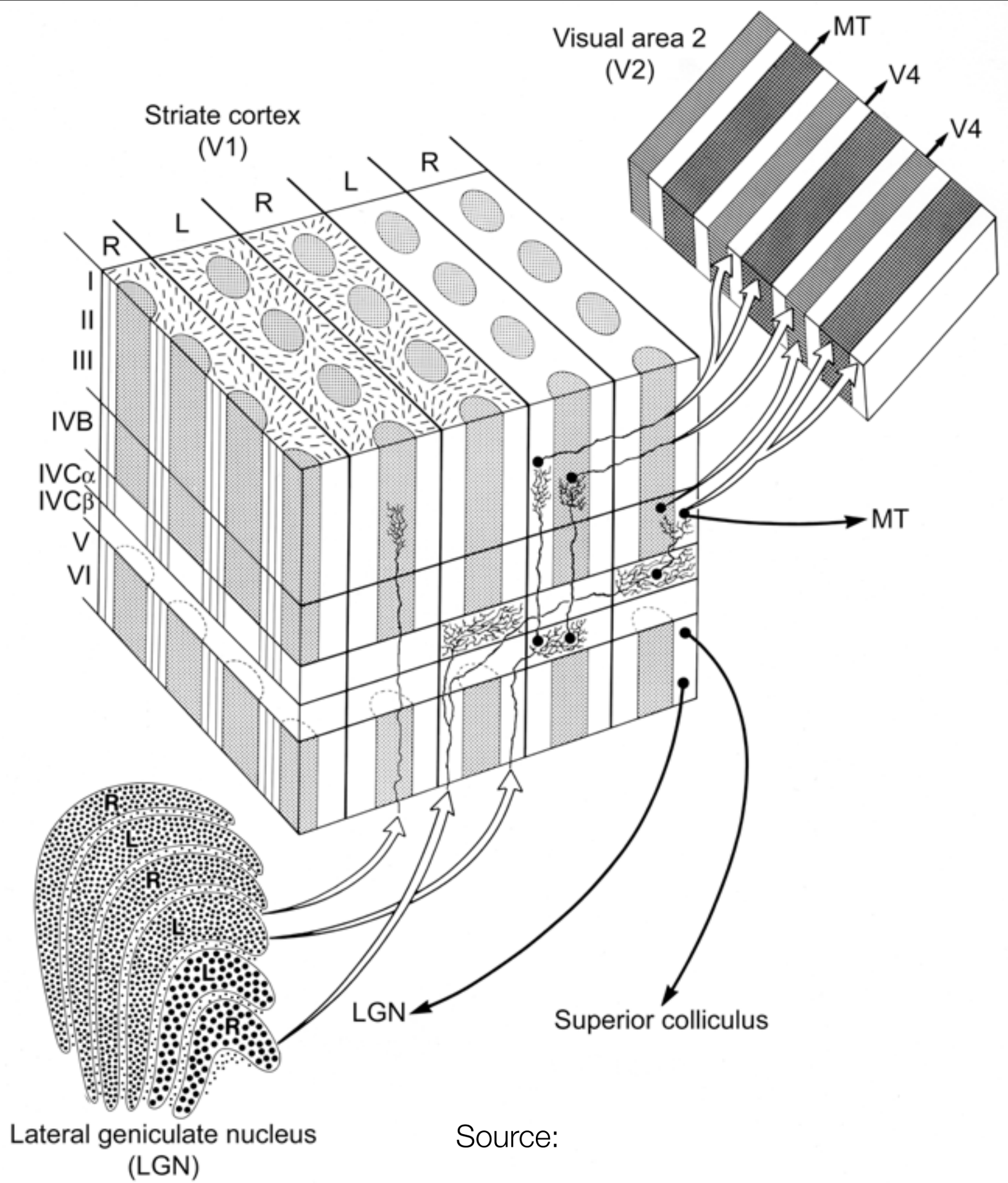
Fig. 13. Tangential section through the human fovea. Larger cones (arrows) are blue cones. From Ahnelt et al. 1987.







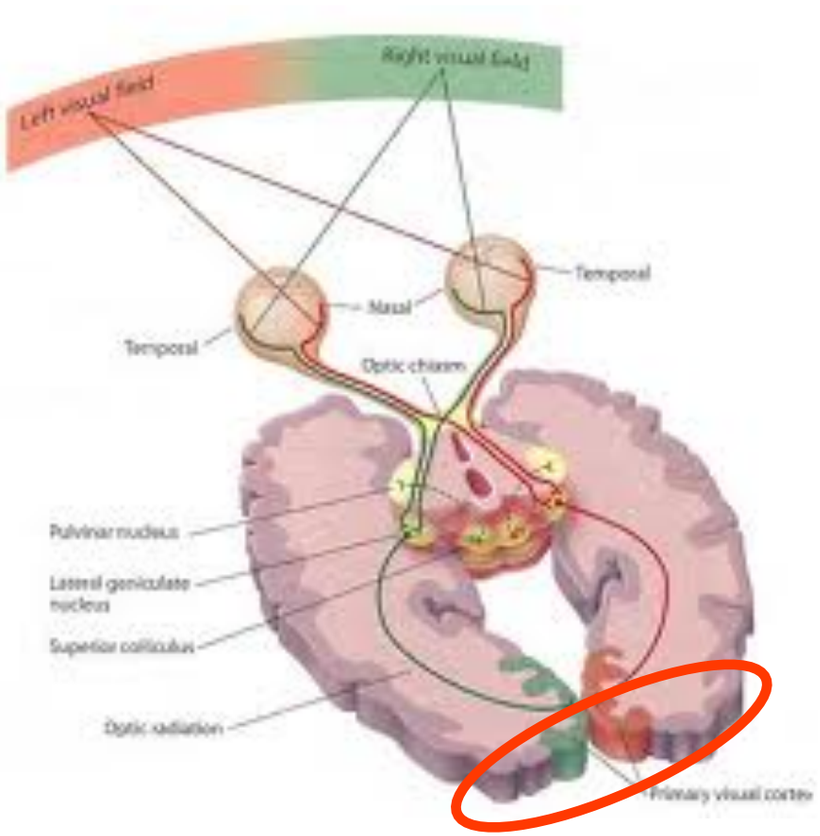
Modified from http://thalamus.wustl.edu/course/eyeret.html


Visual area 2
(V2)
MT
V4
V4
Striate cortex
(V1)
R
L
R
L
R
I
II
III
IVB
IVCα
IVCβ
V
VI
MT
R
L
R
L
L
R
LGN
Superior colliculus
Lateral geniculate nucleus
(LGN)

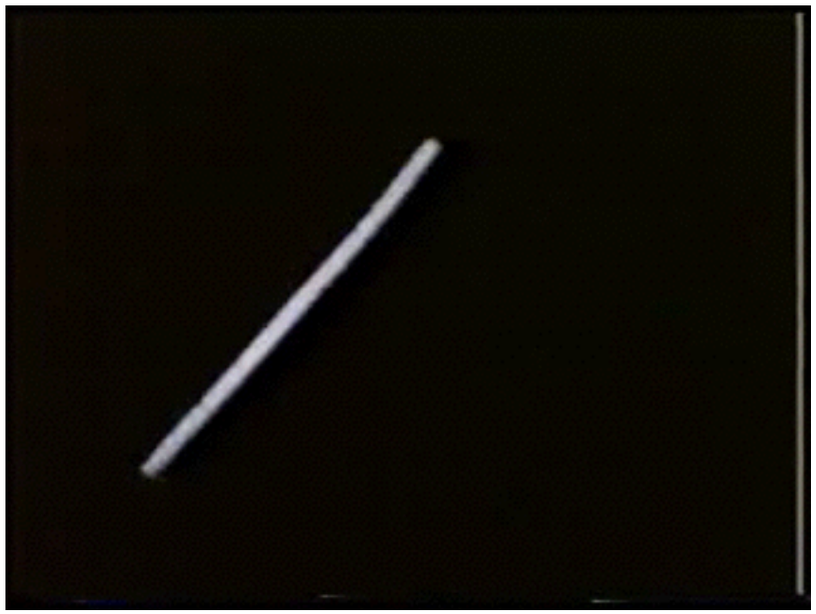
Source:

RF organization in V1

Hubel & Wiesel

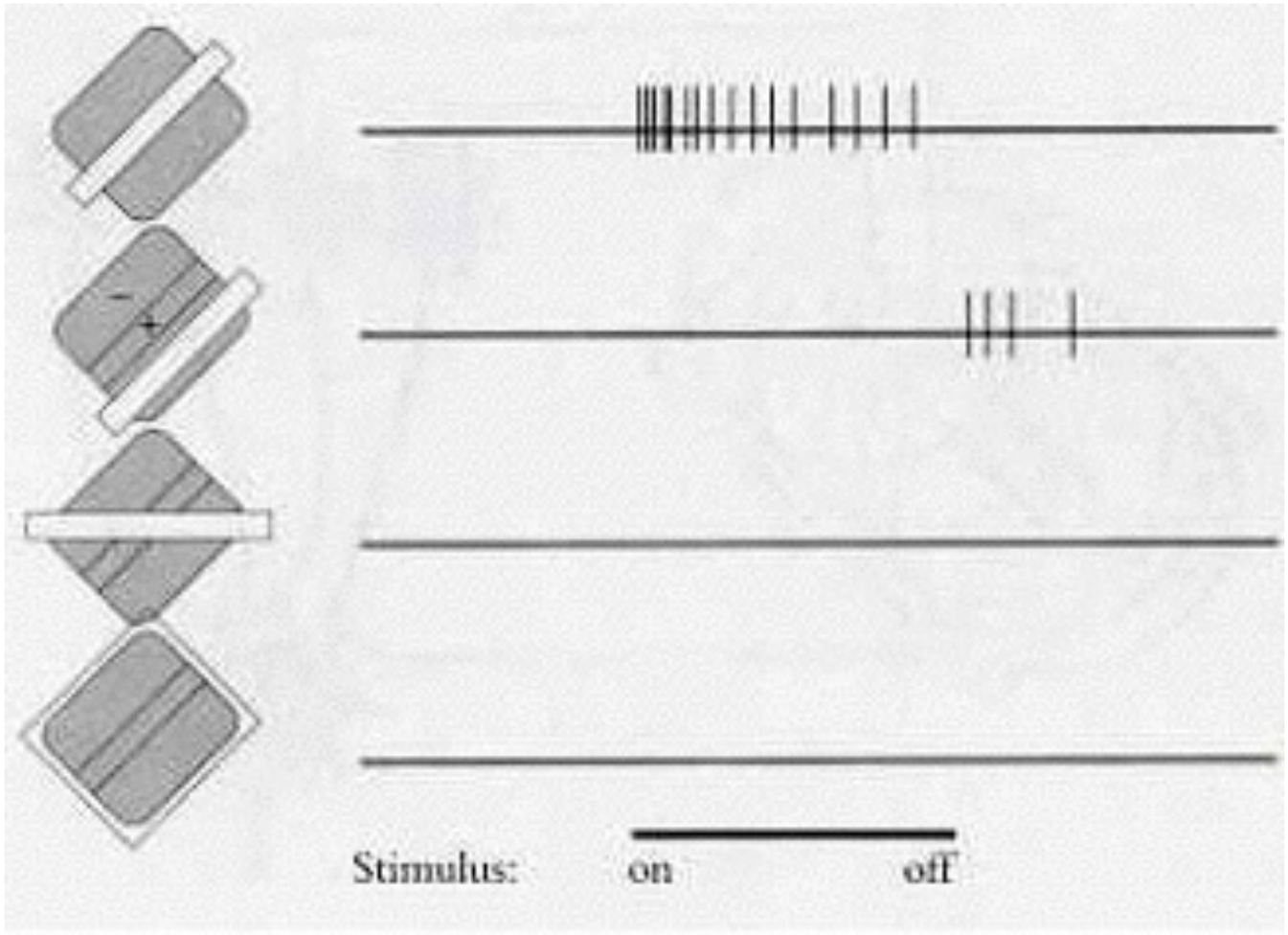


Simple cell



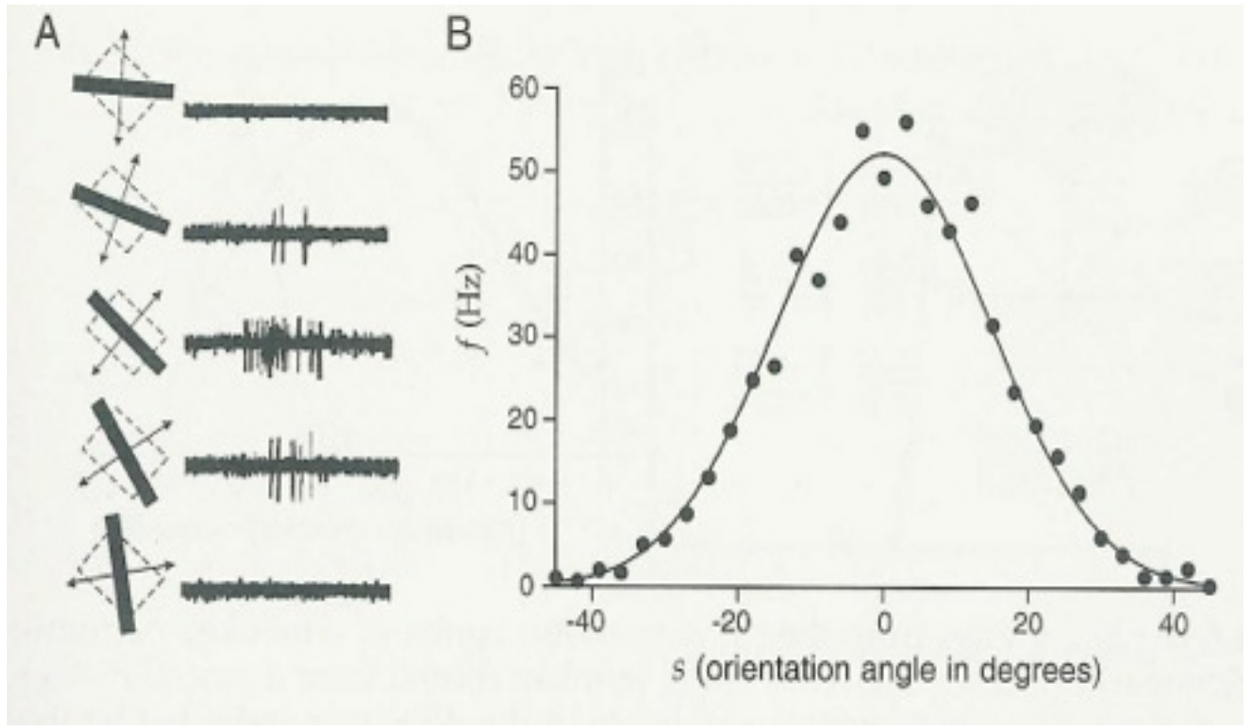
Hubel & Wiesel ’59 ’62 ’68

RF organization in V1



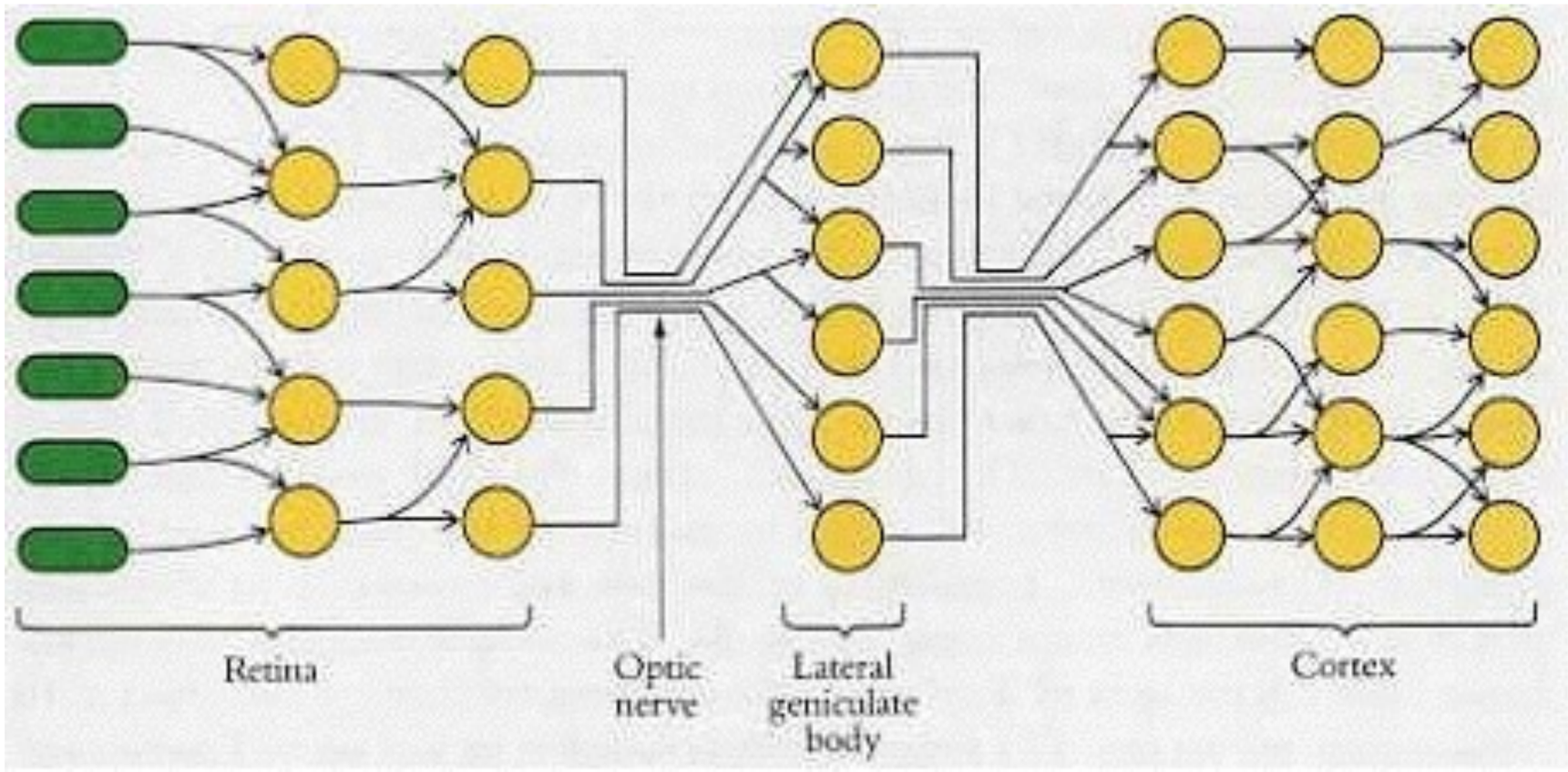
Hubel & Wiesel ’59 ’62 ’68

Orientation tuning in the visual cortex

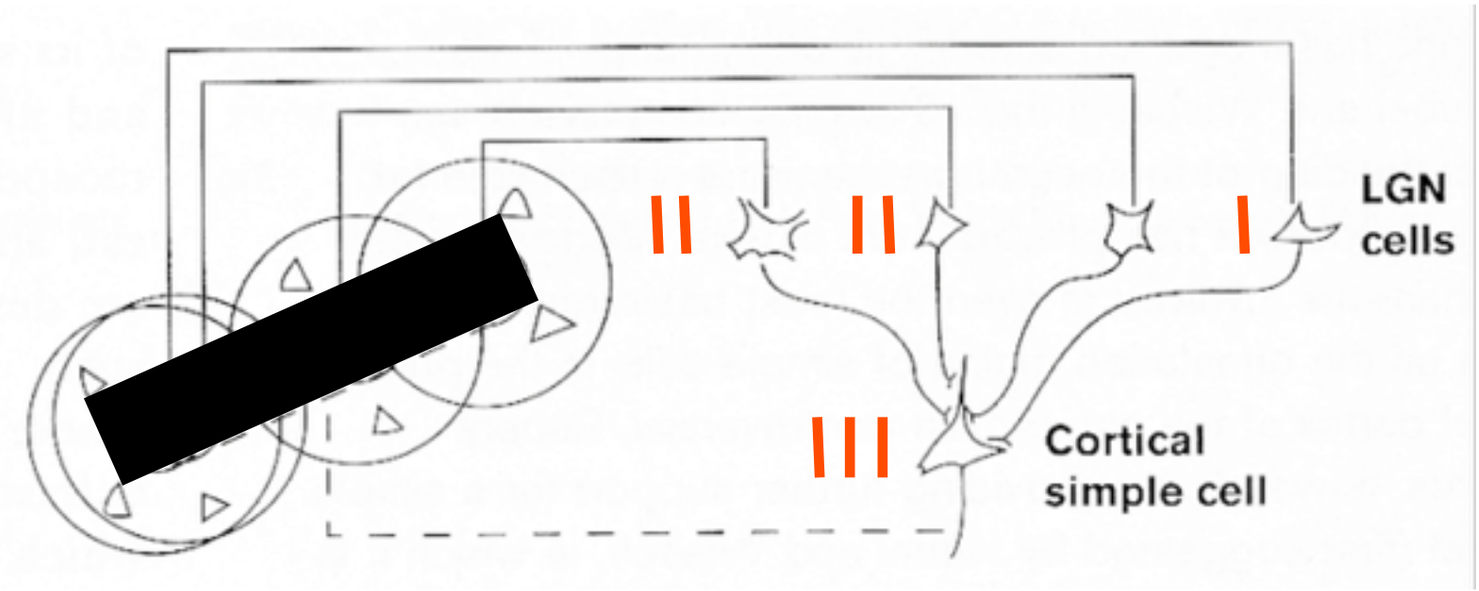


Dayan & Abbott, 2001

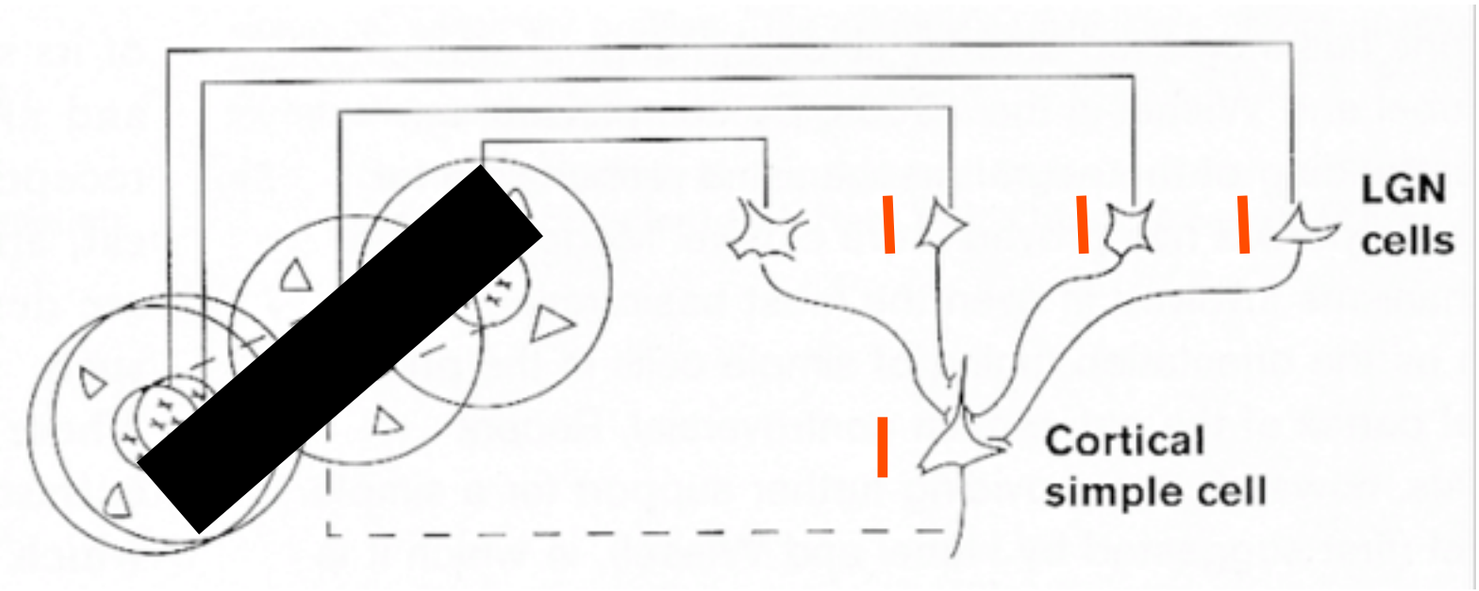
H&W hierarchical model of striate cortex



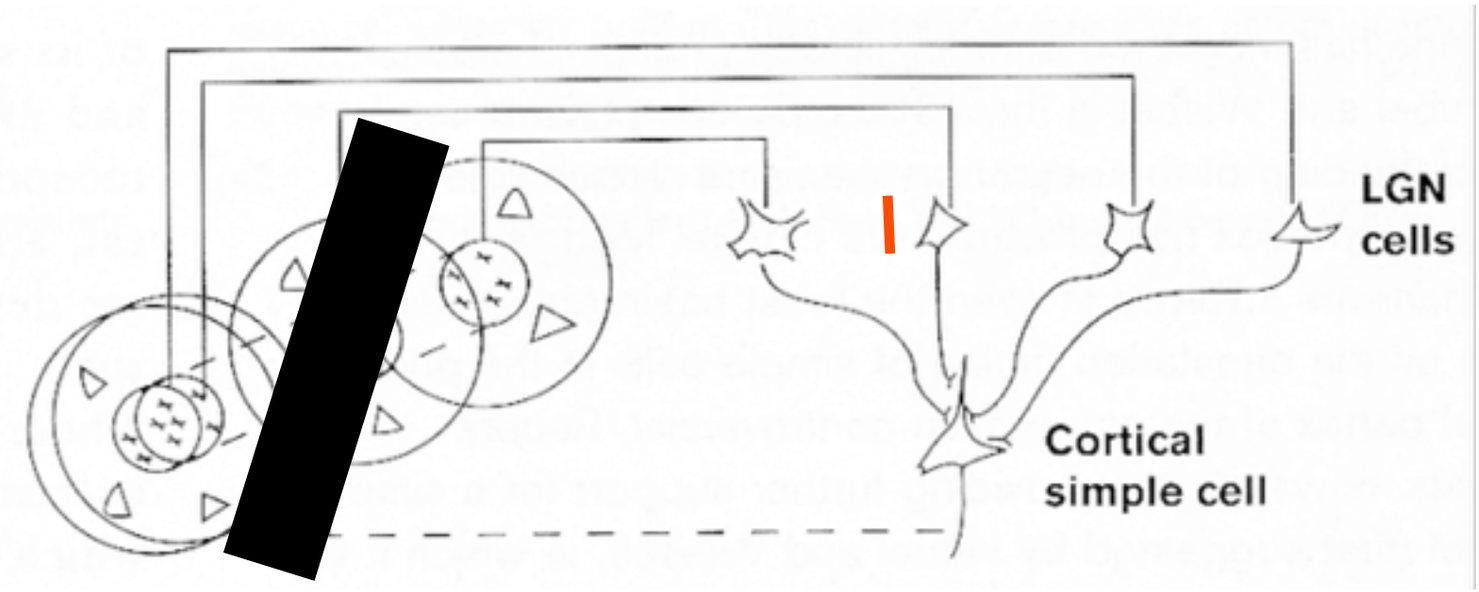
H&W hierarchical model of striate cortex



H&W hierarchical model of striate cortex

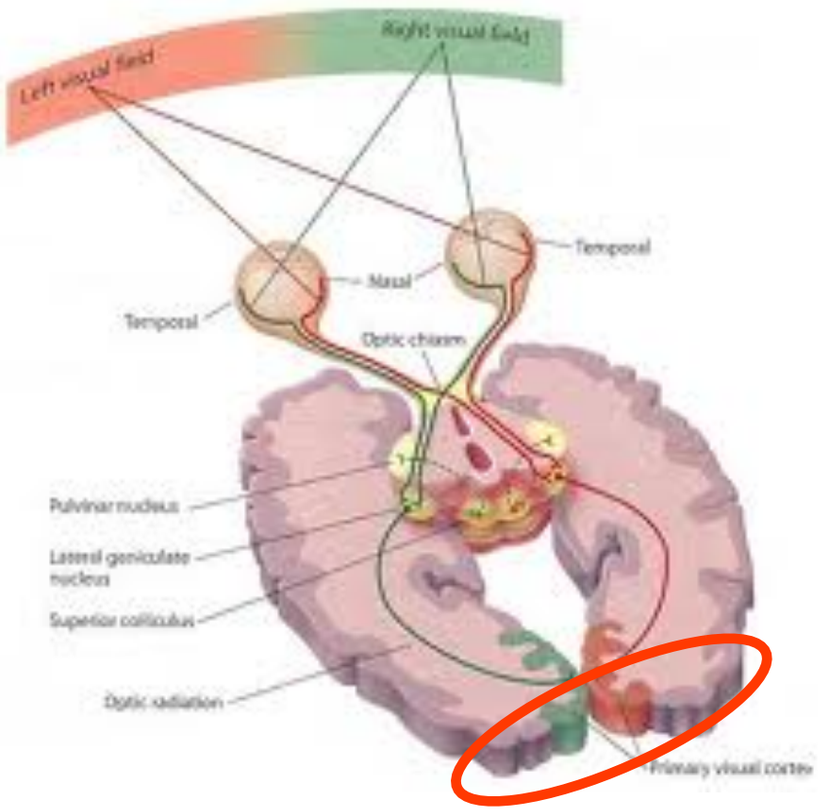


H&W hierarchical model of striate cortex



RF organization in V1

Hubel & Wiesel

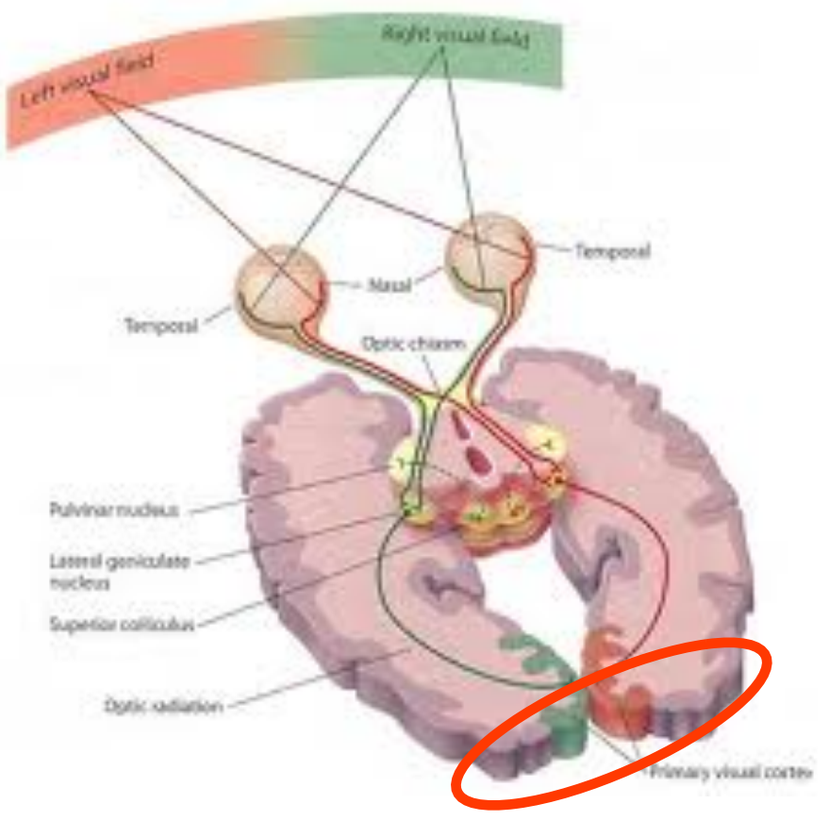


Complex cell

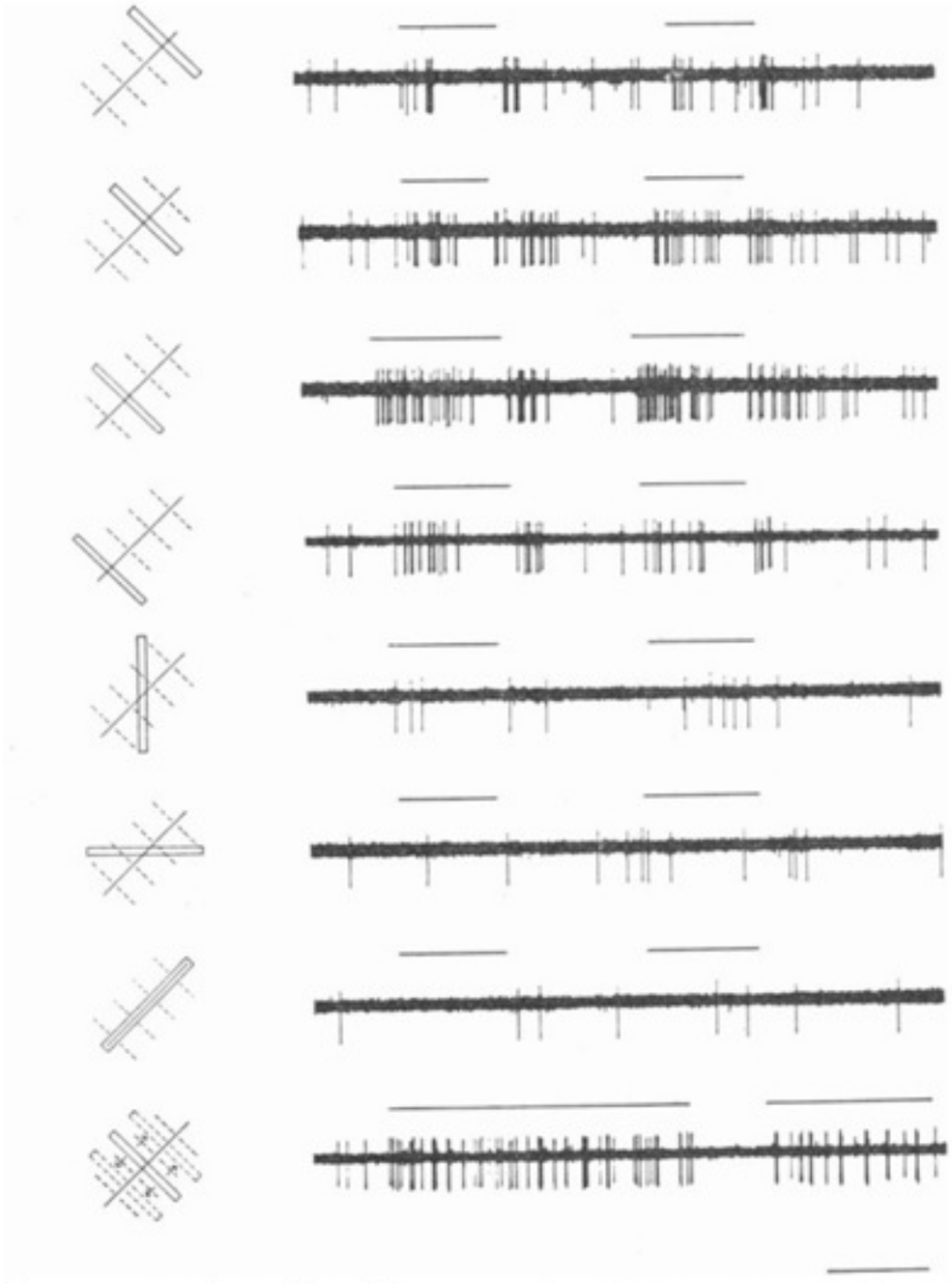
Hubel & Wiesel ’59 ’62 ’68

RF organization in V1

Hubel & Wiesel

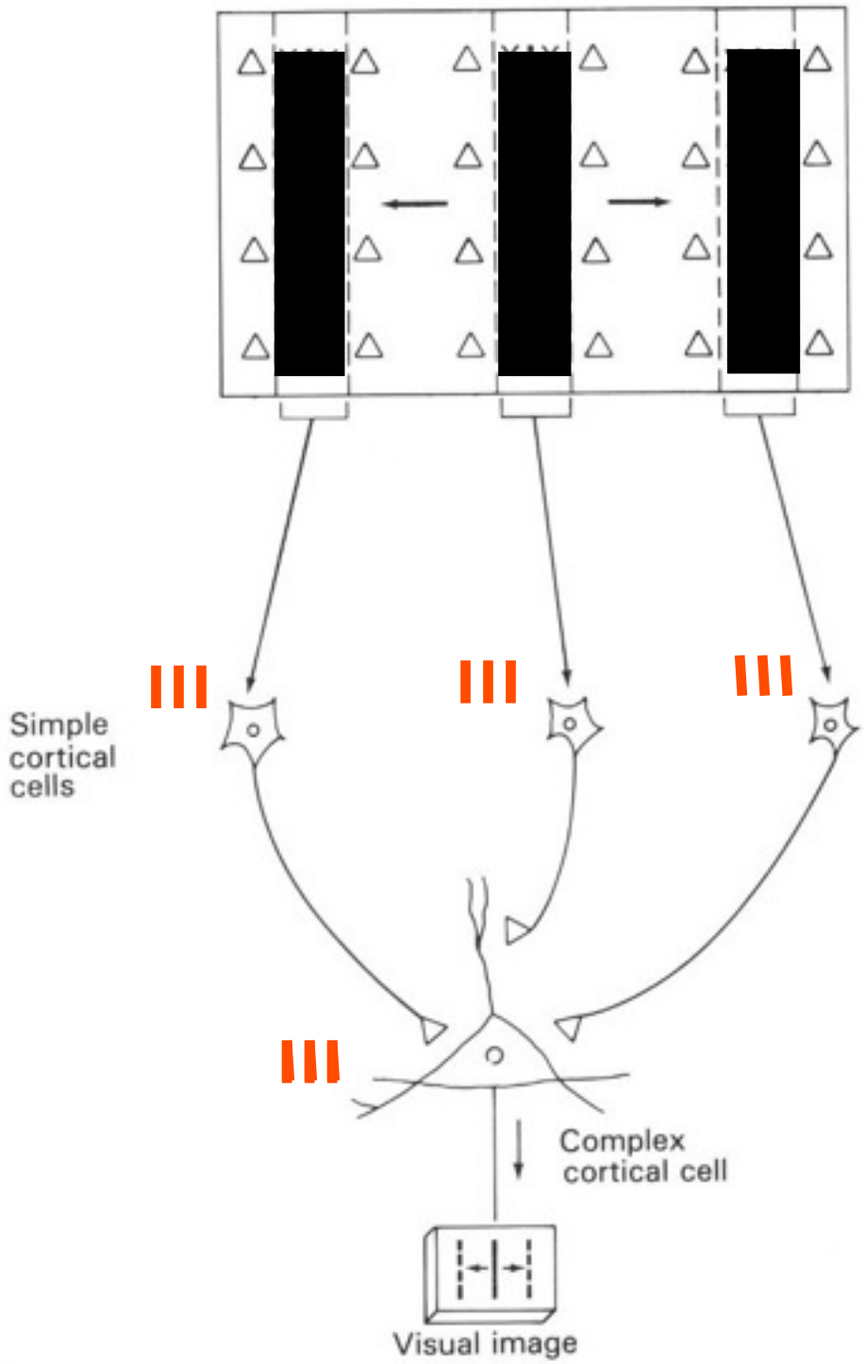


Complex cell



Hubel & Wiesel ’59 ’62 ’68

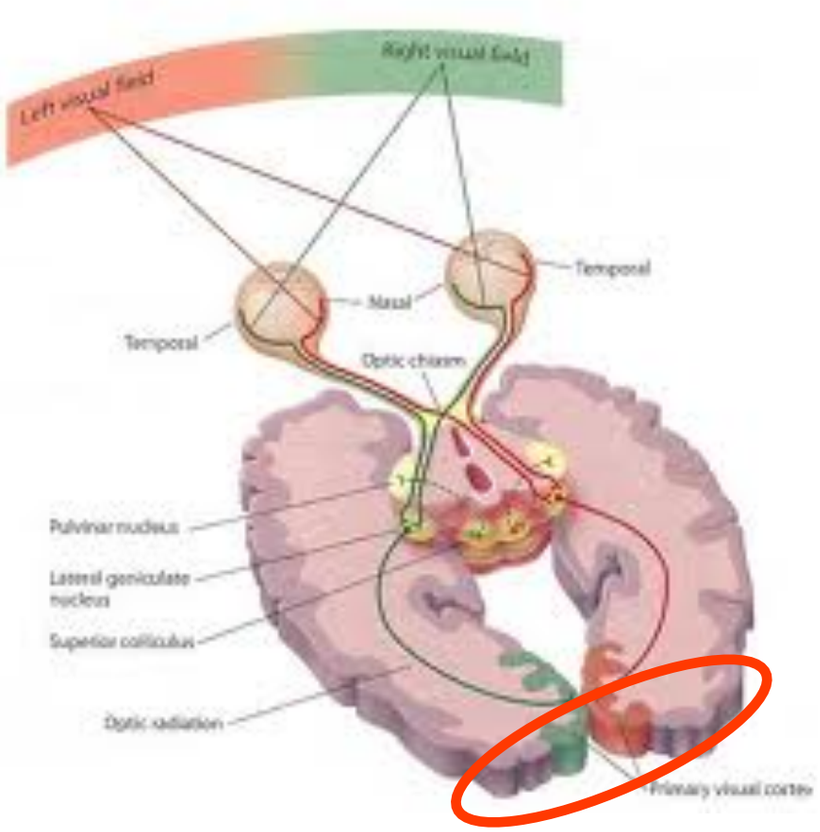
H&W hierarchical model of striate cortex

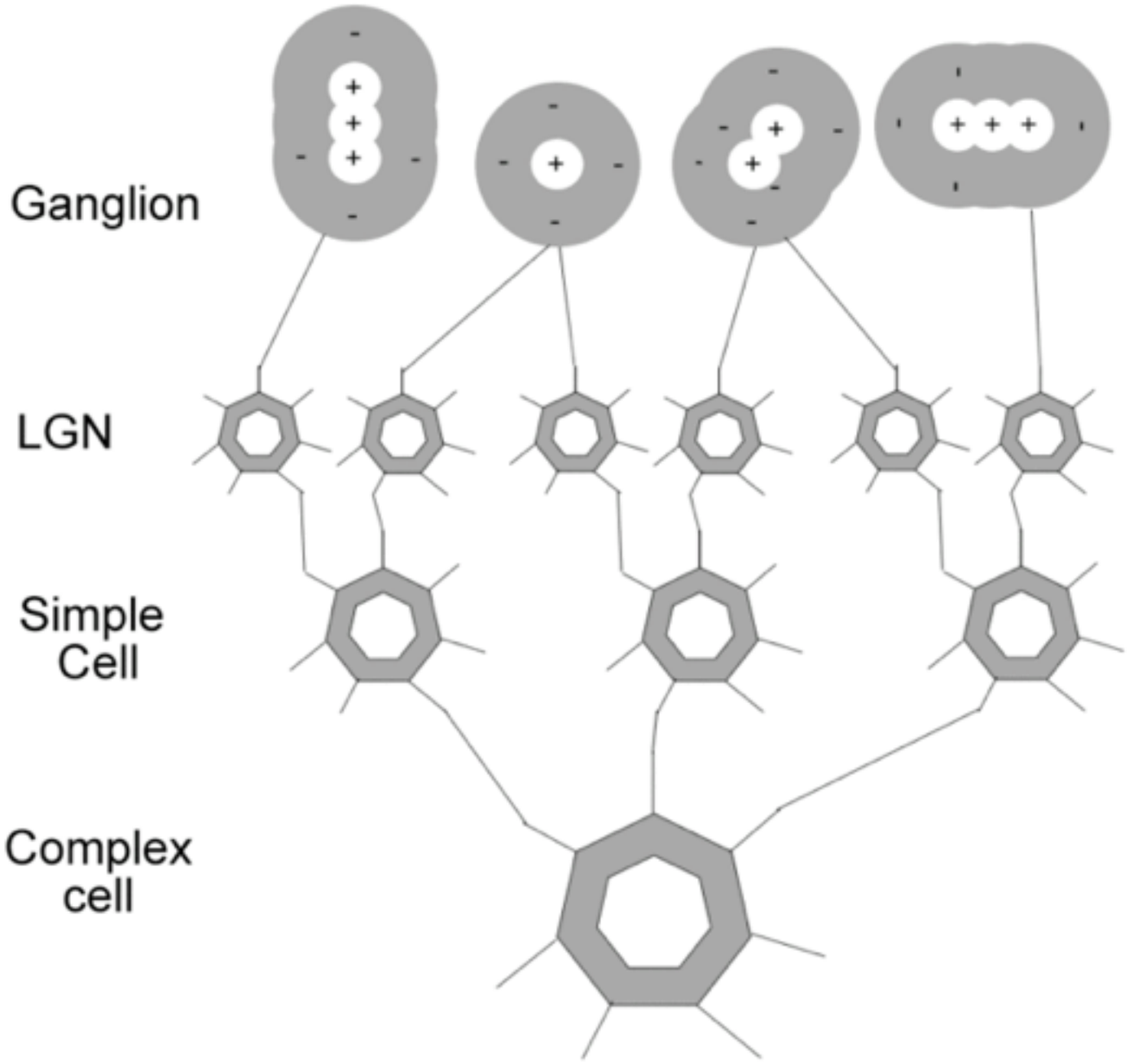


Hubel & Wiesel

RF organization in V1

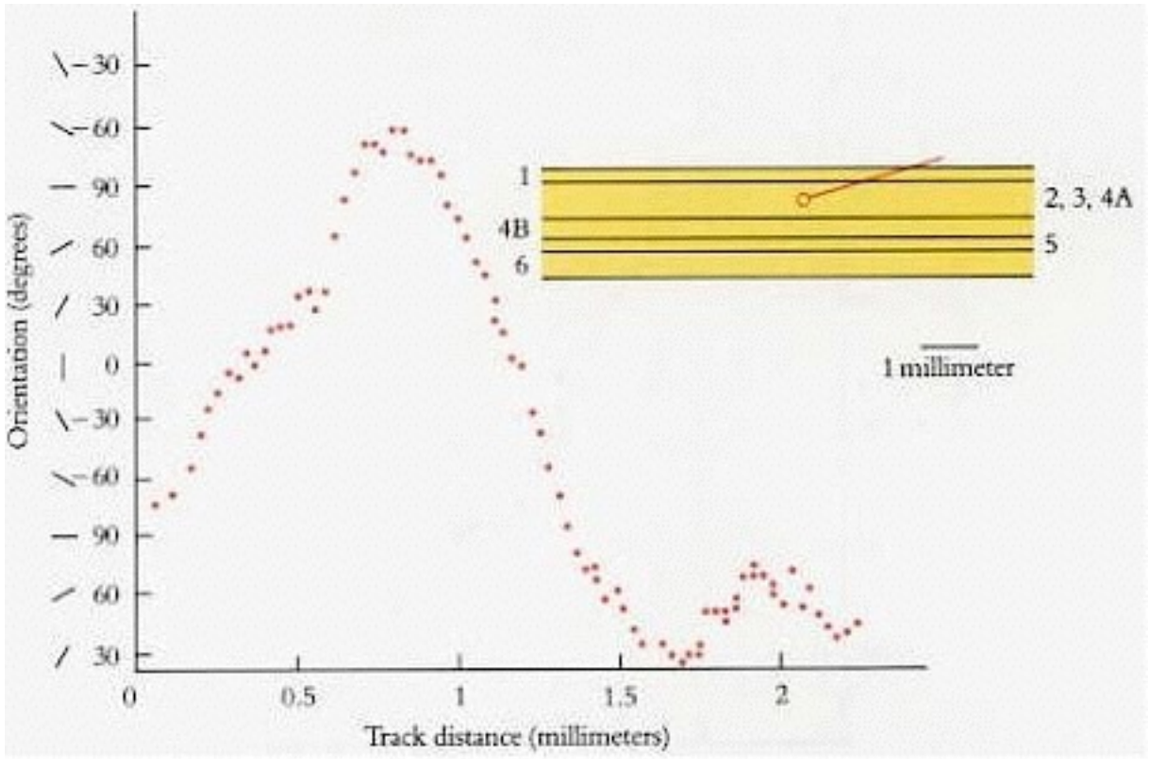
Hubel & Wiesel

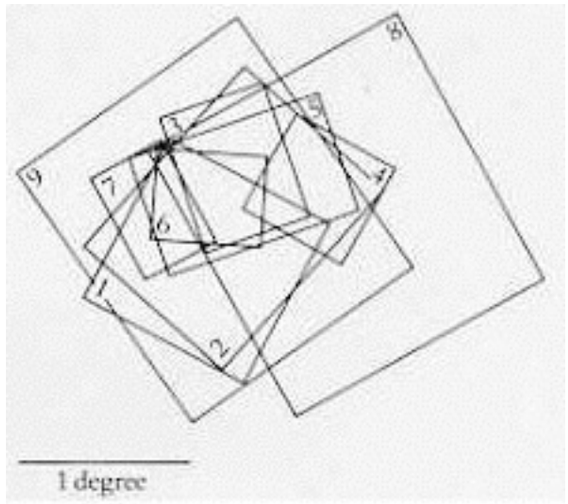




Hubel & Wiesel ’59 ’62 ’68

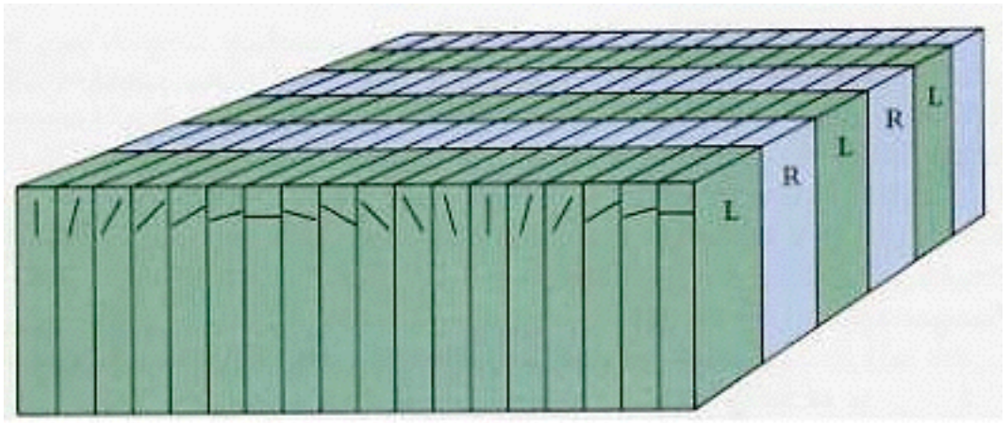
From feature detectors to population codes

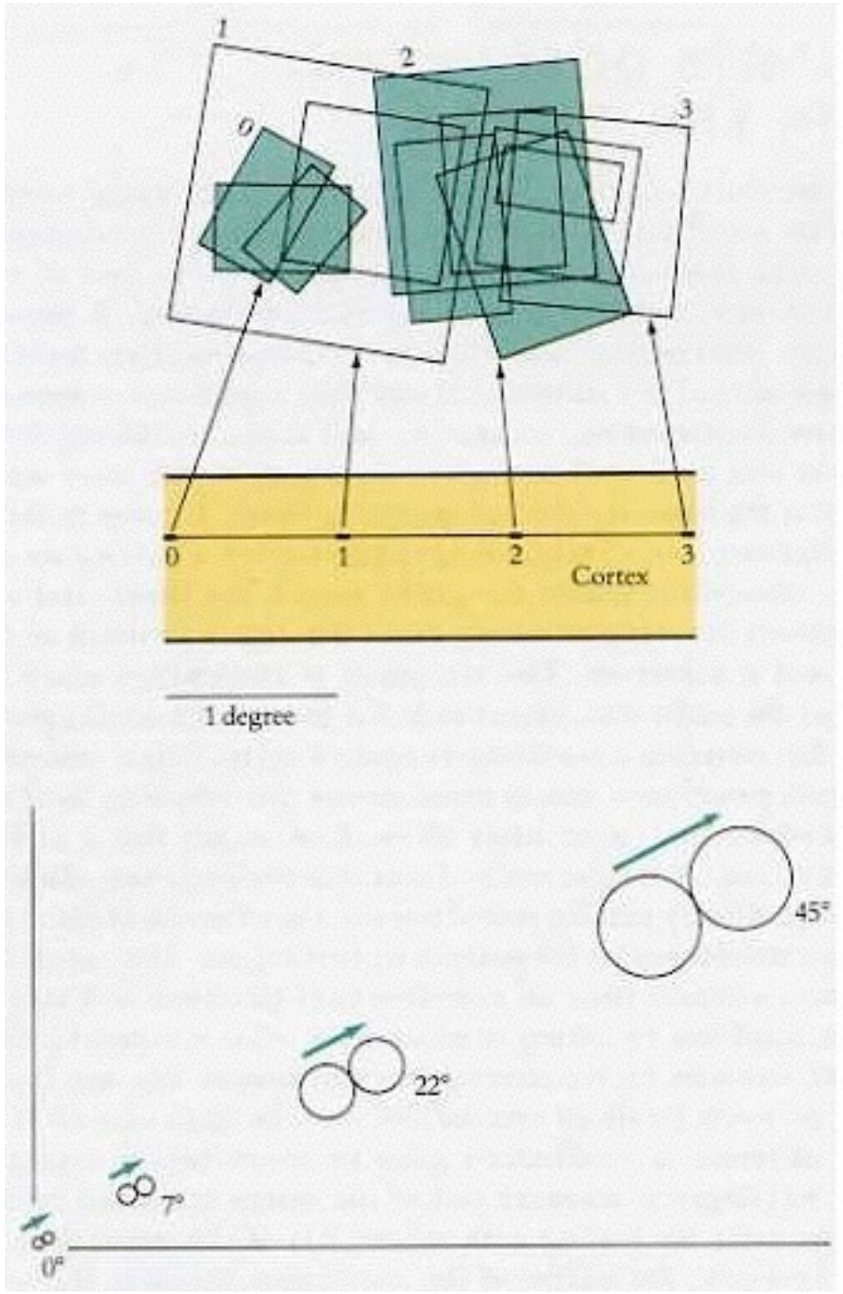




Source: David Hubel

From feature detectors to population codes

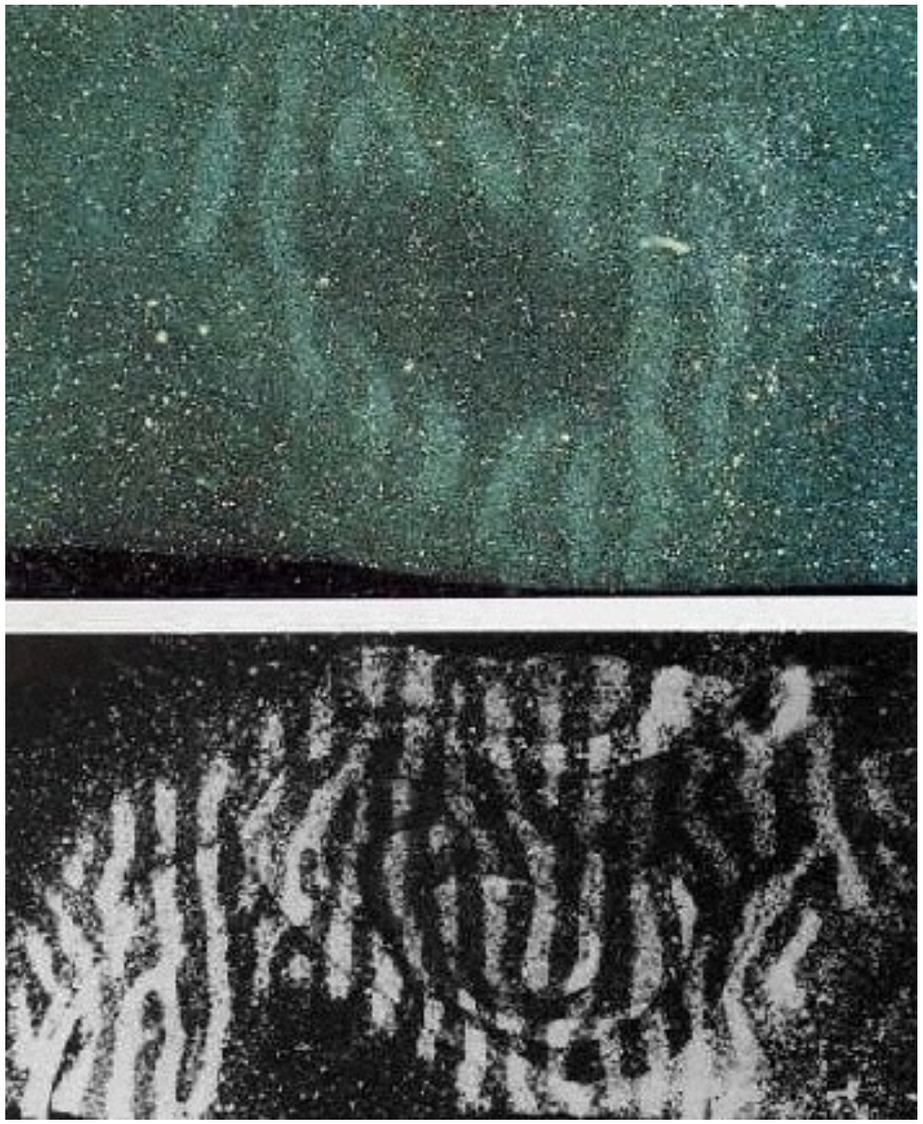


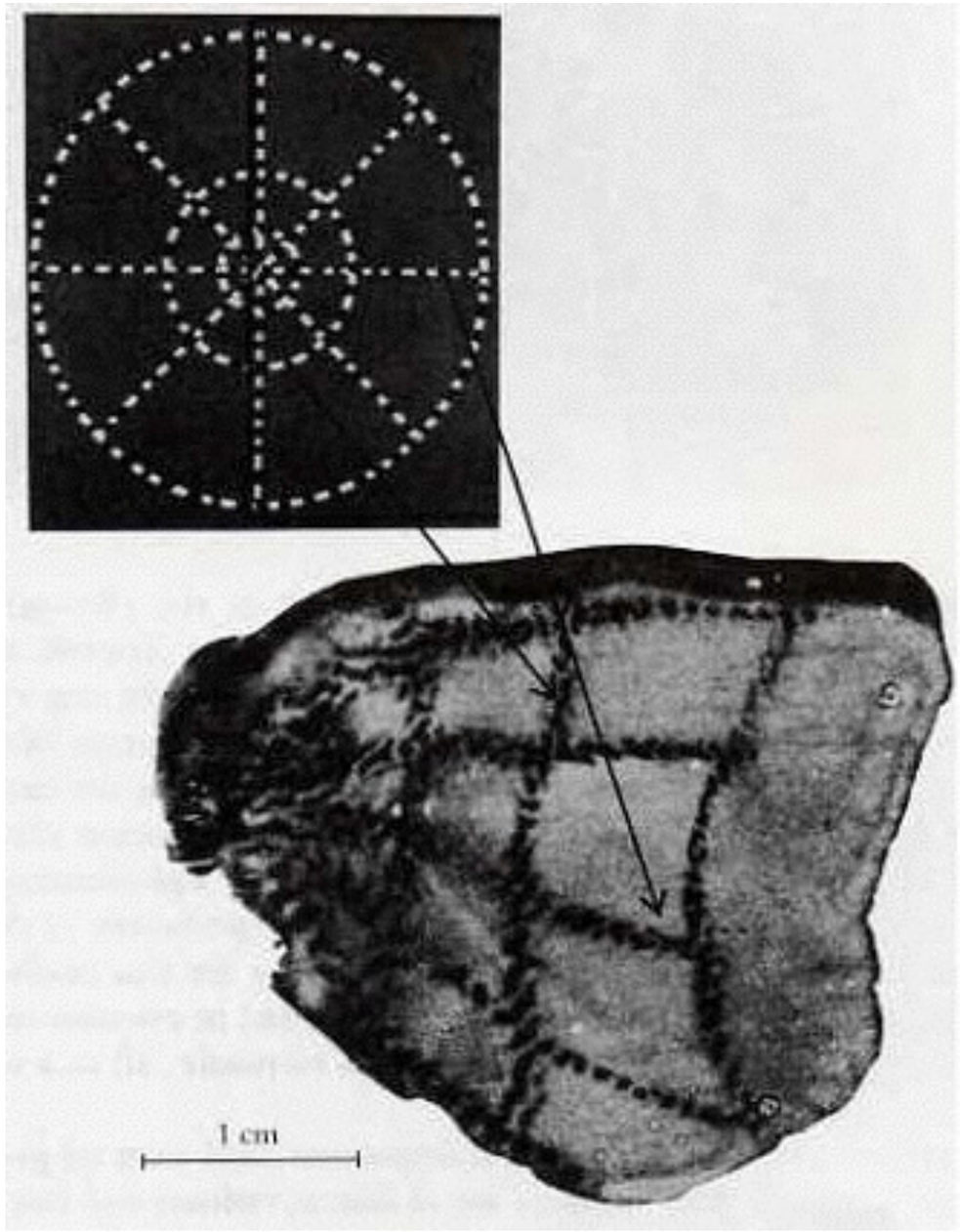


Columnar organization

Source: David Hubel

Seeing with brain maps





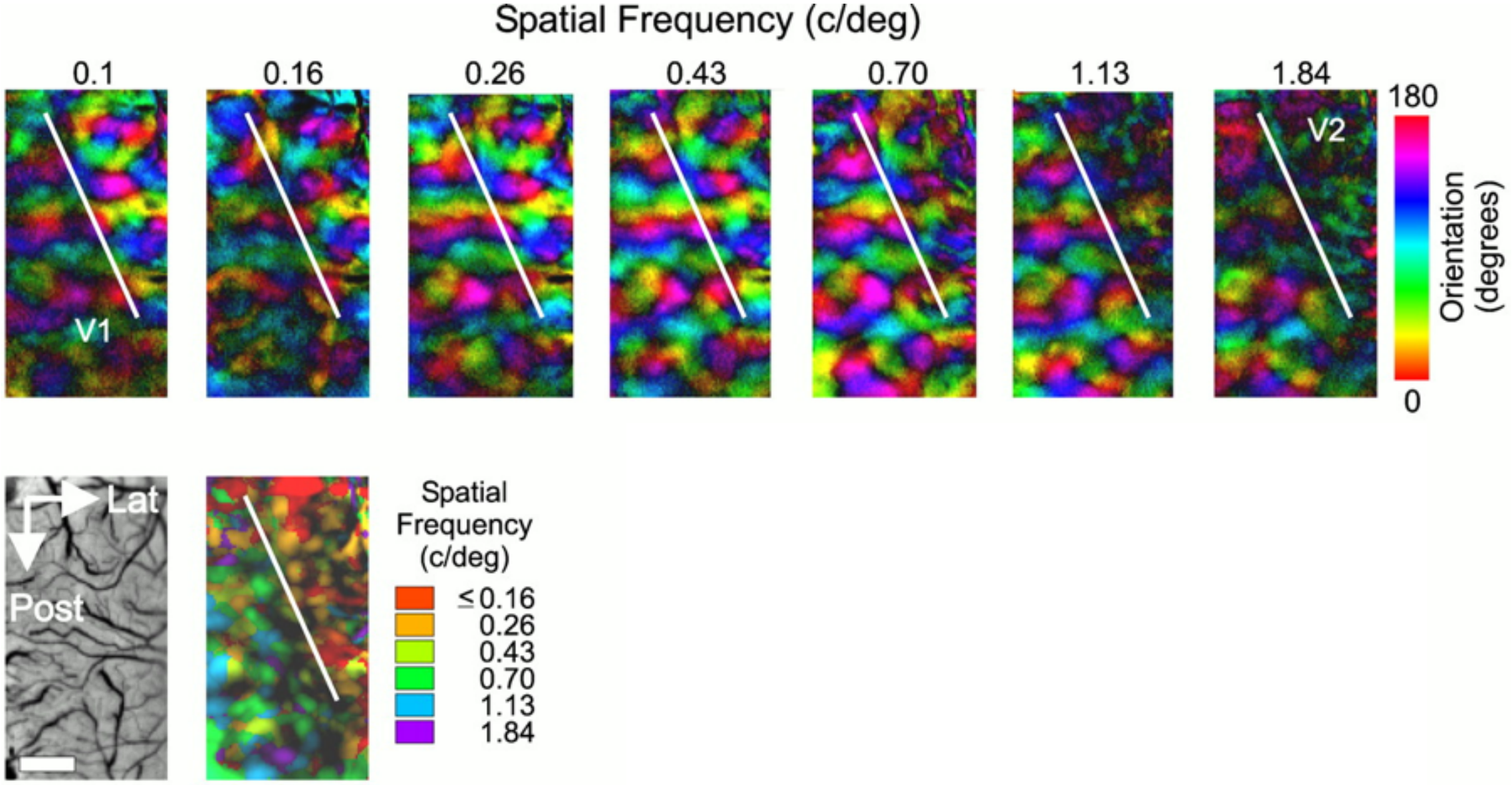
Hubel & Wiesel

Seeing with brain maps

Orientation tuning

Source: Unknown

Frequency channels



Beyond edge detection: Multi-dimensional tuning

Motion direction tuning

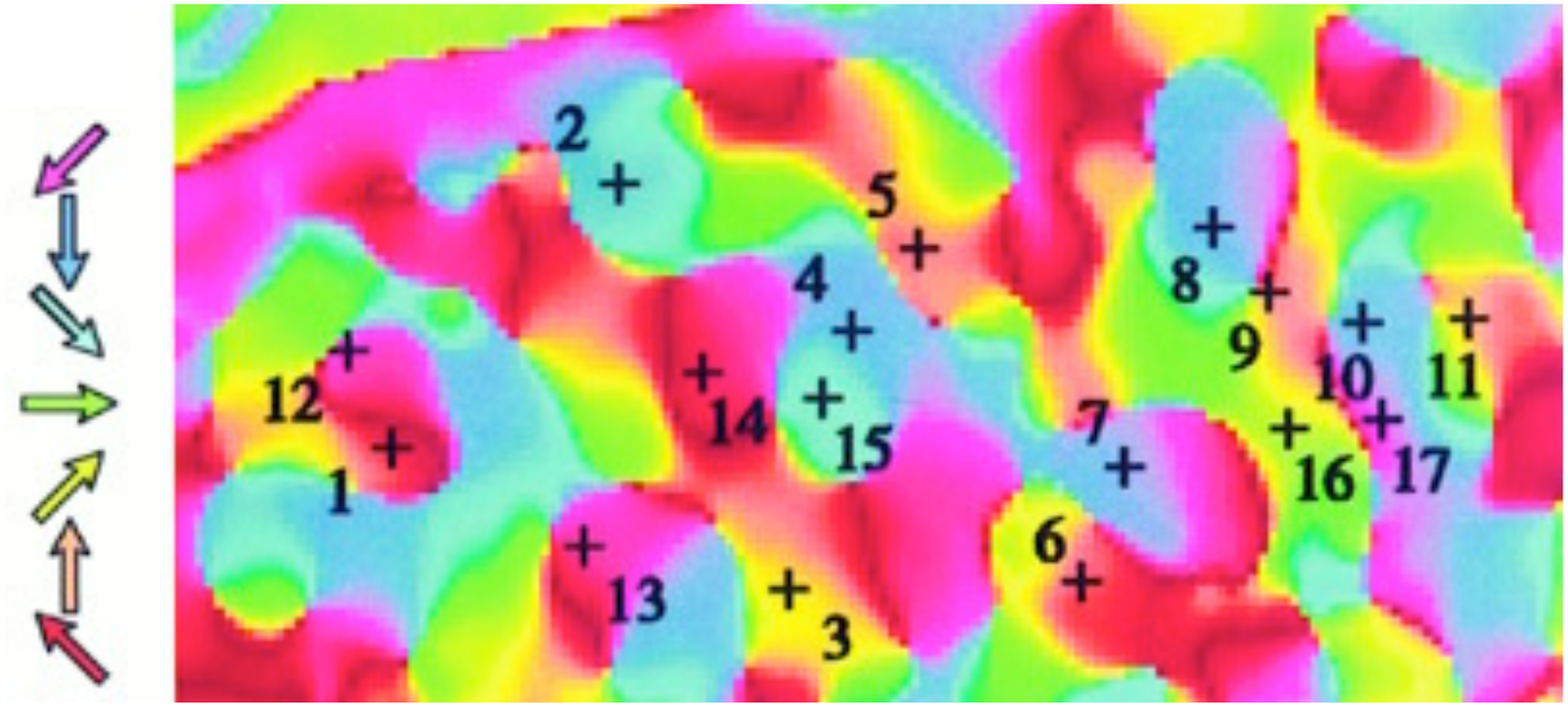
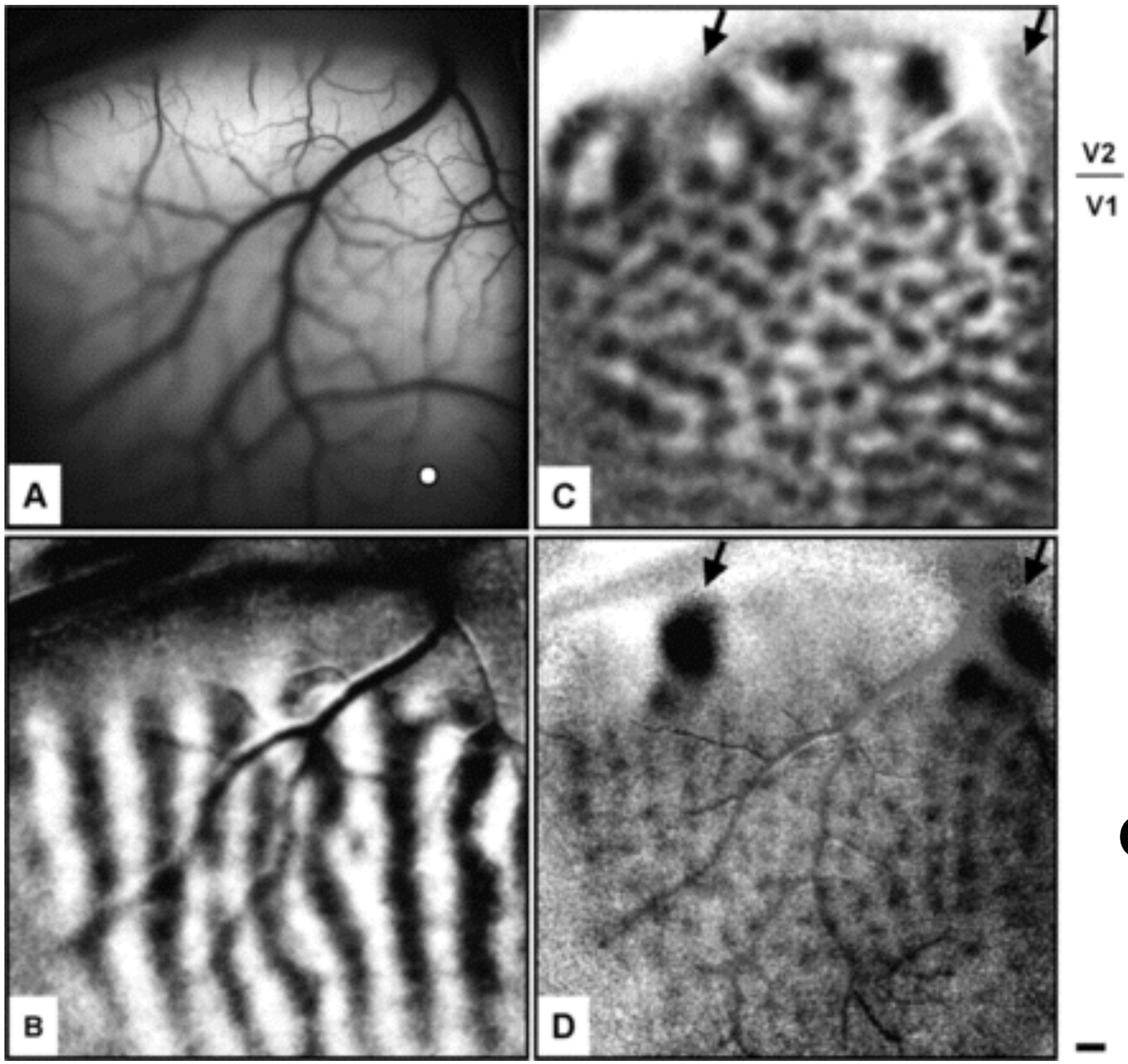


Image source: Shmuel & Grinvald ‘96

Beyond edge detection: Multi-dimensional tuning

Color tuning



Orientation maps

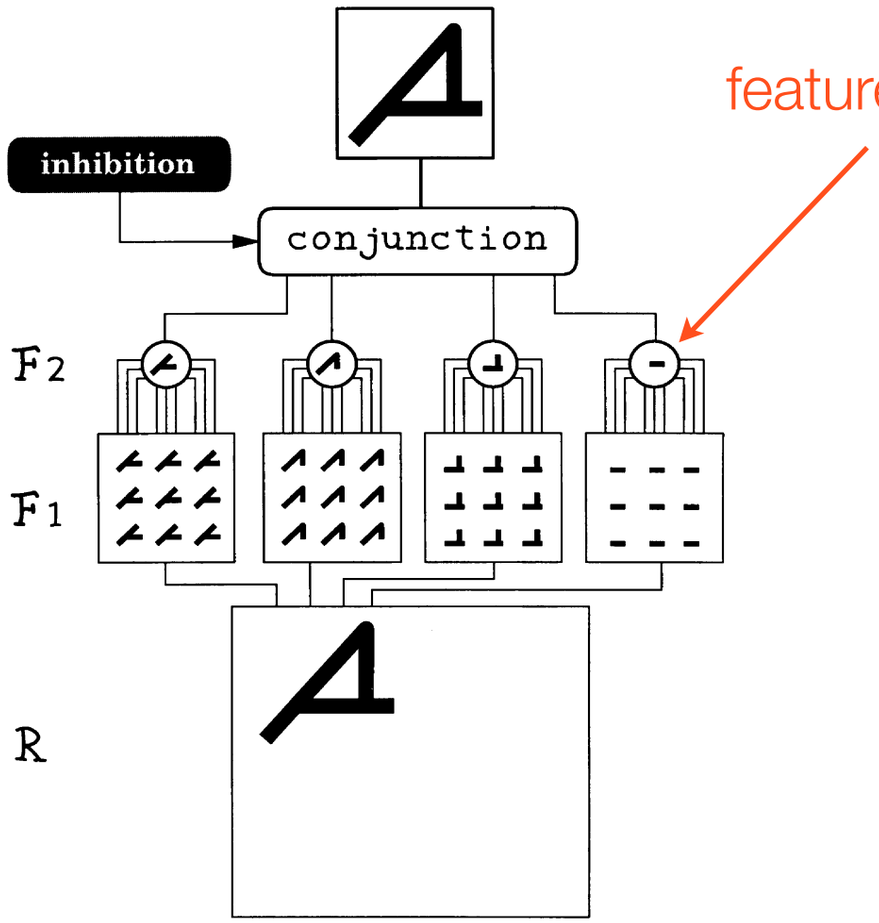
Ocular dominance column

Color ‘blobs’

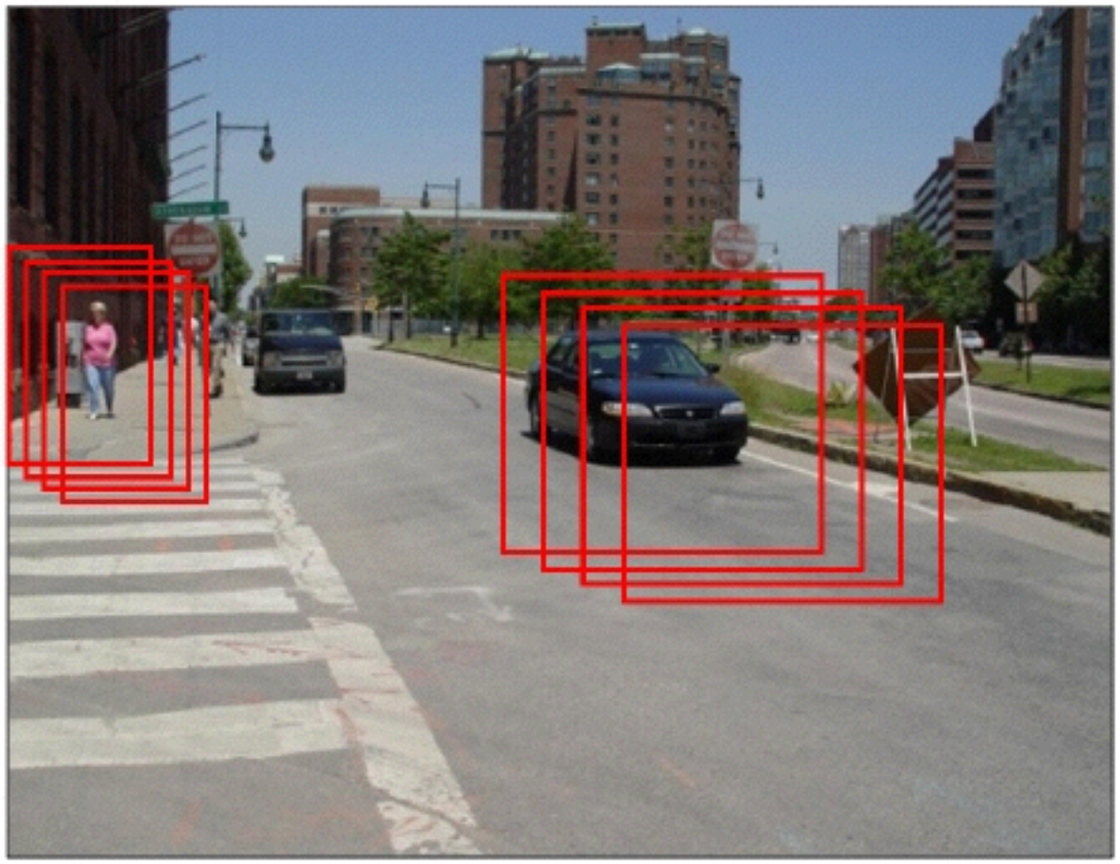
Image source: Lu & Roe ‘08

Visual analysis: Cortex vs. computers

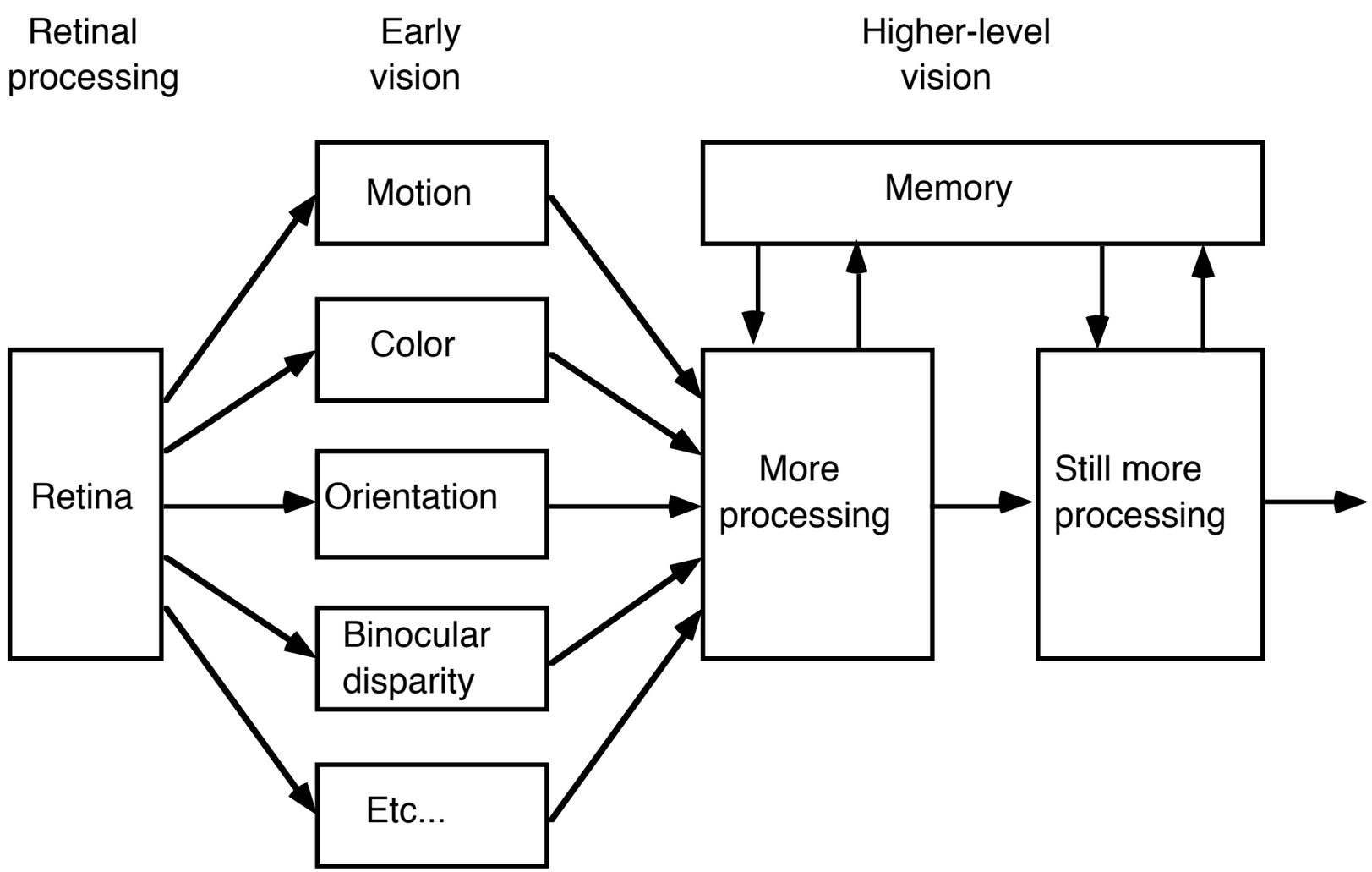
Brains: Full-replication scheme



Computers: Scanning

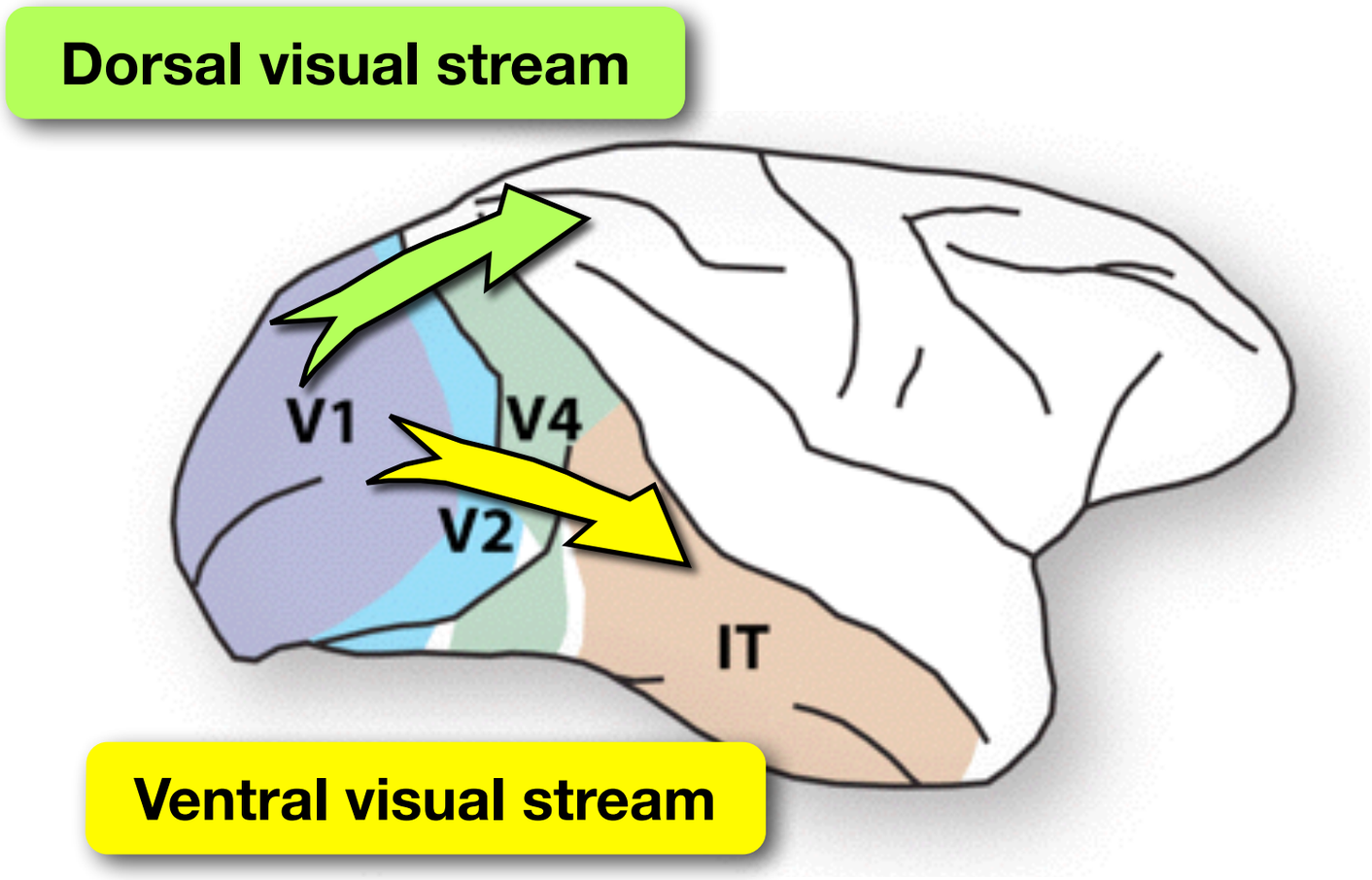


Early vision



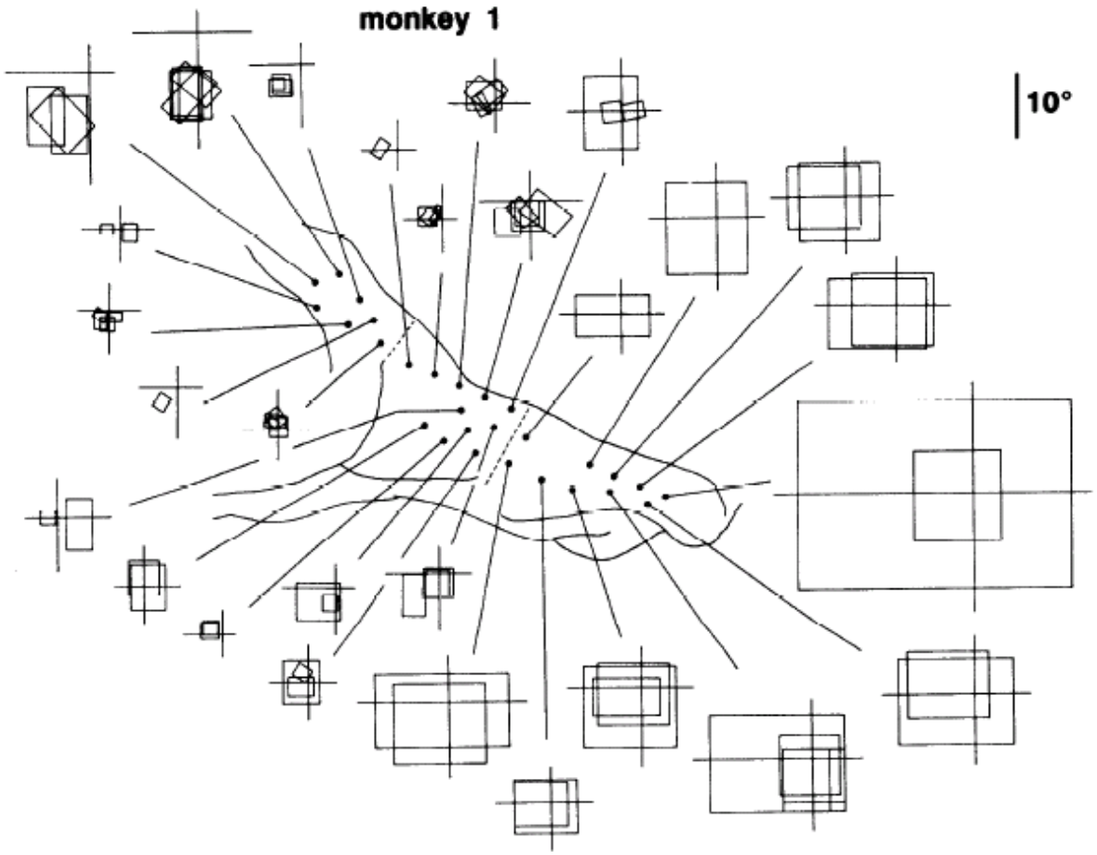
source: Adelson & Bergen ’91

Motion, attention and eye movements

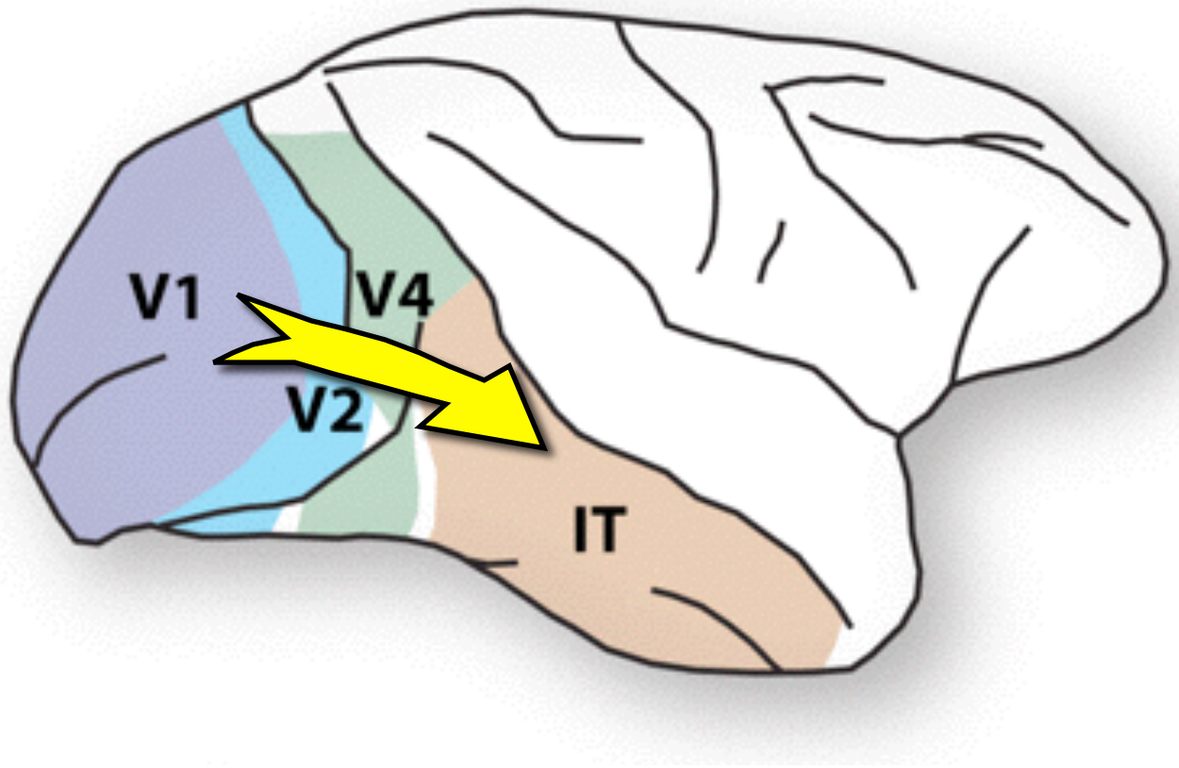


Object, shape, color processing

Streams of processing



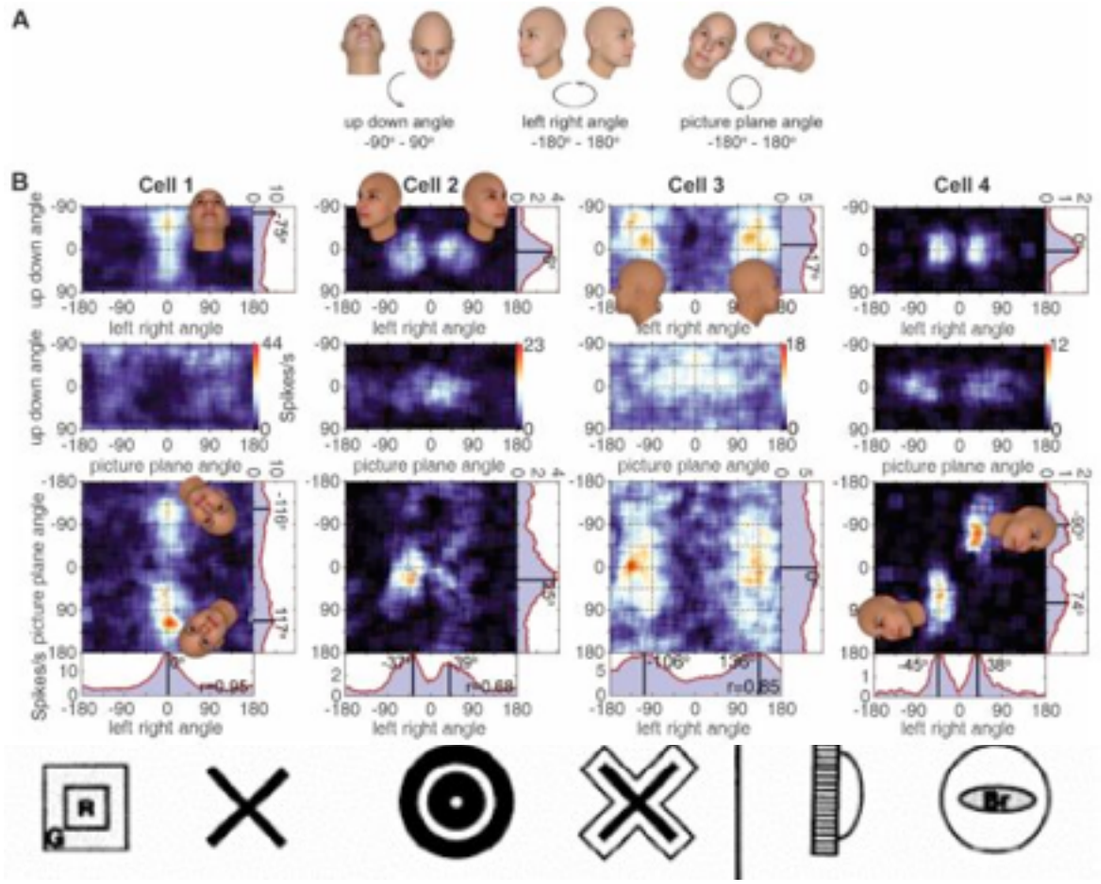
Parallel increase in invariance properties (position and scale) of neurons

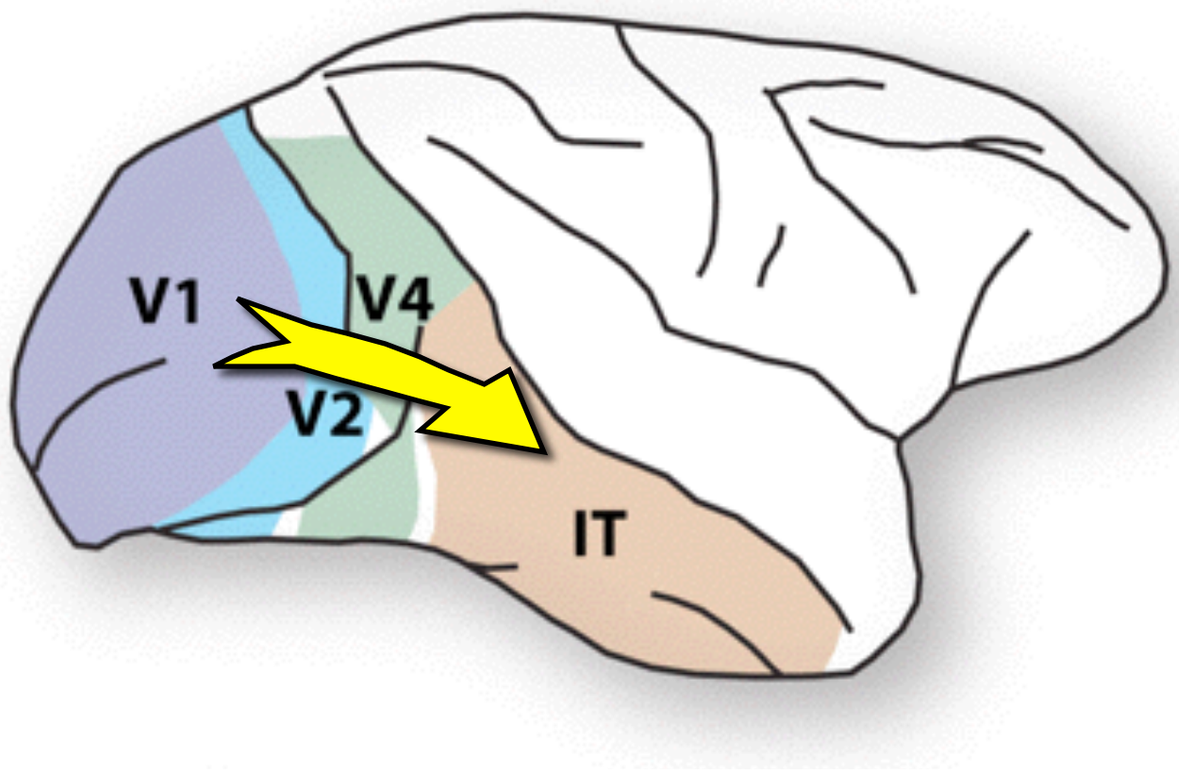


Hierarchical architecture: Function

source: Kobatake & Tanaka 1994
see also Oram & Perrett 1993; Sheinberg & Logothetis 1996; Gallant et al 1996; Riesenhuber & Poggio 1999

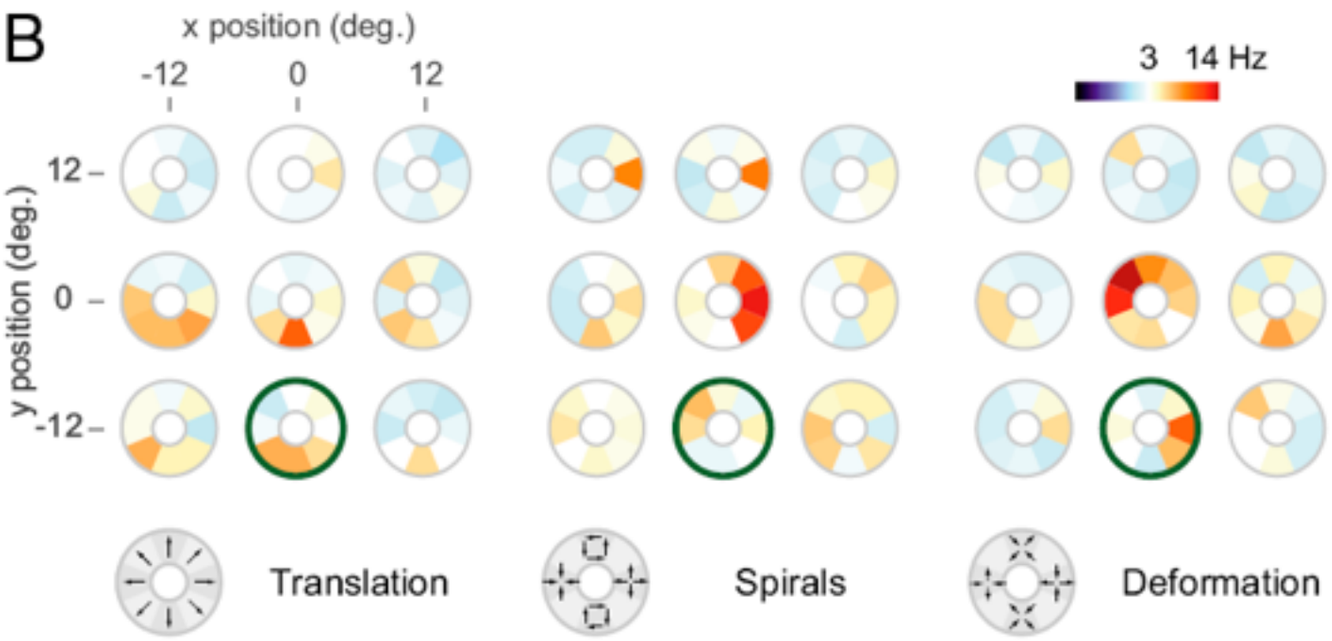
gradual increase in complexity of preferred stimulus



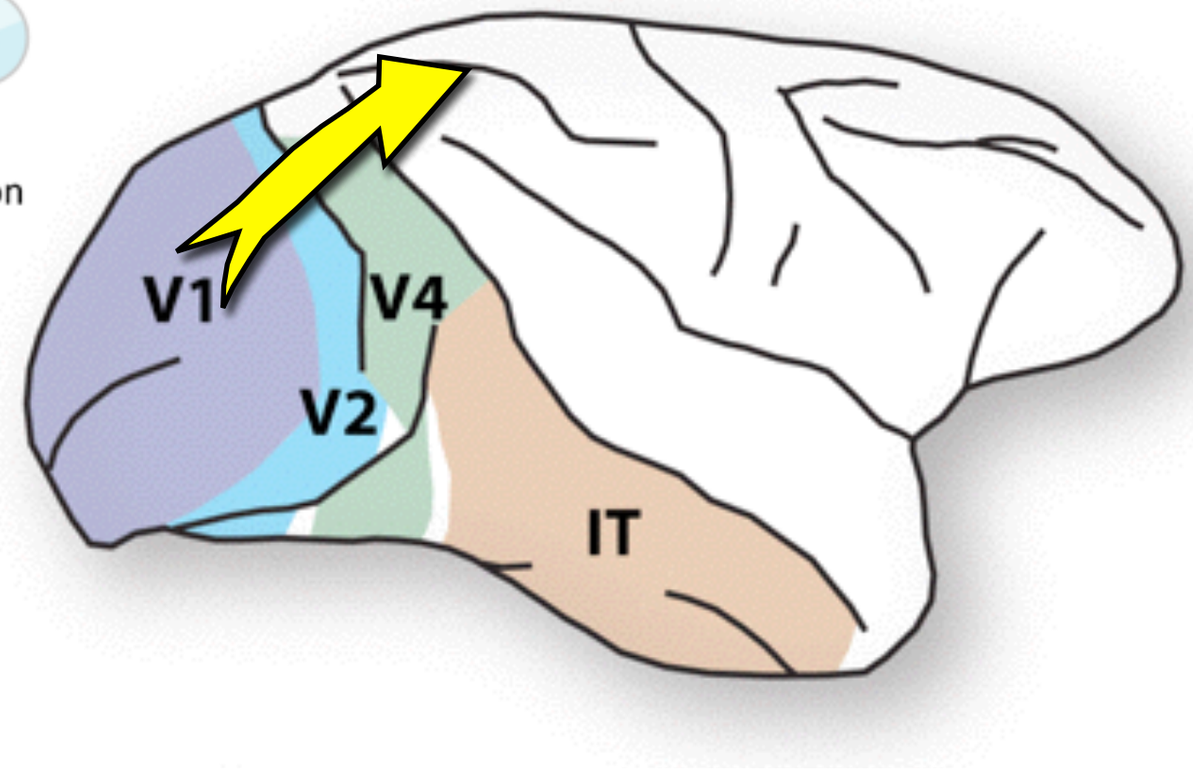


Hierarchical architecture: Function

source: Kobatake & Tanaka ’94; Freiwald & Tsao ’10
see also Oram & Perrett 1993; Sheinberg & Logothetis ‘96; Gallant et al ‘96; Riesenhuber & Poggio ’99

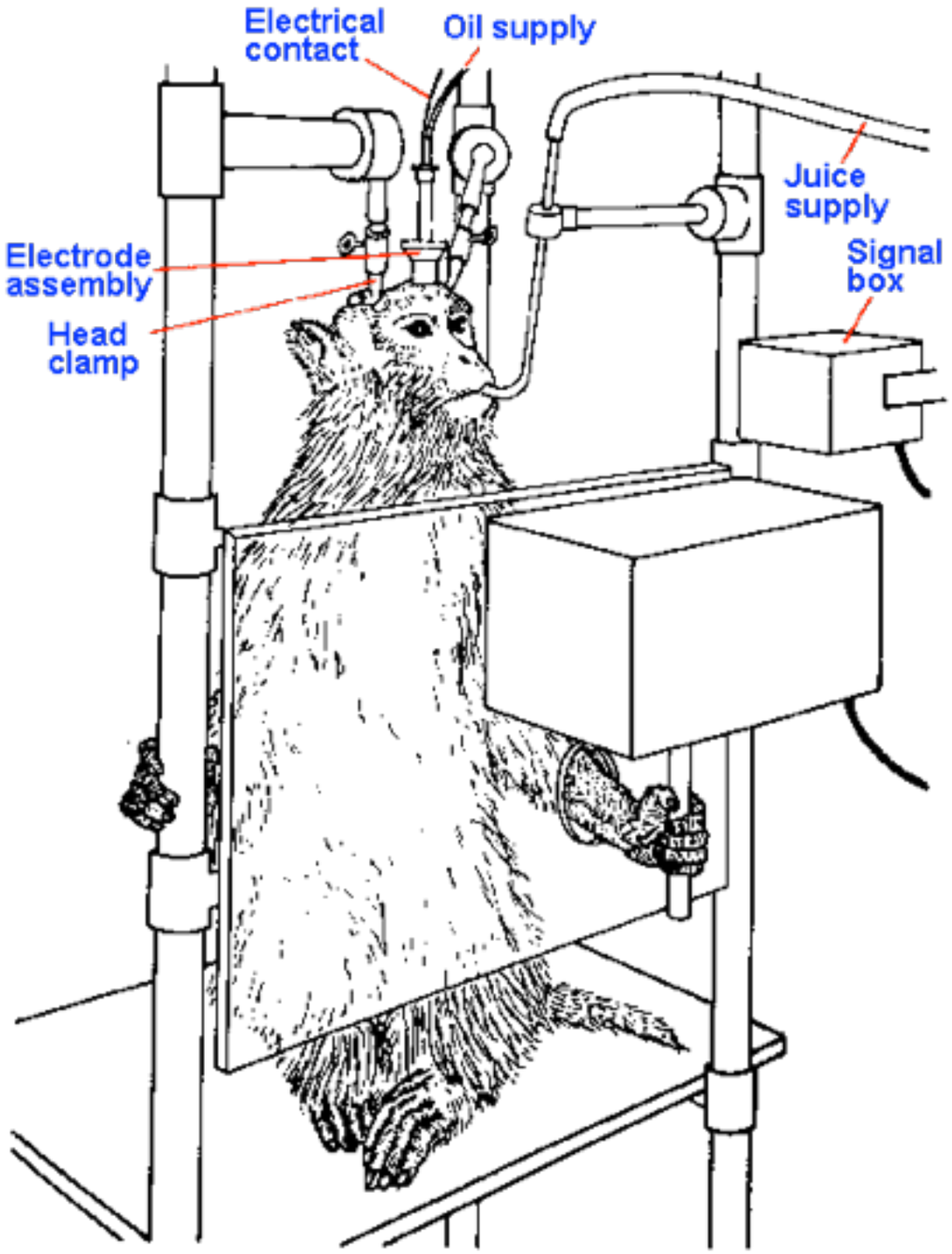


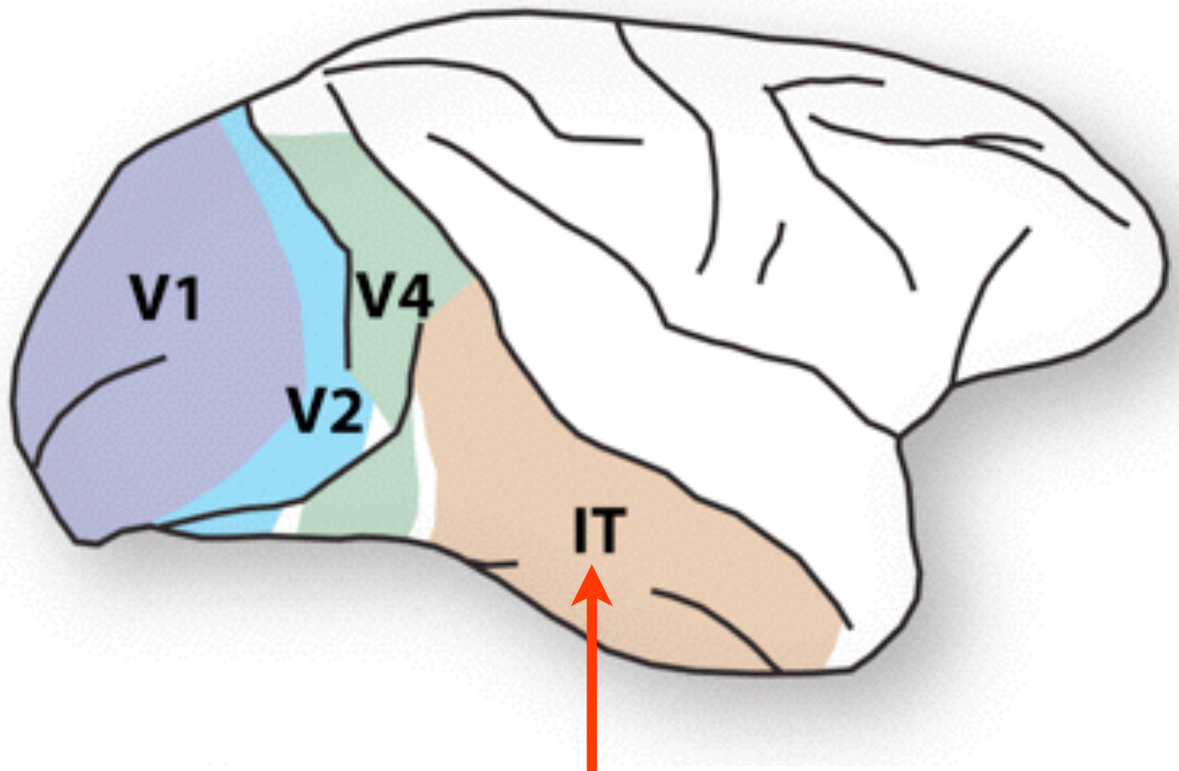
gradual increase in complexity of preferred stimulus



Hierarchical architecture: Function

source: Mineault et al 2011



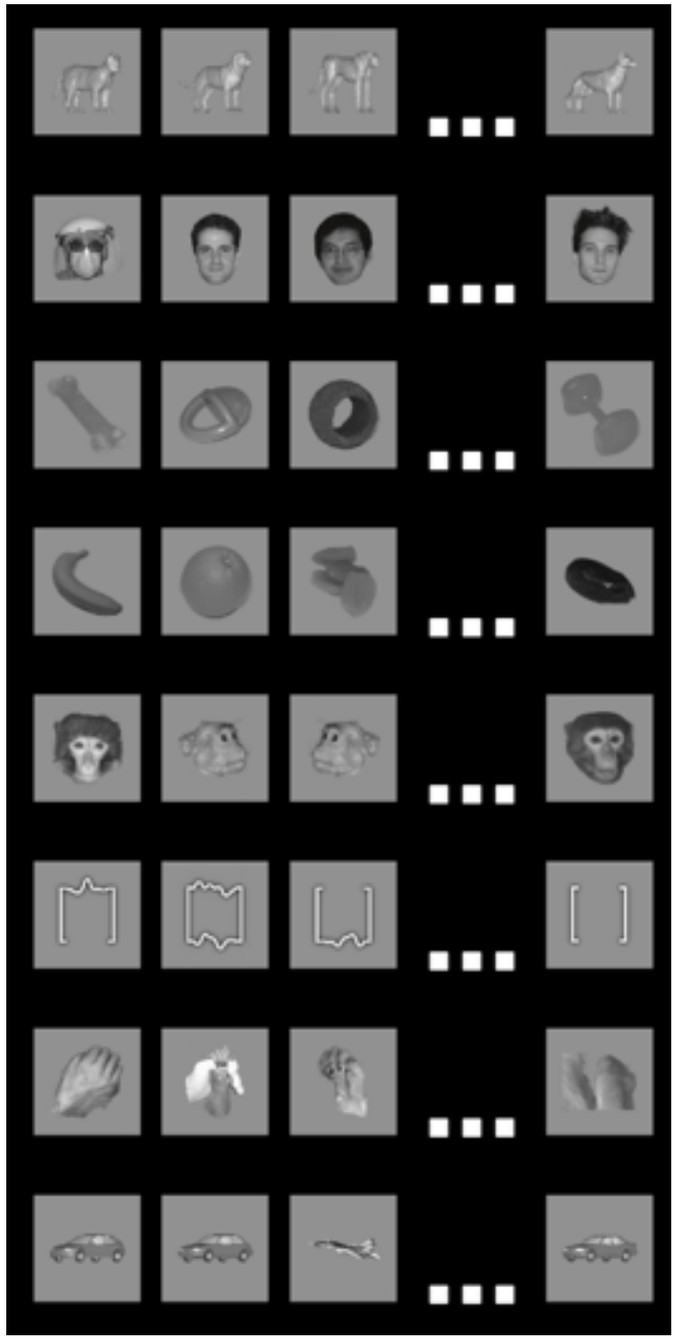


Invariant object category information can be decoded from small populations of cells in IT

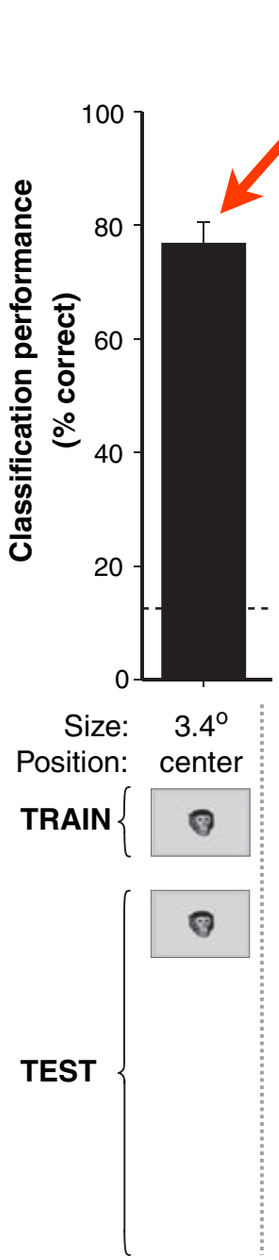
Invariant image representation in the IT

77 unique stimuli

8 object category



Decoding possible from around 100 ms



Invariant representation in IT

Hung et al ’05