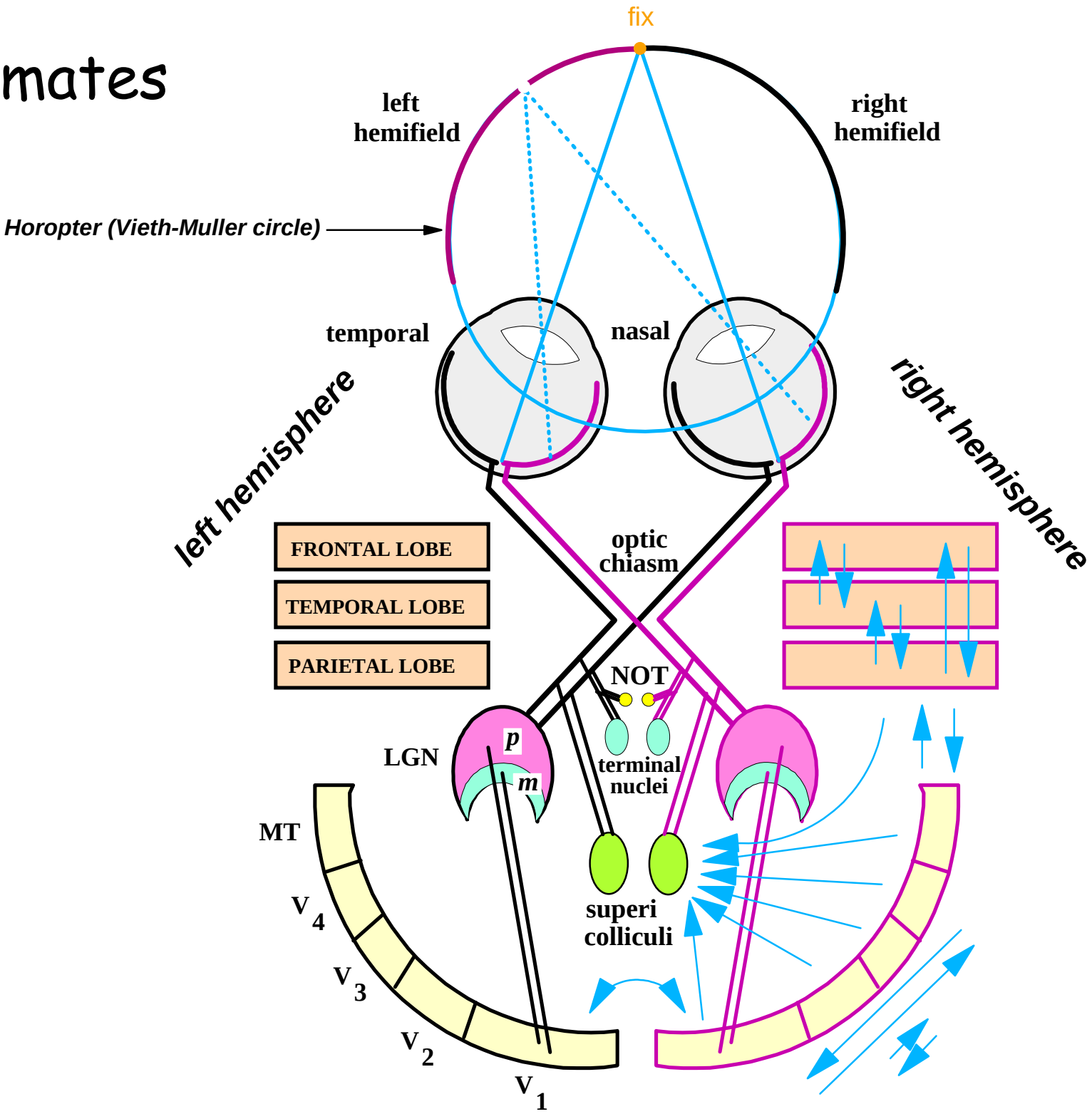
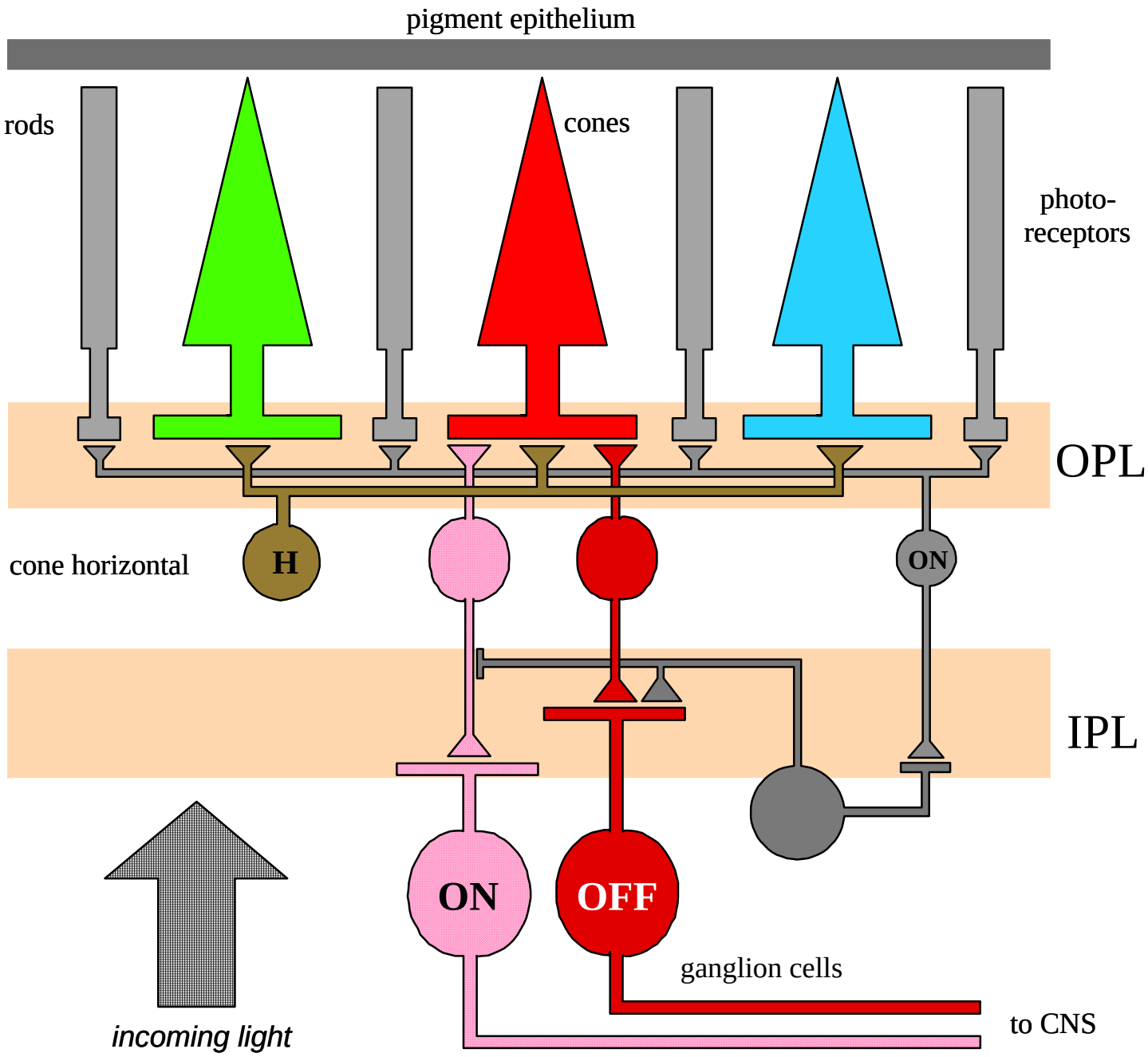
Review,
the visual and oculomotor systems

Basic wiring of the visual system

Primates


fix
left hemifield
right hemifield
Horopter (Vieth-Muller circle)
temporal
nasal
left hemisphere
right hemisphere
FRONTAL LOBE
TEMPORAL LOBE
PARIETAL LOBE
optic chiasm
NOT
LGN
p
m
terminal nuclei
MT
V4
V3
V2
V1
superi colliculi

Retina and LGN


pigment epithelium
rods
cones
photo-
receptors
OPL
cone horizontal
H
ON
IPL
ON
OFF
ganglion cells
to CNS
incoming light

Visual cortex

Transforms in V1

Orientation

Direction

Spatial Frequency

Binocularity

ON/OFF Convergence

Midget/Parasol Convergence

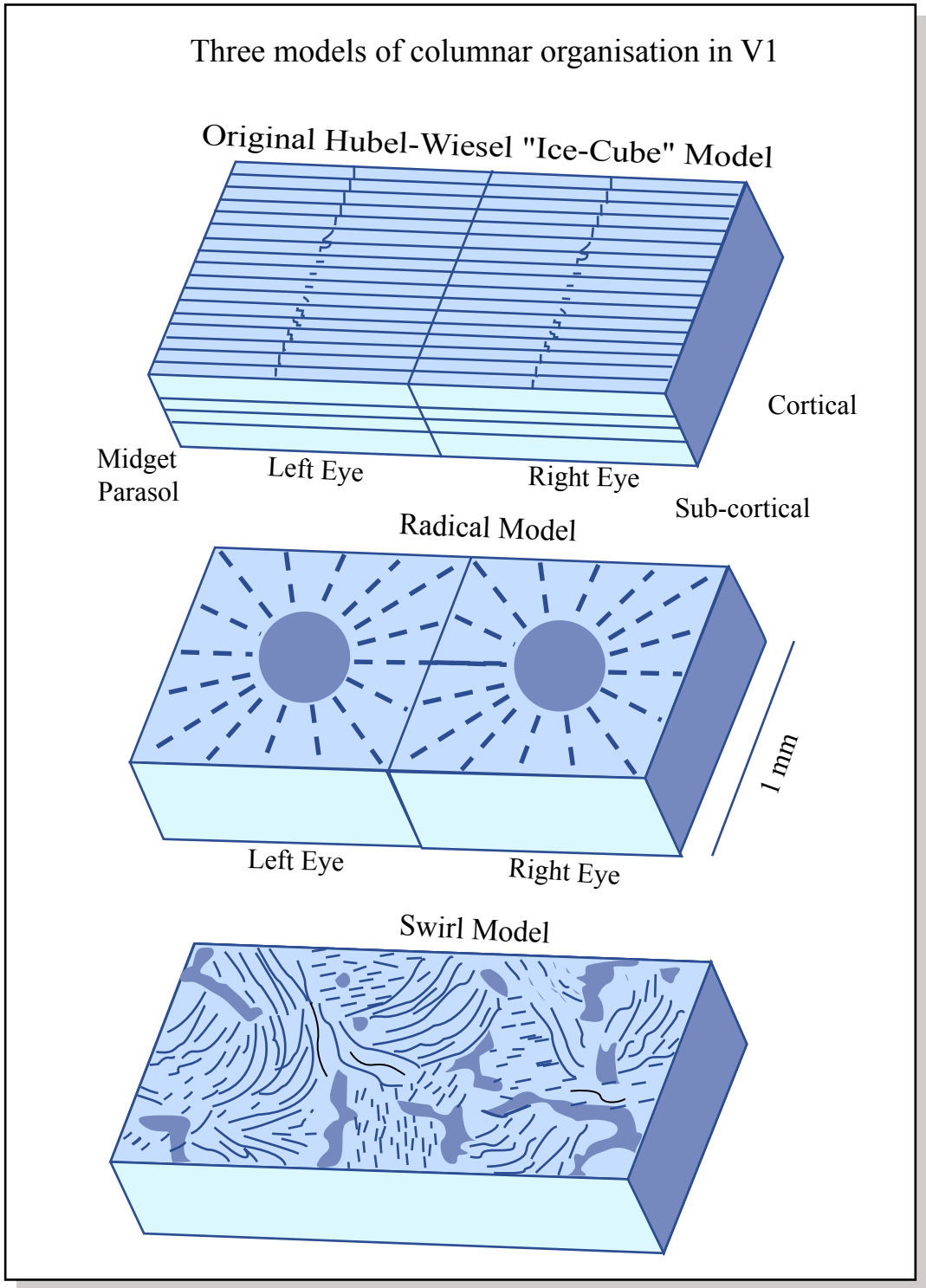
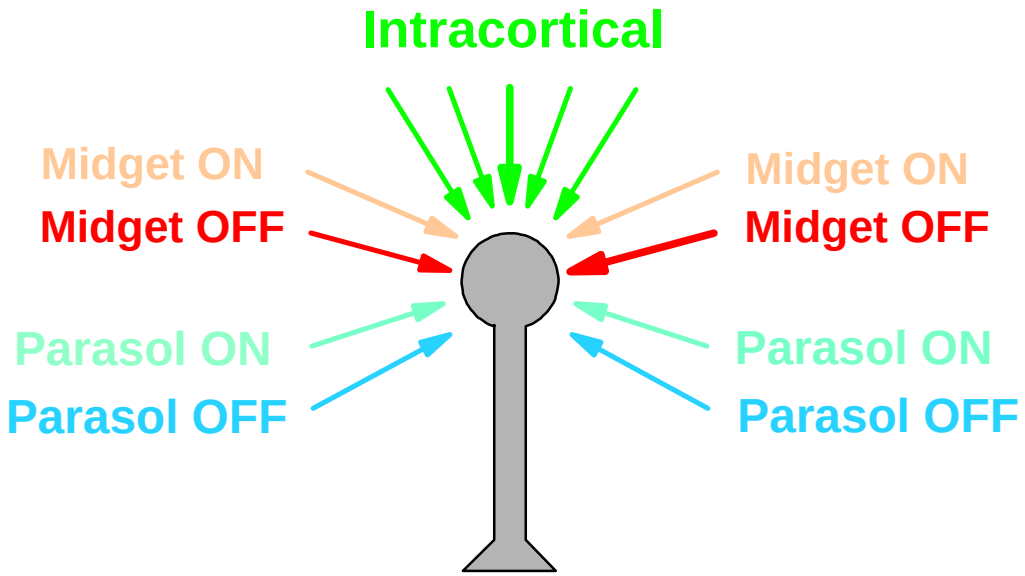


Figure by MIT OCW.

Striate Cortex Output Cell

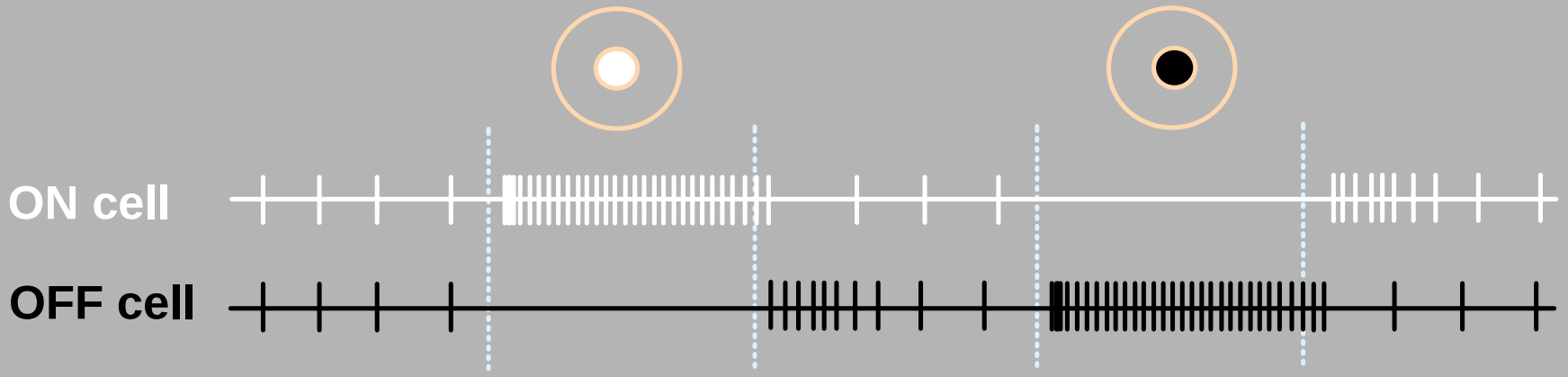


The ON and OFF Channels

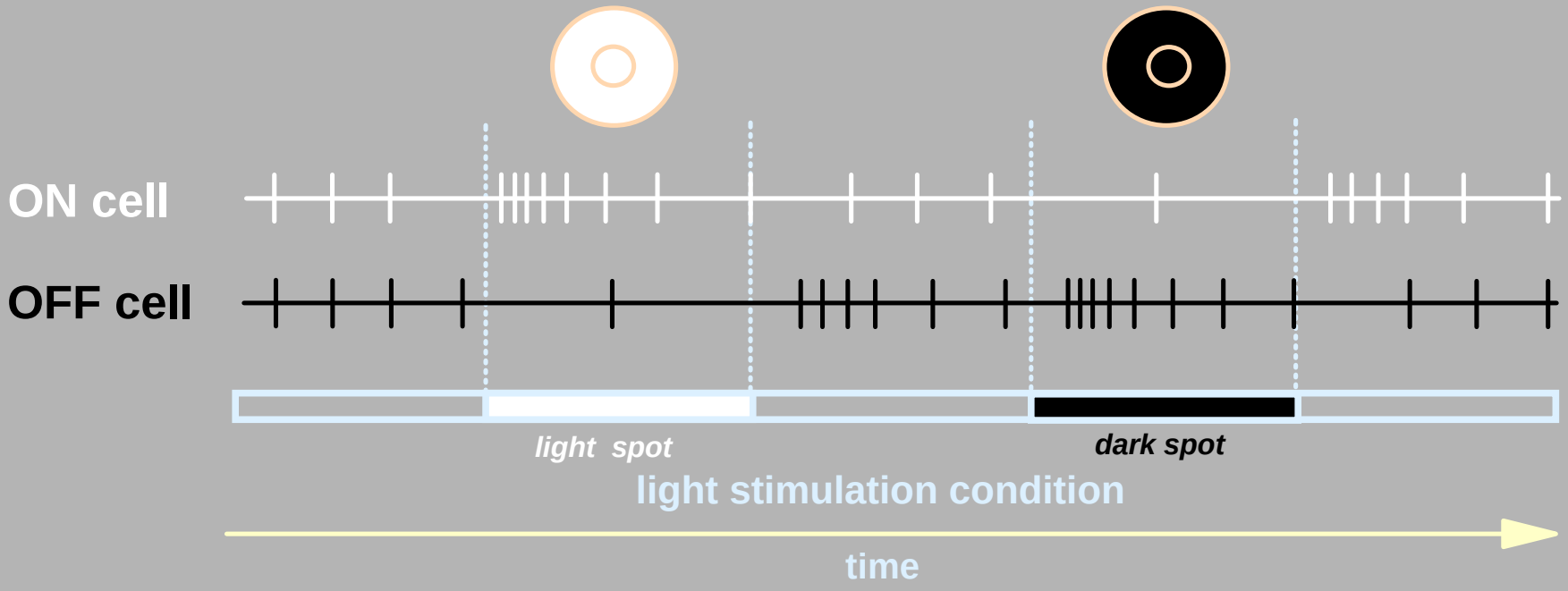
The receptive fields of three major classes of retinal ganglion cells

Action potentials discharged by an ON and an OFF retinal ganglion cell

Stimulation confined to receptive field center

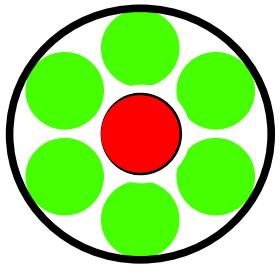


Stimulation of the entire receptive field

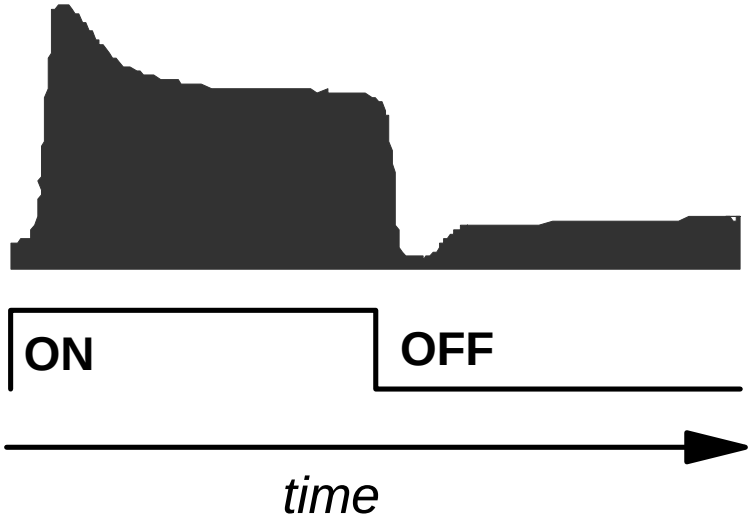


The midget and parasol channels

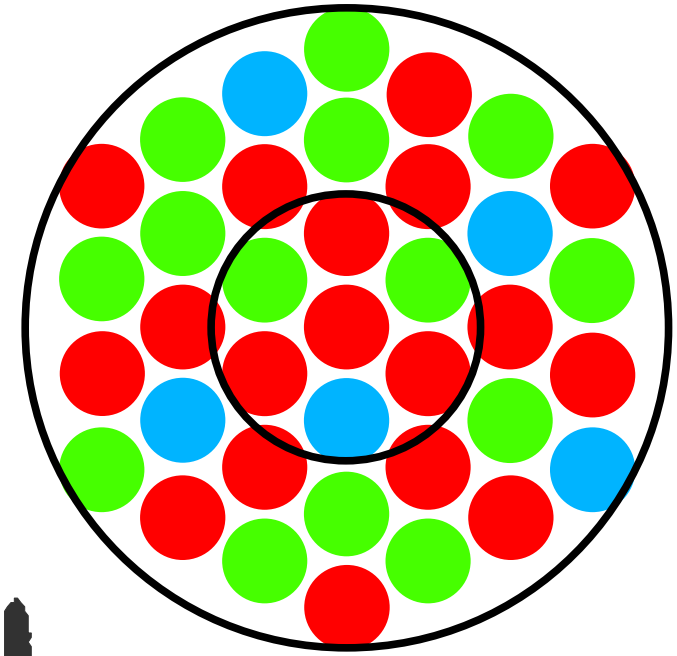
MIDGET SYSTEM

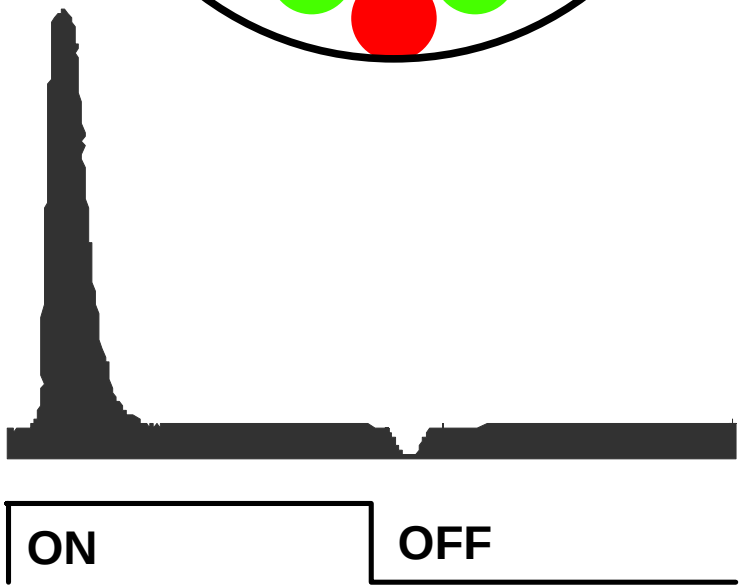


neuronal response profile

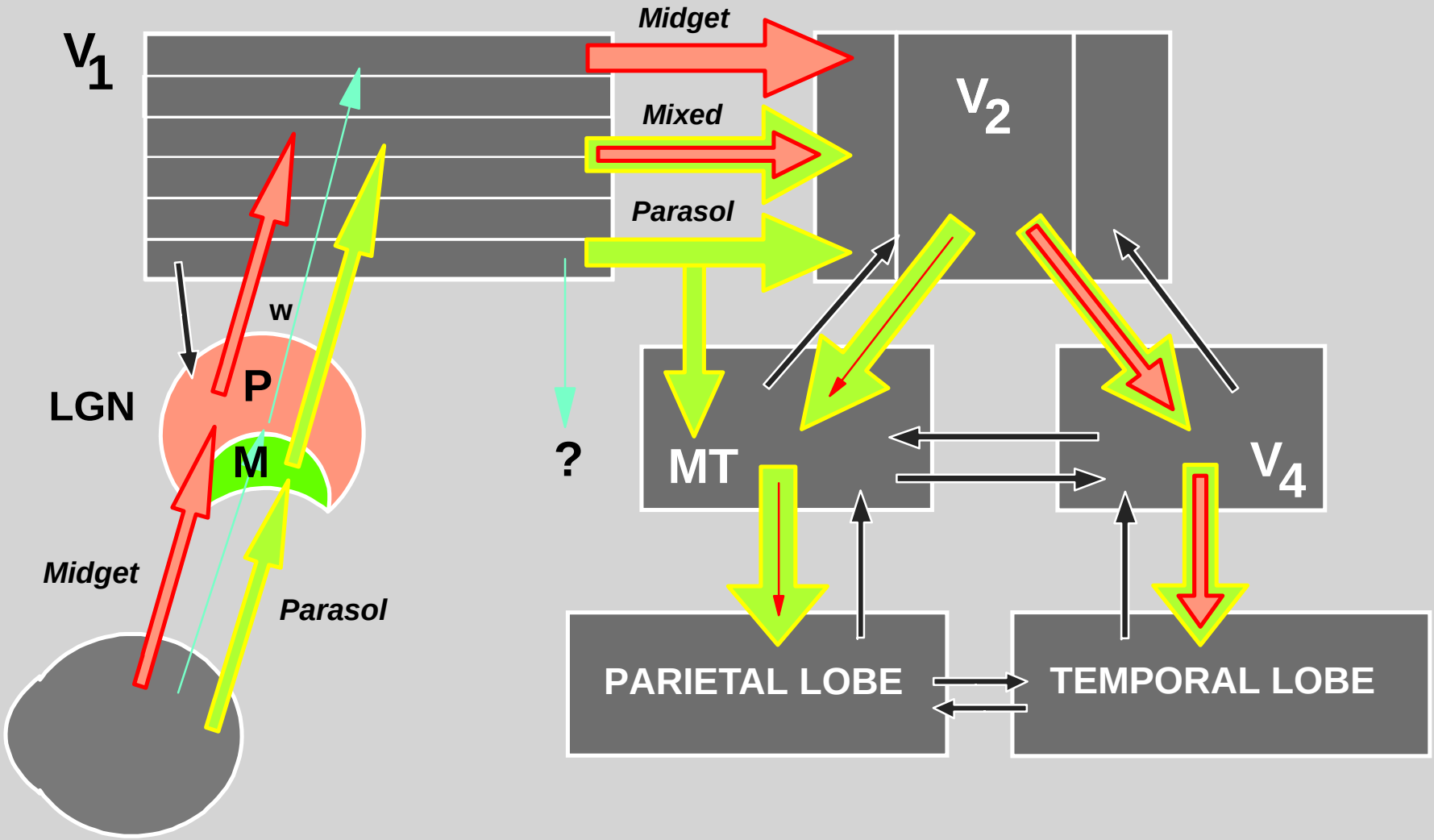


PARASOL SYSTEM





Projections of the midget and parasol systems



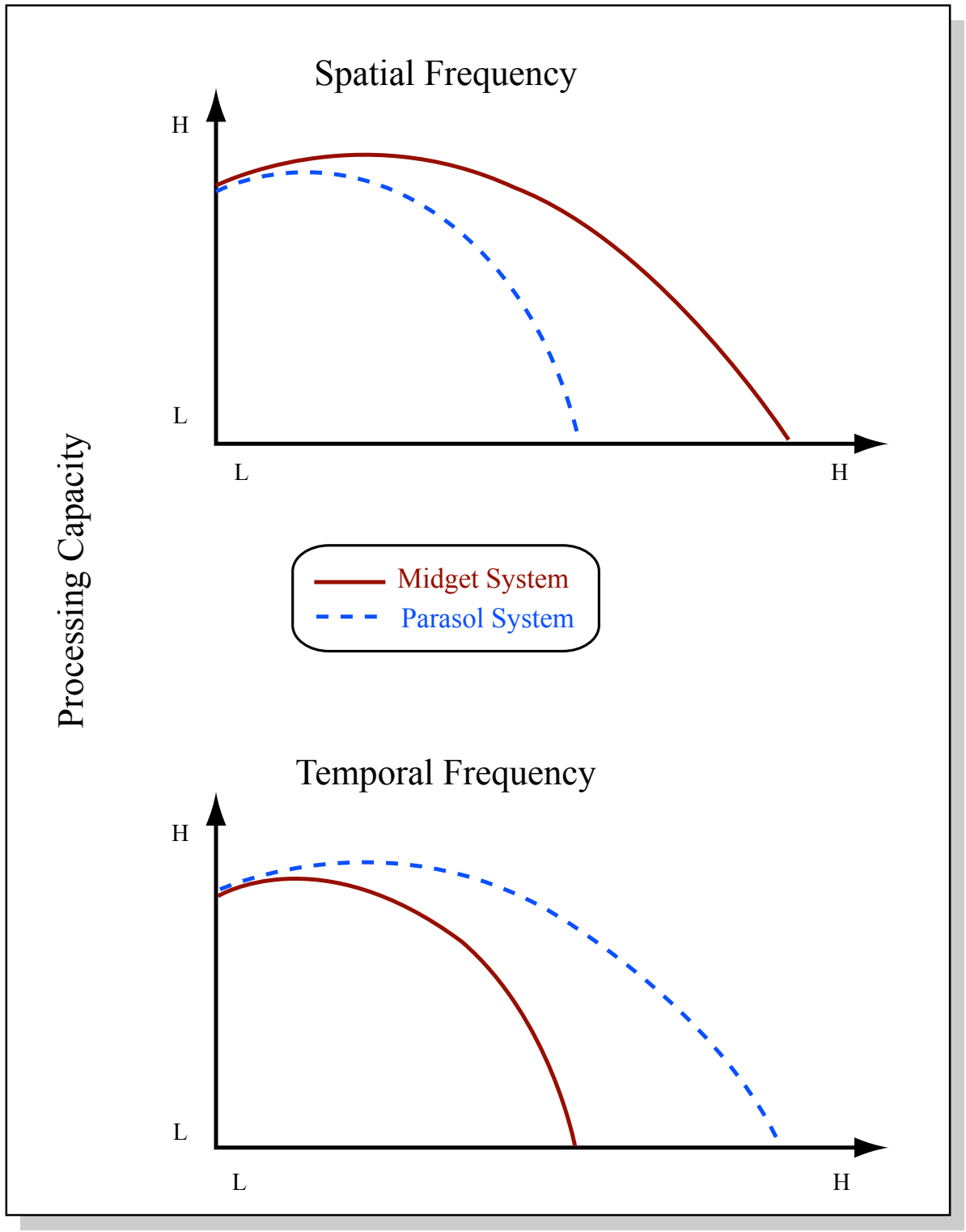


Figure by MIT OCW.

Color vision and adaptation

Basic facts and rules of color vision

1. There are three qualities of color: hue, brightness, saturation

2. There is a clear distinction between the physical and psychological attributes of color: wavelength vs. color, luminance vs. brightness.

3. Peak sensitivity of human photoreceptors (in nanometers):
   S = 420, M = 530, L = 560, Rods = 500

4. Grassman's laws:
   1. Every color has a complimentary which when mixed propery yields gray.
   2. Mixture of non-complimentary colors yields intermediates.

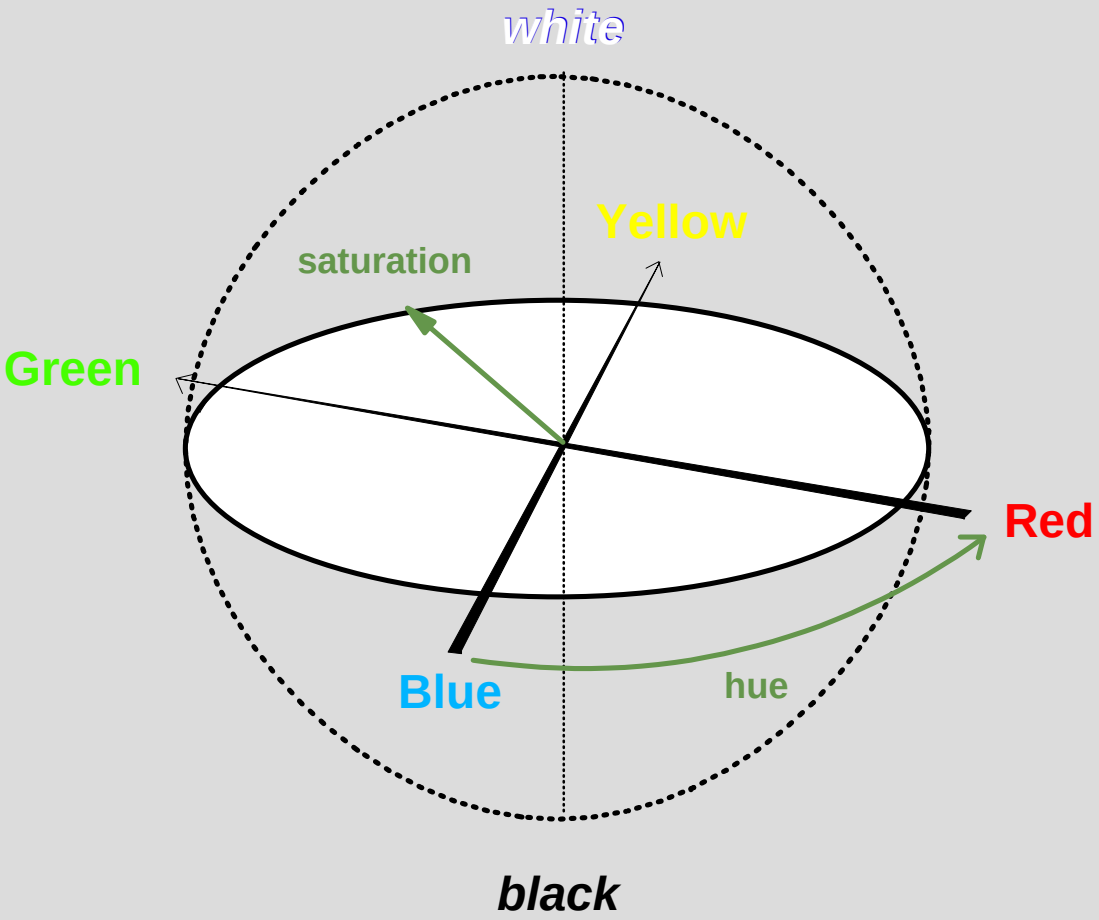
5. Abney's law:
   The luminance of a mixture of differently colored lights is equal to the sum of the luminances of the components.

6. Metamers: stimuli producing different distributions of light energy that yield the same color sensations.

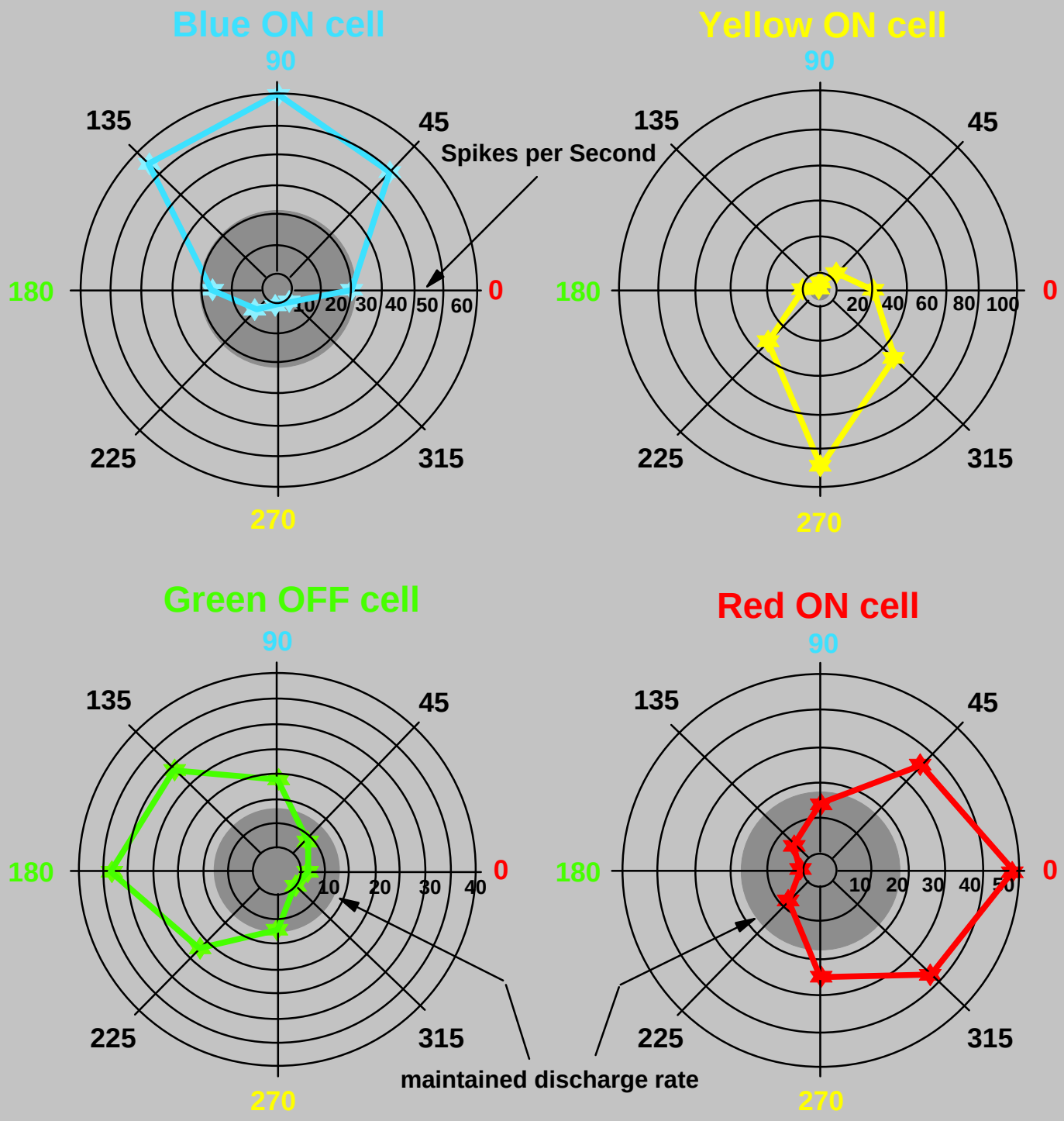
Basic facts about light adaptation

1. Range of illumination is 10 log units. But reflected light yields only a 20 fold change (expressed as percent contrast).
2. The amount of light the pupil admits into the eye varies over a range of 16 to 1. Therefore the pupil makes only a limited contribution to adaptation.
3. Most of light adaptation takes place in the photoreceptors.
4. Any increase in the rate at which quanta are delivered to the eye results in a proportional decrease in the number of pigment molecules available to absorb those quanta .
5. Retinal ganglion cells are sensitive to local contrast differences, not absolute levels of illumination.

The color circle



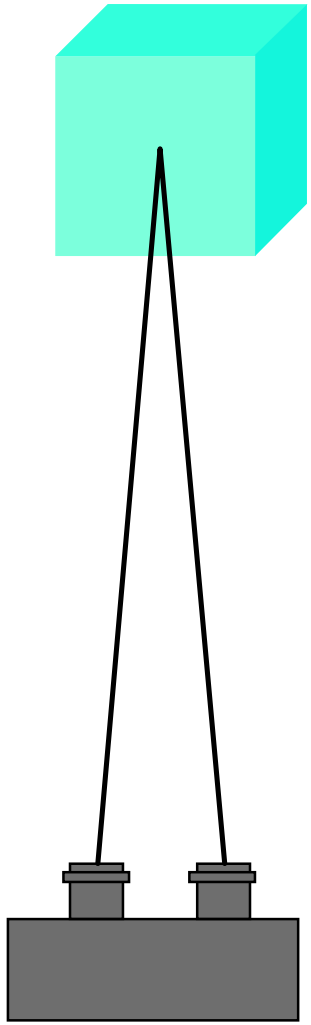
Response to Different Wavelength Compositions in LGN



Depth perception

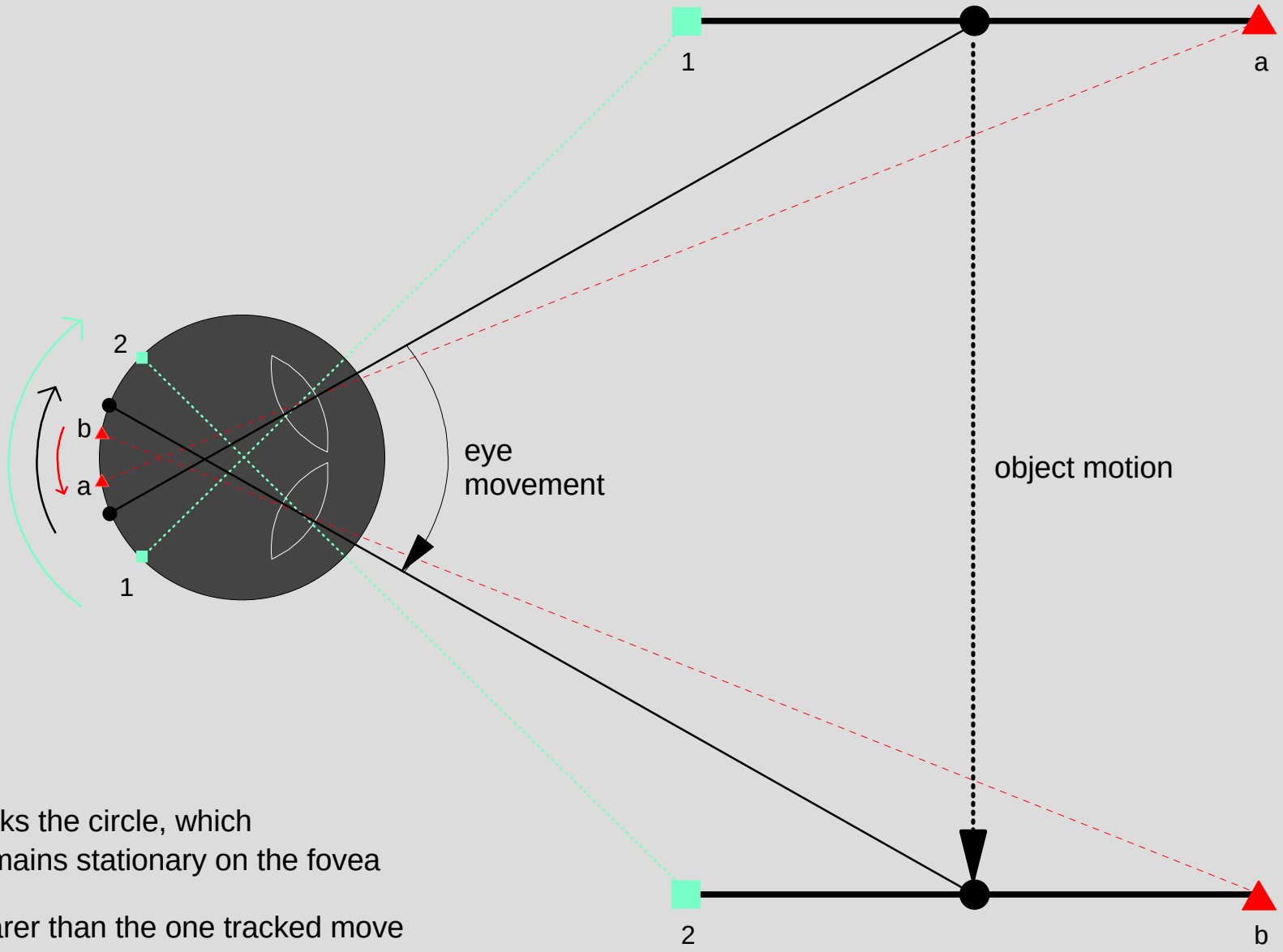
Cues used for coding depth in the brain

Oculomotor cues	Visual cues
accommodation vergence	*Binocular* stereopsis
	Monocular motion parallax shading interposition size perspective



stereo camera

MOTION PARALLAX, the eye tracks



The eye tracks the circle, which therefore remains stationary on the fovea

Objects nearer than the one tracked move at greater velocities on the retinal surface than objects further; the further objects actually move in the opposite direction on the retina.

Form perception

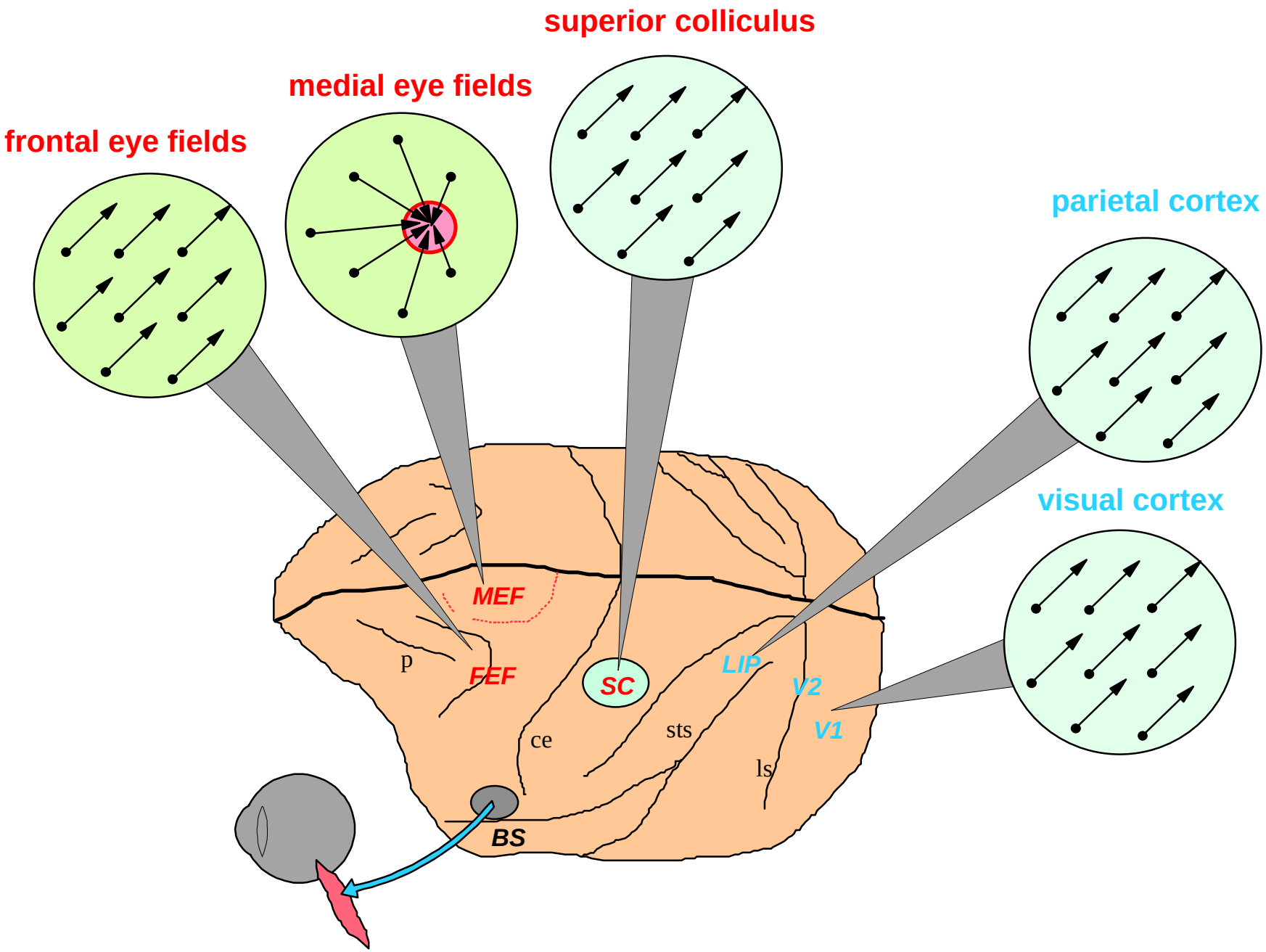
Three general theories of form perception:

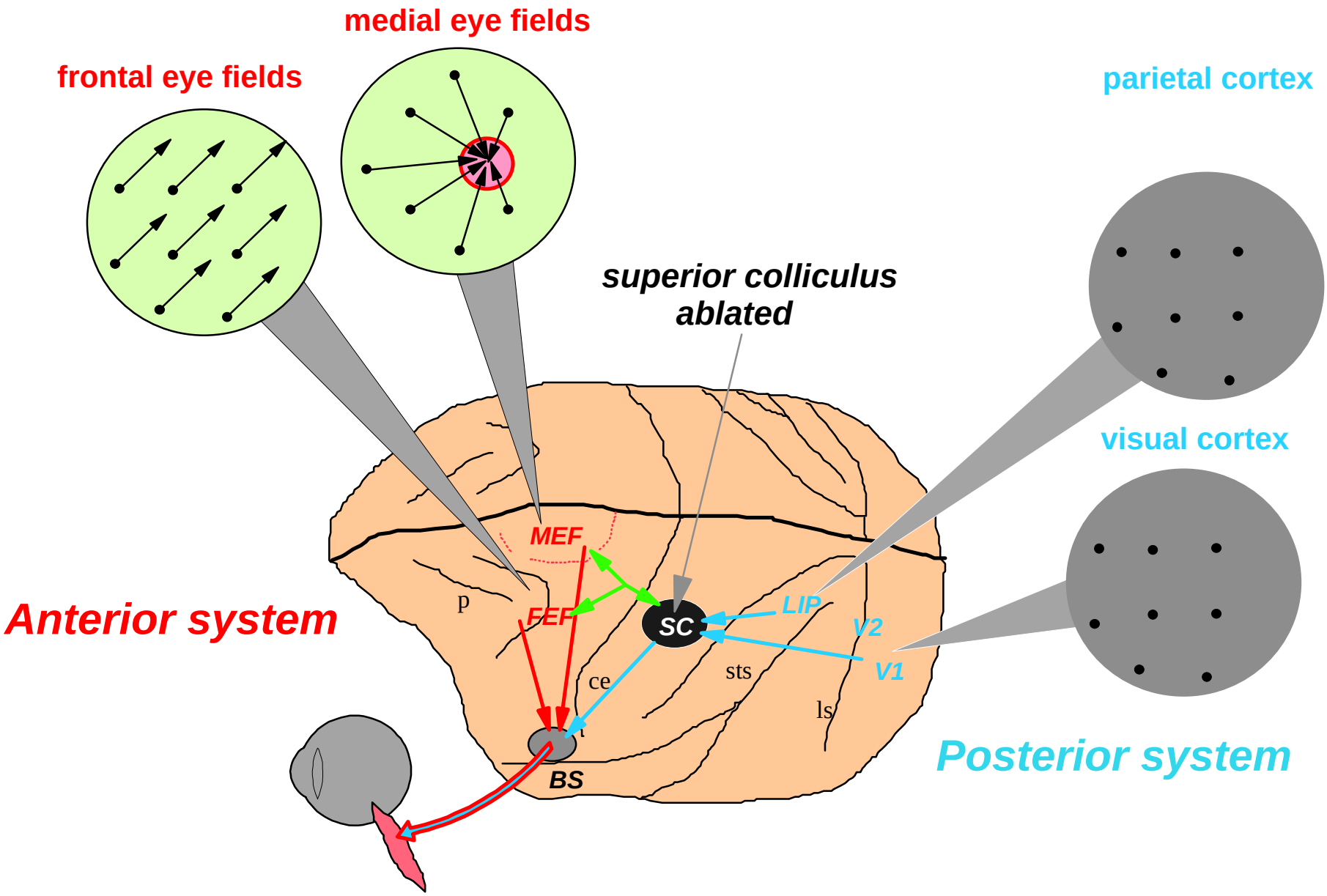
1. Form perception is accomplished by neurons that respond selectively to line segmens of different orientations..

2. Form perception is accomplished by spatial mapping of the visual scene onto visual cortex.

3. Form perception is accomplished by virtue of Fourier analysis.

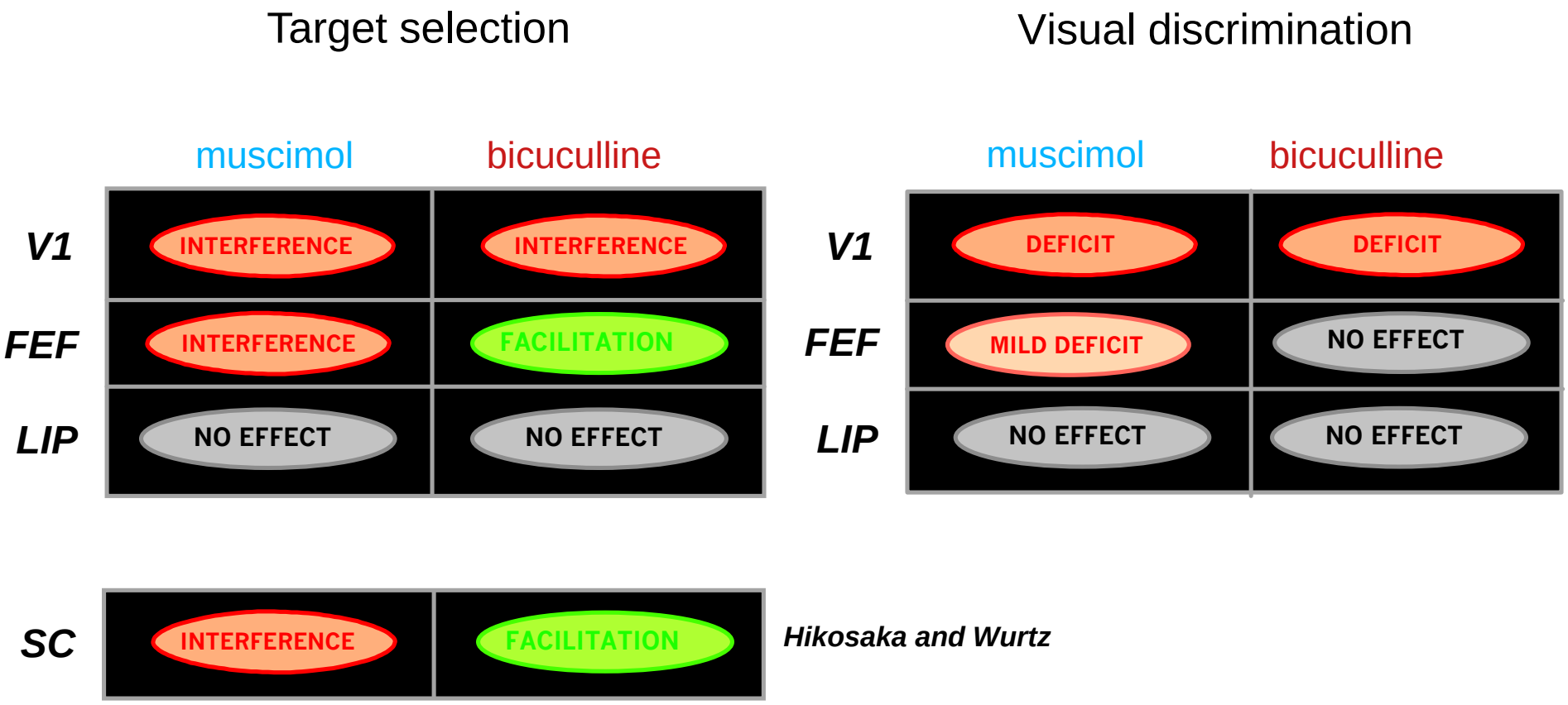
Eye-movement control


superior colliculus
medial eye fields
frontal eye fields
parietal cortex
visual cortex
MEF
FEF
SC
LIP
V2
V1
p
ce
sts
ls
BS

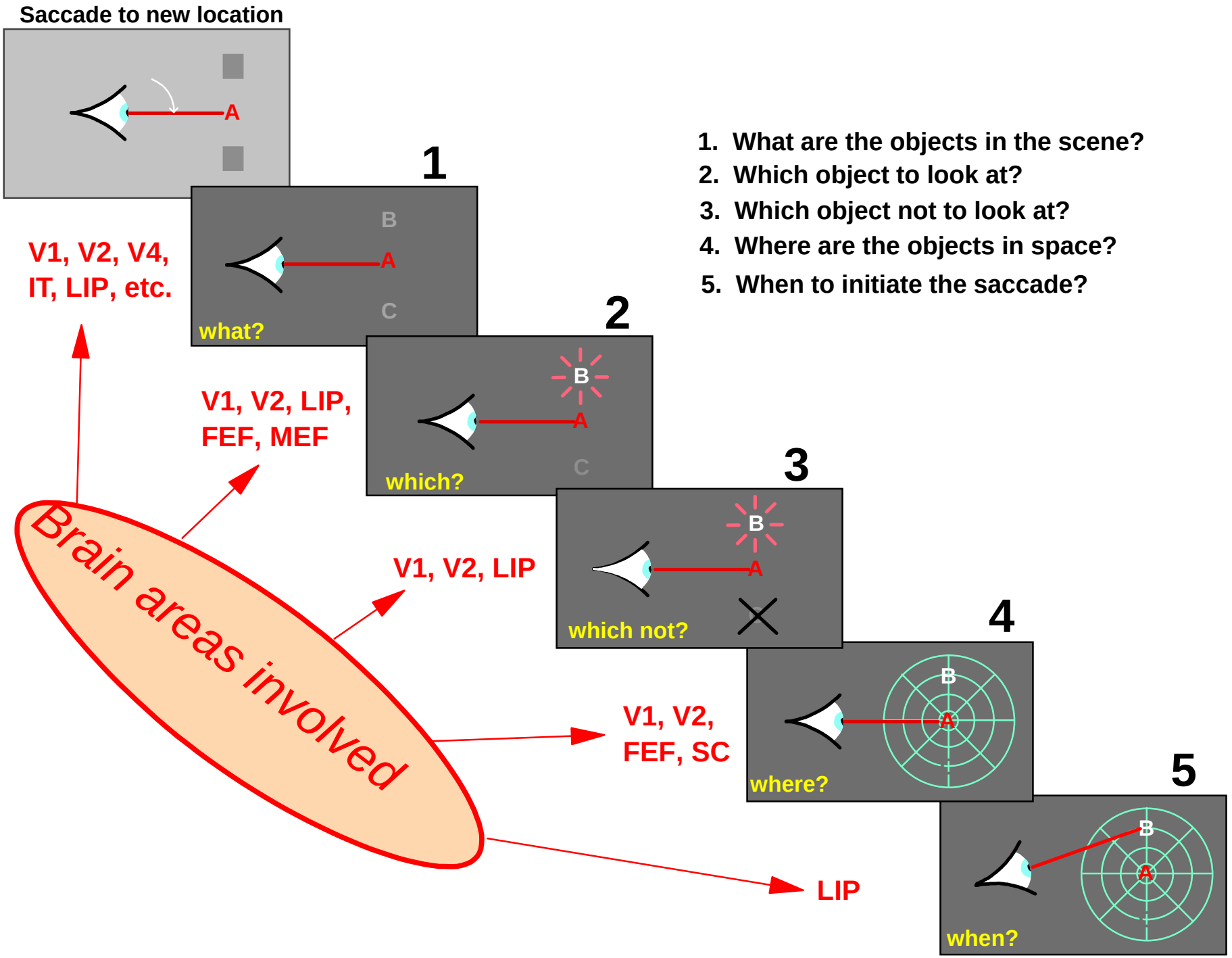

medial eye fields
frontal eye fields
parietal cortex
superior colliculus
ablated
visual cortex
MEF
FEF
SC
LIP
V2
V1
p
ce
sts
ls
BS
Anterior system
Posterior system

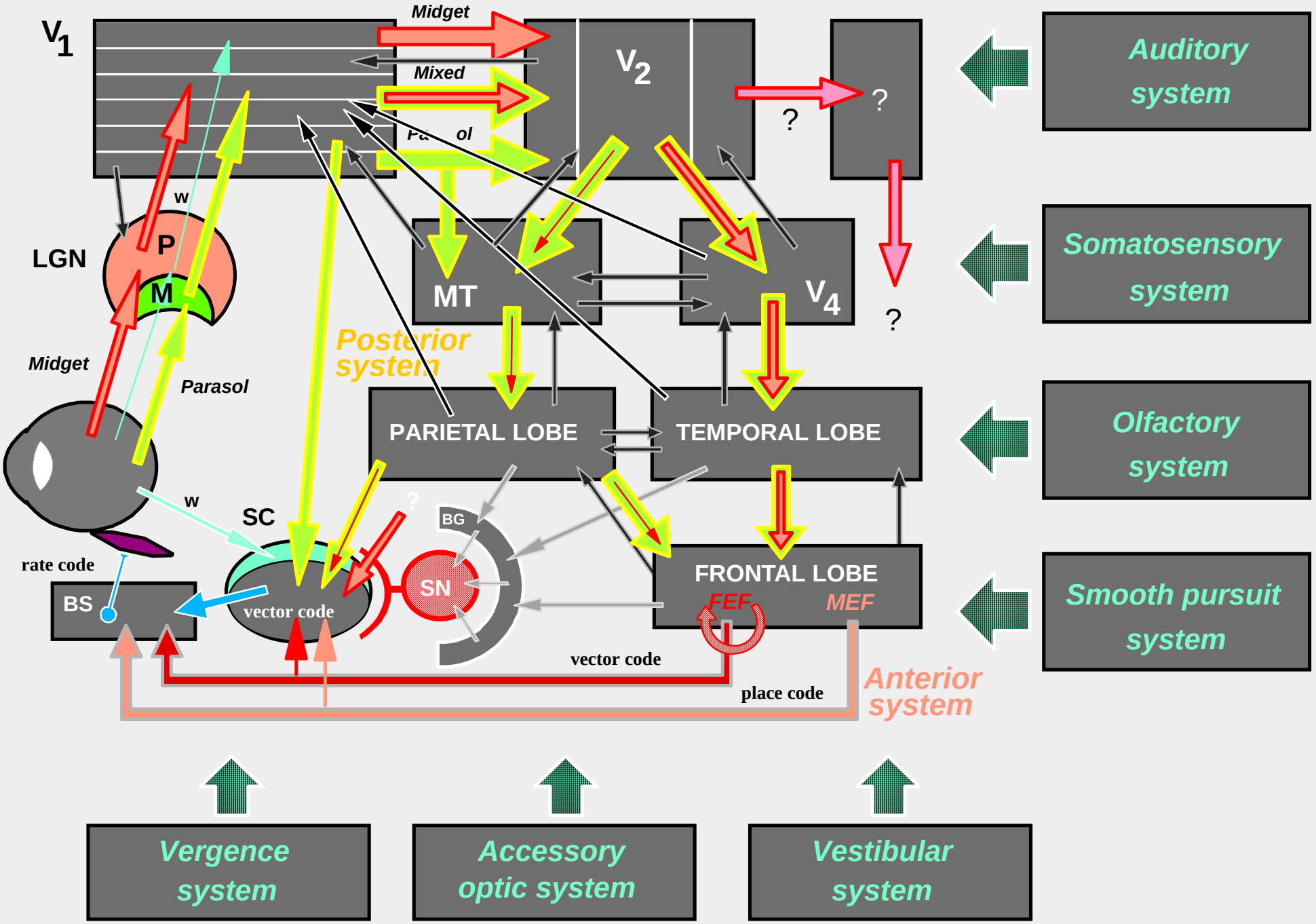
Summary of the effects of electrical stimulation:

Summary of the effects of the GABA agonist muscimol and the GABA antagonist bicuculline



Hikosaka and Wurtz


Saccade to new location
A
1
B
A
C
what?
2
B
A
C
which?
3
B
A
which not?
4
B
A
where?
5
B
A
when?
1. What are the objects in the scene?
2. Which object to look at?
3. Which object not to look at?
4. Where are the objects in space?
5. When to initiate the saccade?
V1, V2, V4,
IT, LIP, etc.
V1, V2, LIP,
FEF, MEF
V1, V2, LIP
V1, V2,
FEF, SC
LIP
Brain areas involved


V1
Midget
Mixed
V2
?
?
Auditory system
w
LGN
P
M
MT
V4
?
Somatosensory system
Midget
Parasol
Posterior system
PARIETAL LOBE
TEMPORAL LOBE
Olfactory system
w
SC
BG
rate code
BS
vector code
SN
FRONTAL LOBE
FEF
MEF
Smooth pursuit system
vector code
place code
Anterior system
Vergence system
Accessory optic system
Vestibular system

Motion perception

Summary of cell types in V1

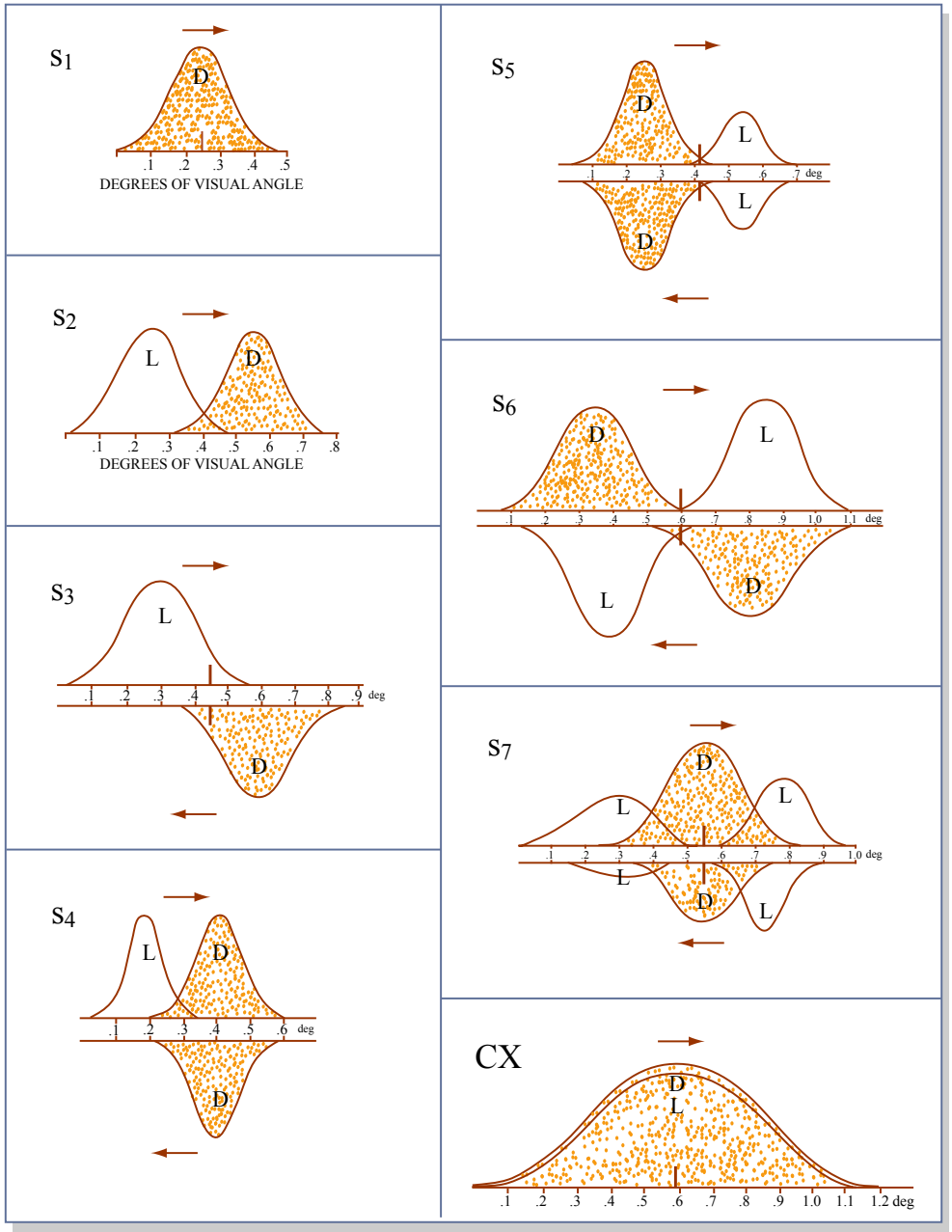
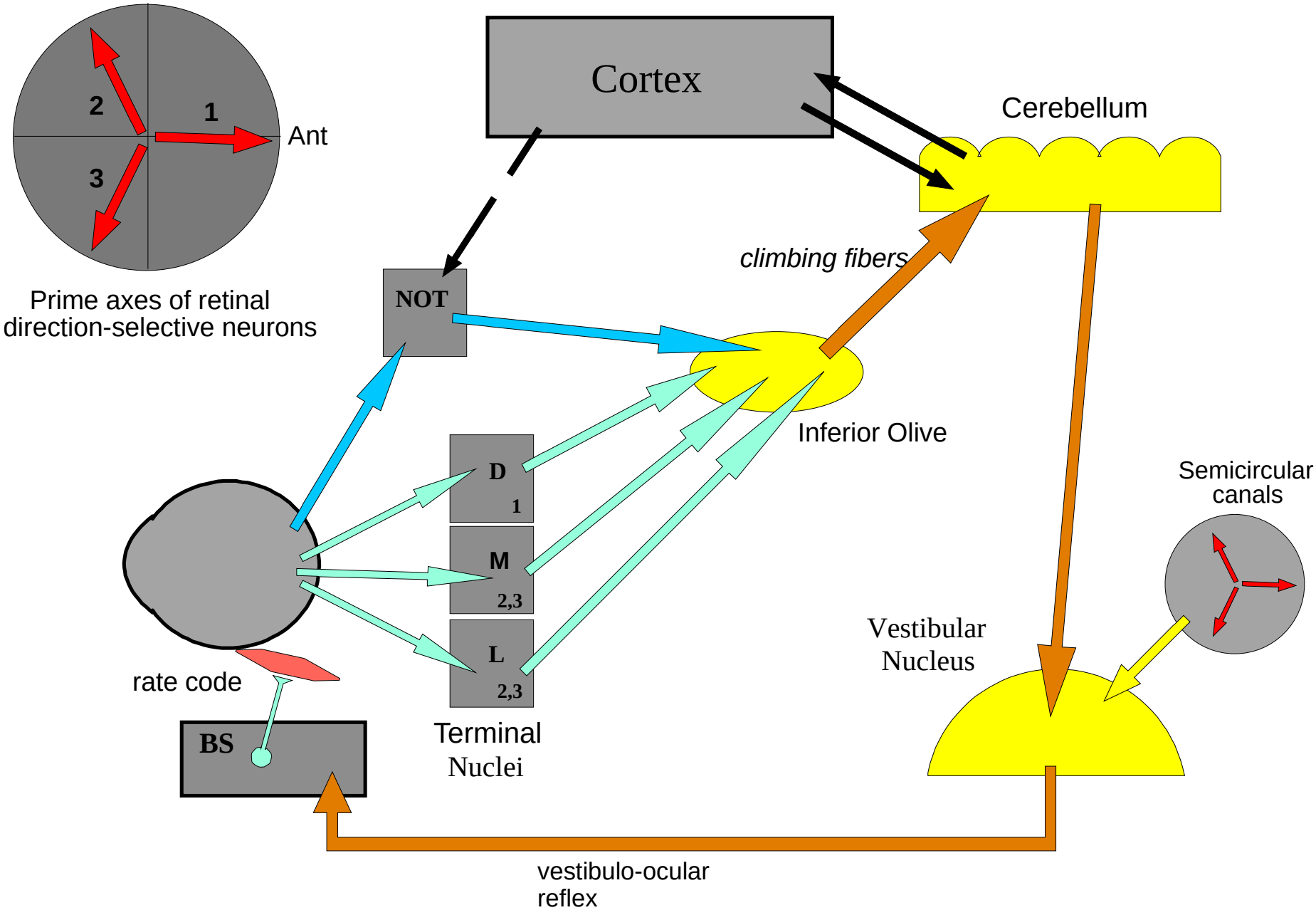


Figure by MIT OCW.

Major Pathways of the Accessory Optic System (AOS)

Velocity response of AOS neurons = 0.1-1.0 deg/sec
Number of AOS RGCs in rabbit = 7K out of 350K



Effects of lesions on vision

Summary of lesion deficit magnitudes

	VISUAL CAPACITY		PLGN	MLGN	V_4	MT
BASIC VISUAL FUNCTIONS	color vision		severe	none	mild	none
	texture perception		severe	none	mild	none
	pattern perception	fine	severe	none	mild	none
	shape perception	fine	severe	none	mild	none
		coarse	mild	none	none	none
	brightness perception		none	none	none	none
	coarse scotopic vision		none	none	none	none
	contrast sensitivity	fine	severe	none	mild	mild
		coarse	mild	none	none	mild
	stereopsis	fine	severe	none	none	none
		coarse	pronounced	none	none	none
	motion perception		none	moderate	none	moderate
	flicker perception		none	severe	none	pronounced
INTERMEDIATE	choice of "lesser" stimuli		severe	none	severe	none
	visual learning		not tested	not tested	severe	none
	object transformation		not tested	not tested	pronounced	not tested

Prosthetics

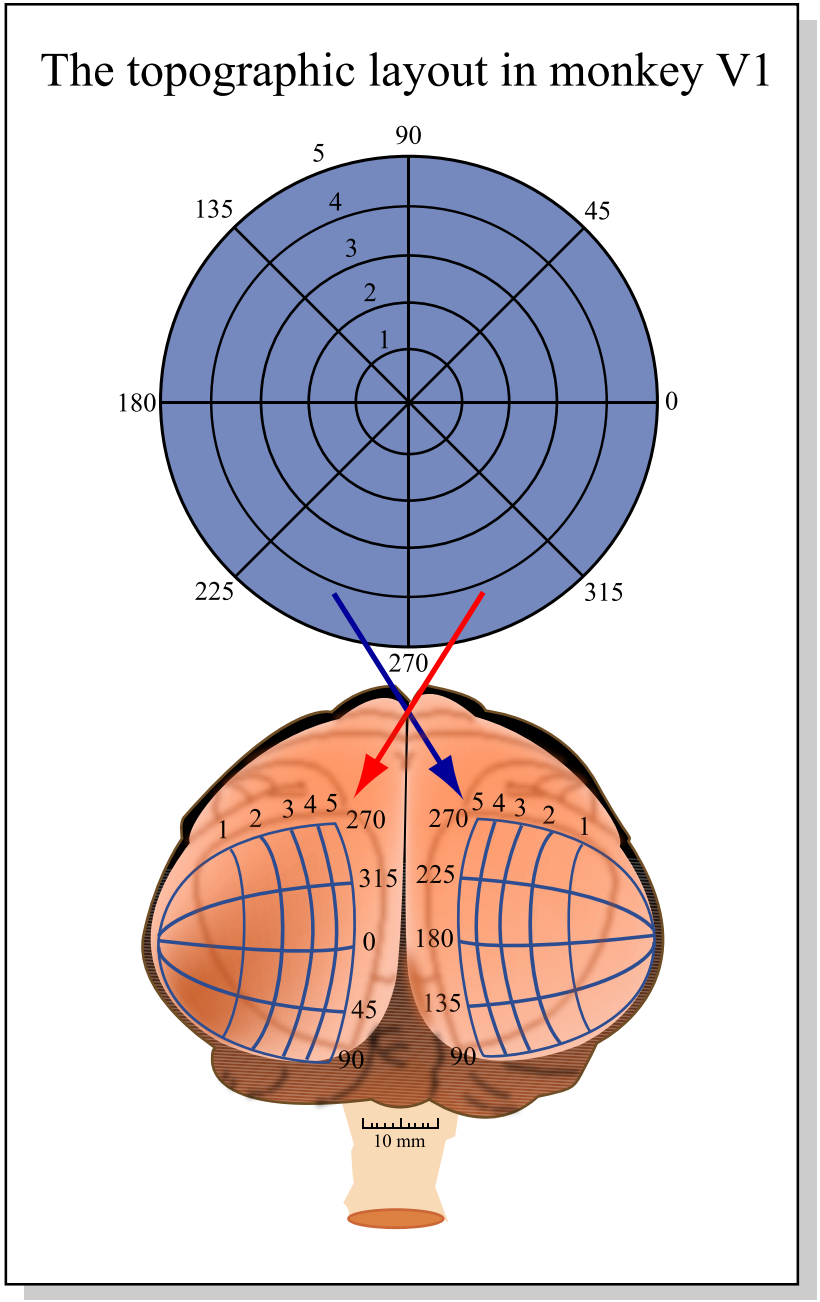
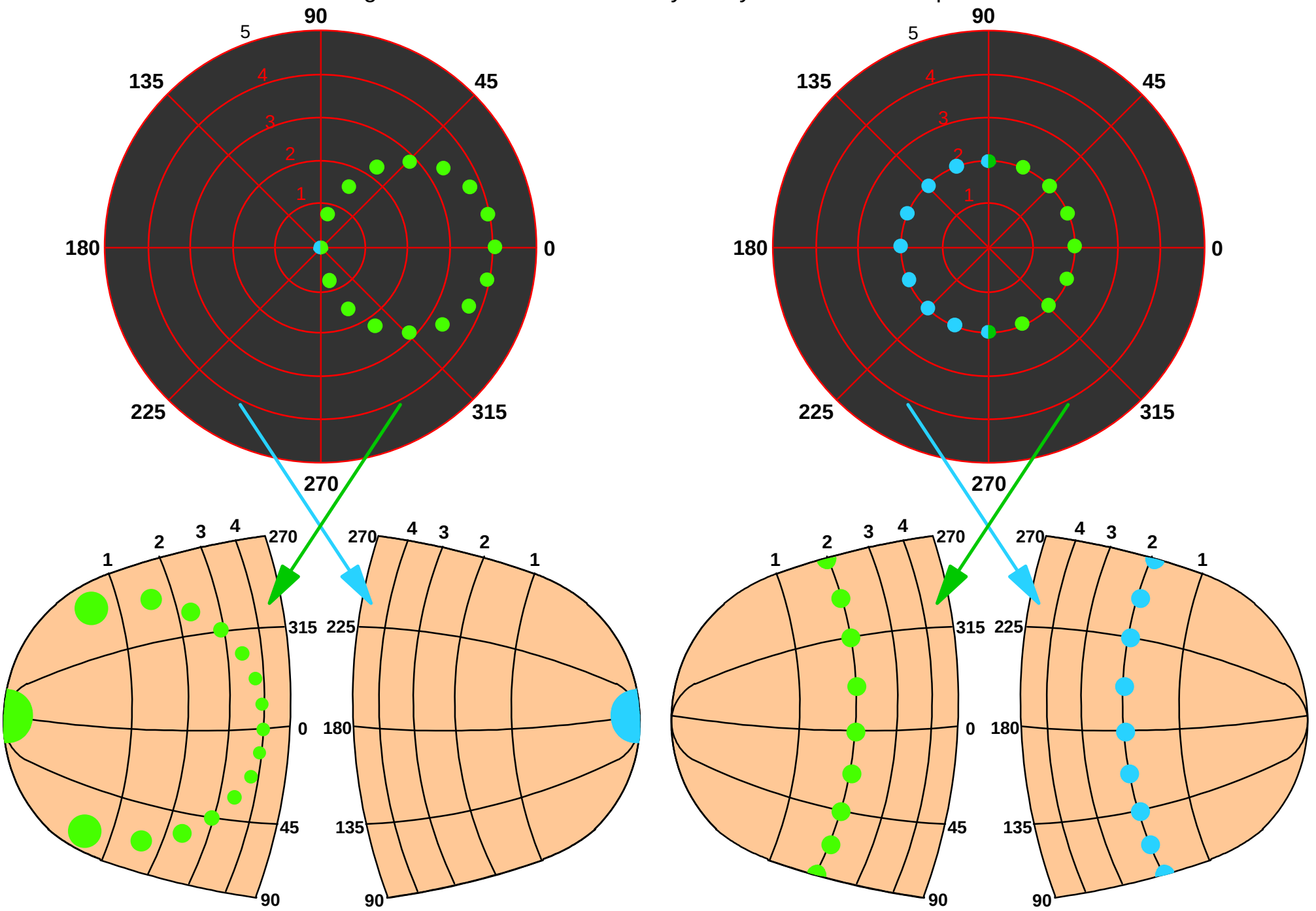


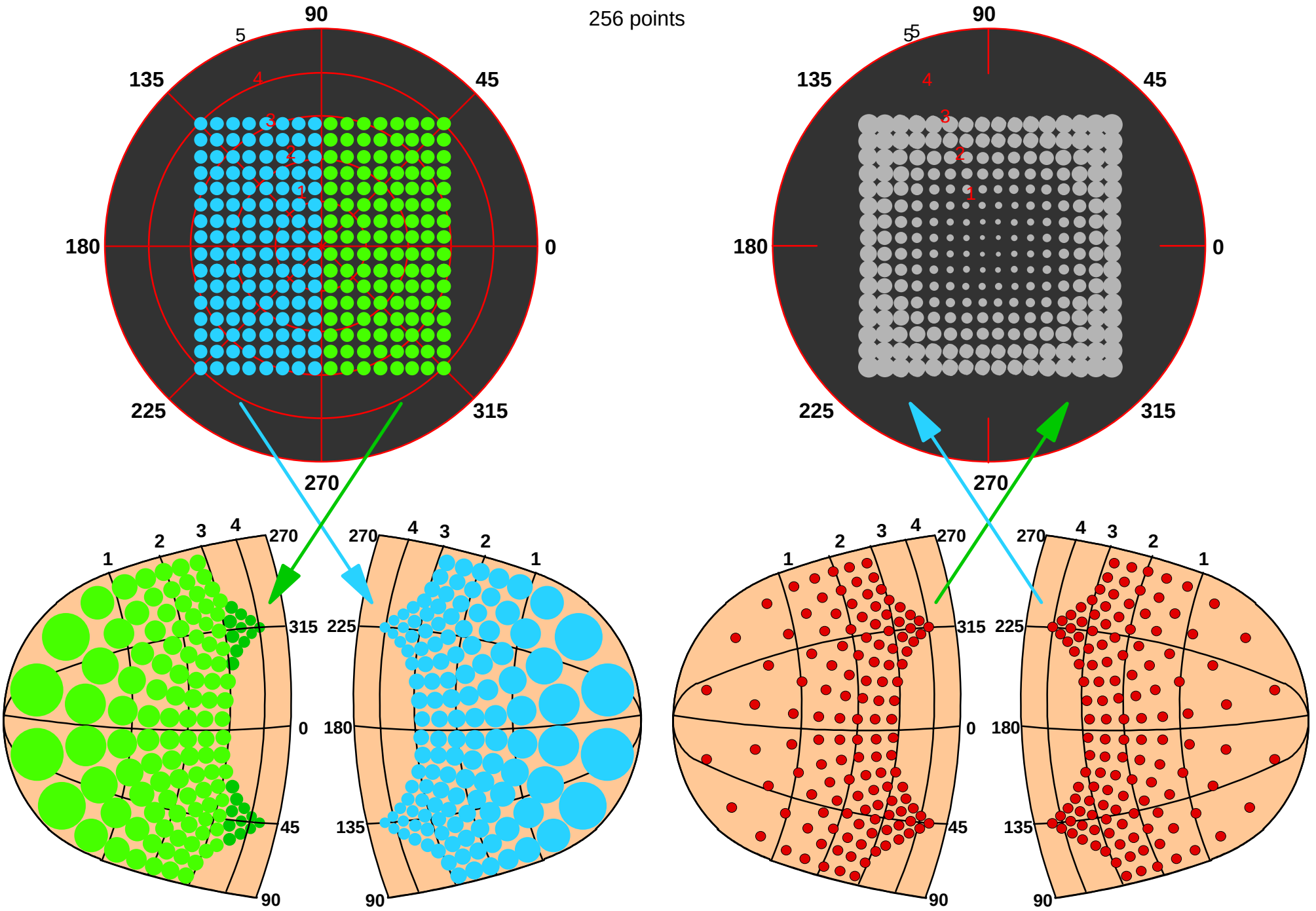
Figure by MIT OCW.

The size and location of the regions activated in the monkey V1 by the dotted circle presented in the visual field



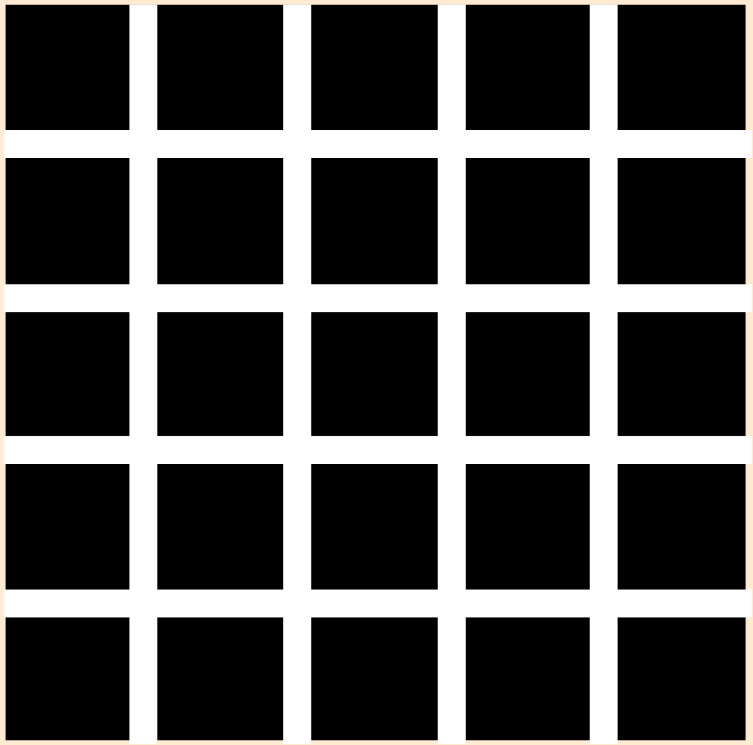
The size and location of the regions activated in the monkey V1 by the dots presented in the visual field

256 points

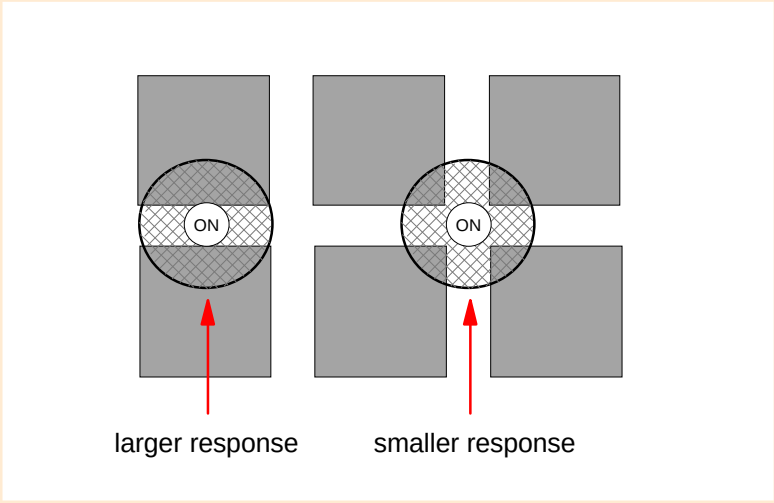


Illusions

The Hermann grid illusion

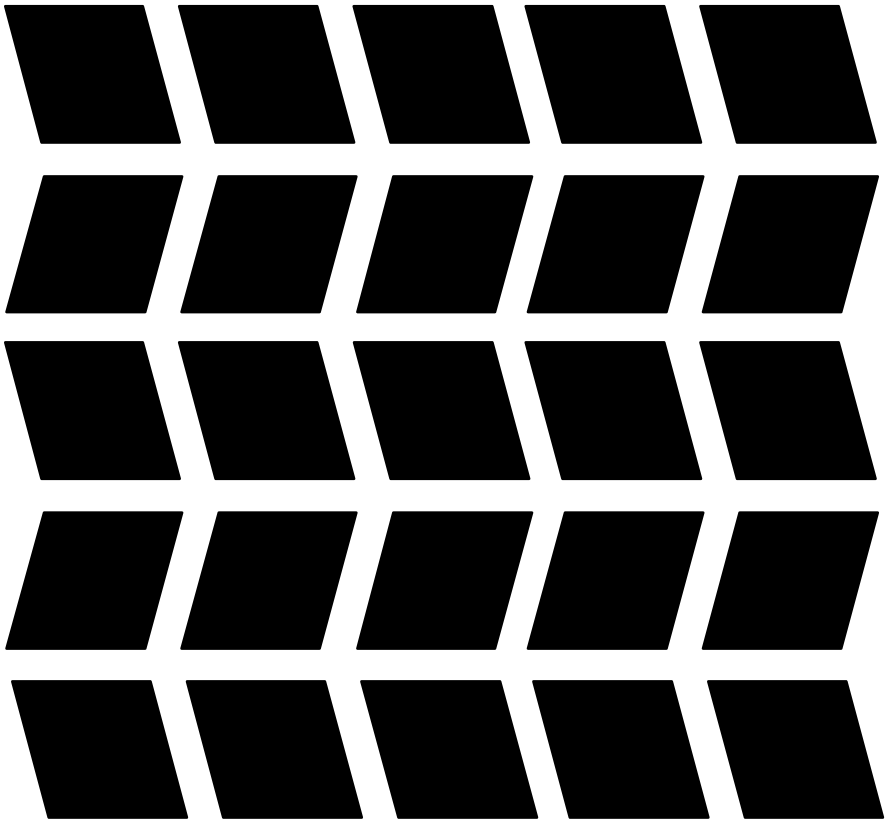


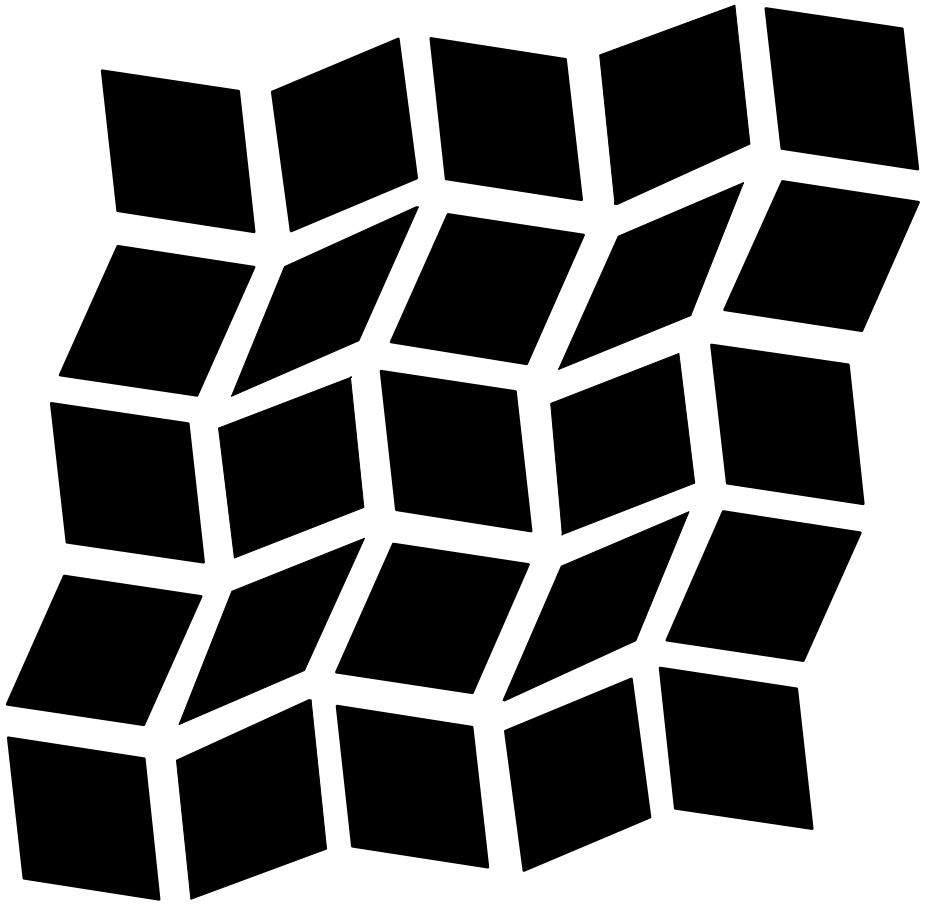
The most widely cited theory purported to explain the illusion:



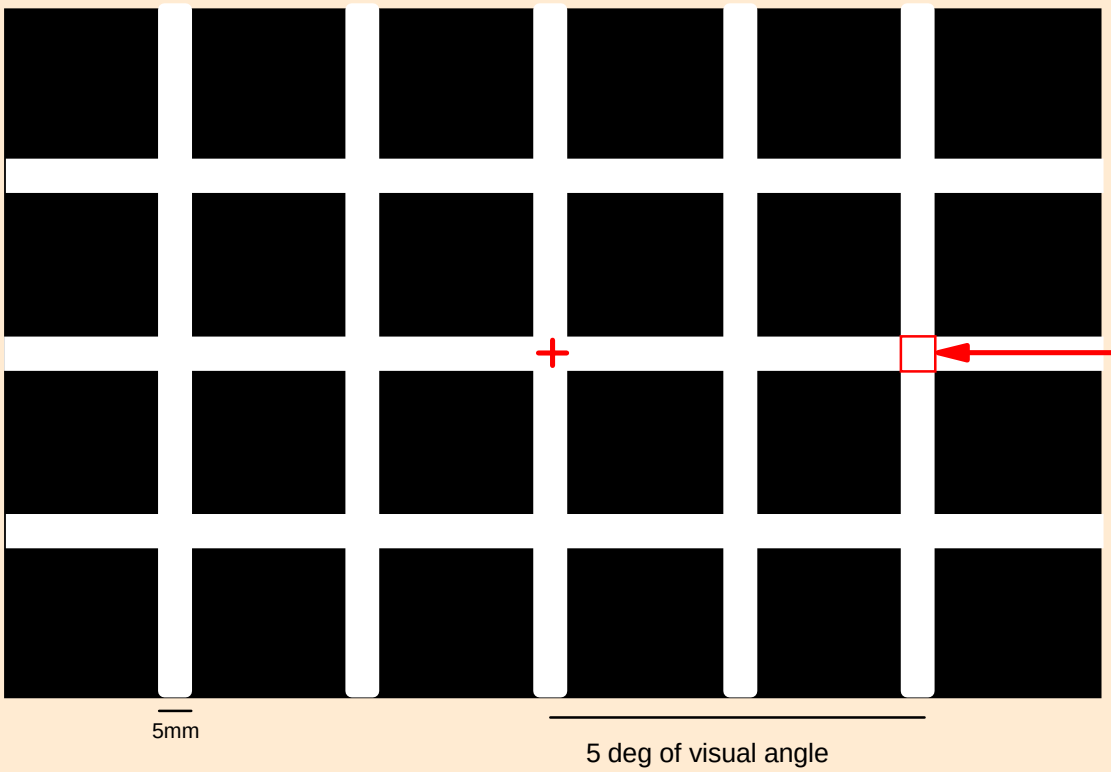
Due to antagonistic center/surround organization, the activity of ON-center retinal ganglion cells whose receptive fields fall into the intersections of the grid produces a smaller response than those neurons whose receptive fields fall elsewhere.

Differently oriented vertical and horizontal lines reduce illusion



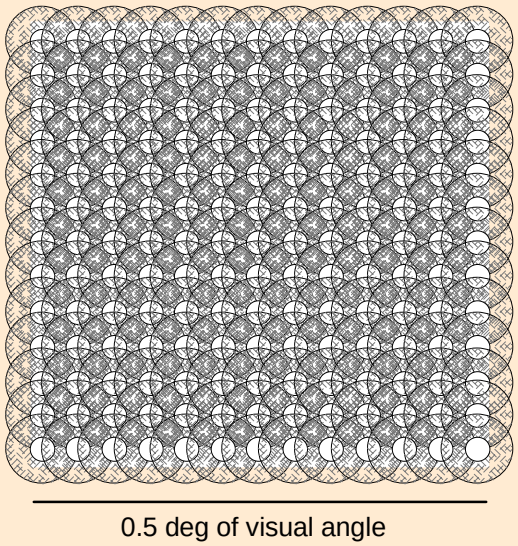


Retinal ganglion cell receptive field layout at an eccentricity of 5 degrees



At the eccentricity of 5 degrees the 0.5 by 0.5 degree visual angle area outlined impinges on 365 midget cells and 50 parasol cells. Half of these are ON and half OFF cells. The layout of the ON cells is shown in B and C.

Retinal midget cells



Retinal parasol cells