# Chap.4. Sensation & perception

Movement
Latin animus means “consciousness”

Sea squirt

swimming immature larvae has primitive devices comparable to brain
immotile mature form consumes its own brain

For stationary life forms no brain is necessary

http://www.horizons-2000.org/2.%20Ideas%20and%20Meaning/Topics/NeuroPsychology.htm

# How is light registered in the brain?

Conversion of light energy into electrical impulses
Two light sensitive cells

- rod: sensitive to light (mediated by rhodopsin)
- cone: sensitive to color
  - wavelength dependent excitation of red, green, or blue cells

Images are relayed into the brain with an enormous bias

- retina is more concerned with states of change (spatiotemporal)
  - such as contrasting edges or movement

Nerve fibers exiting via the blind spot to the thalamus and then to visual cortex
What happen in the visual cortex?

# Patients with visual problems

1. A woman damaged in the visual cortex
   deficient in detecting moving objects
2. George Riddoch
   see movement but not shape or color
3. See form and movement but not experience color
   deficit of cones or damage to visual cortex
4. See movement and color but not form: agnosia (failure to recognize)
   see objects but not identify
   vary in its severity and time dependent
   Is it because there is a gradual process of integrating patterns?

Vision of form, movement, and color occur independently of each other
They are processed simultaneously but in different parts of the brain
How and where they are integrated?

A hypothesis of grand central station

- convergence of different pathways
- but there should be a area which, when damaged,
  - leads to complete loss of vision

A hypothesis of interactive parallel brain regions

- connections between brain regions are not directed to converge
  - into an executive center
- but are likely to take the form of balanced dialogues between them

## Seeing and recognition

Is it possible to separate visual event from

- the intervention of consciousness into the visual process?
- activation of parts of brain under visual process
  - is reproduced under unconsciousness condition

Blind sight

Separation of visual process from conscious awareness
- patients who cannot see but guess objects: blind sight
- meaning that the brain is still functioning
  - but the consciousness is lost of actually seeing the object

Rupture in the balanced circuitry: suggested by Zeki
- dialogue between brain regions are not operational
- balance between the two signals (feedback pathways)
  - signals to cortex for processing
  - signals intercepting the incoming information
  - (modification of the information leading to final conscious experience)

Blind sight is conditional: physical entity and properties of the object

Prosopagnosia: face blindness

- the reverse of blind sight: awareness without recognition
- but improved by psychological linkage
- consciousness depends on more than one factor

Perceptions are unified wholes

- depending on personal characters
- visual process (objective) + consciousness (subjective)

<u>Vision in three steps</u>

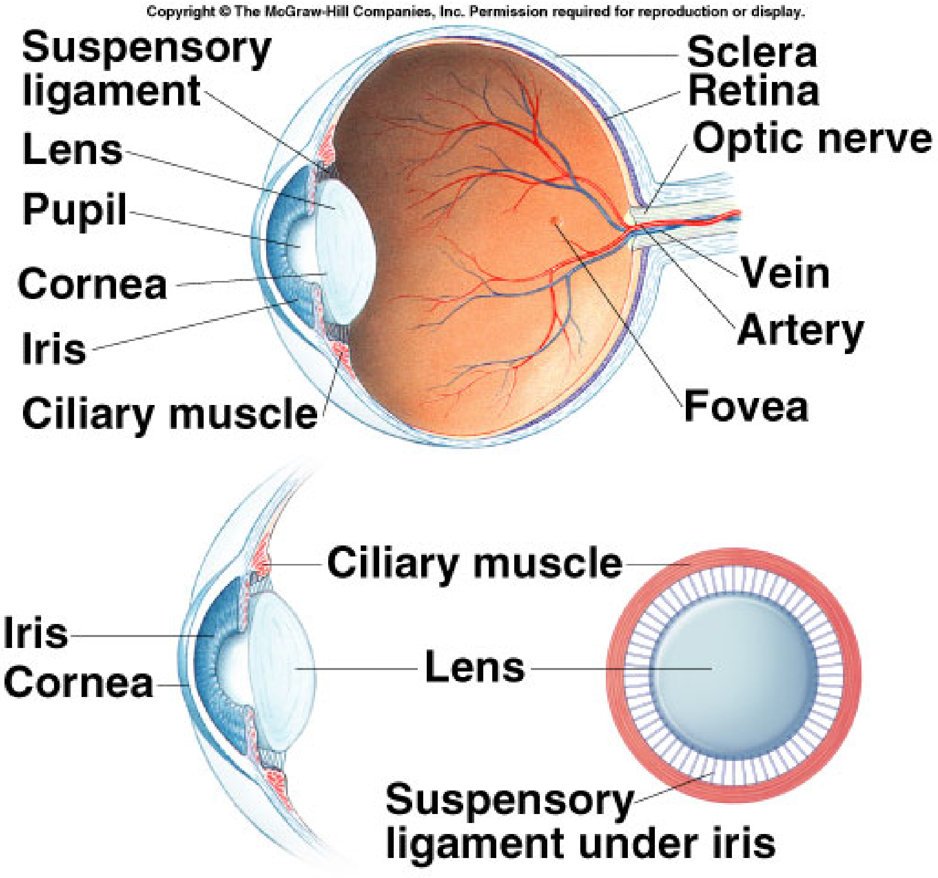
- Visual transduction
- Visual processing
- Recognition (conscious awareness)

Why the electrical signal in the visual cortex is experienced as vision?
Learn through experience?
Linked to movement?

A mixing of senses: synesthesia

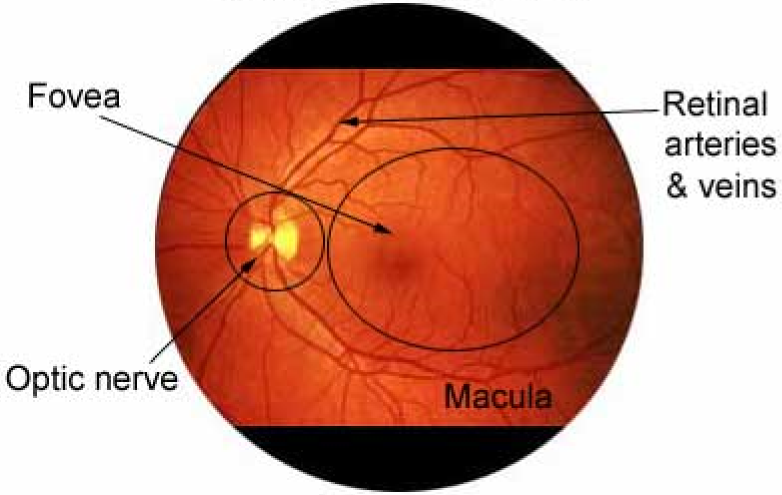
- see musical notes in colors
- mostly in childhood or schizophrenia or hallucination
- probably a problem of association cortex
  - a malfunctioning of physiology rather than anatomy

# Human Eye

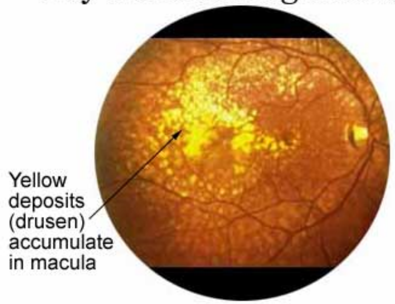



http://optics.snu.ac.kr/on-line/bong/eye1.html

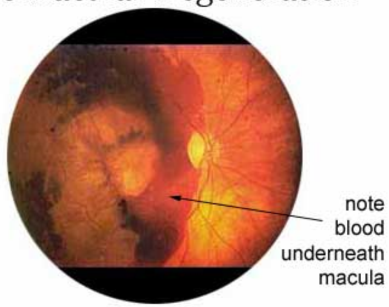
## Normal Macula




## Dry Macular Degeneration




## Wet Macular Degeneration



# Structure of the Retina

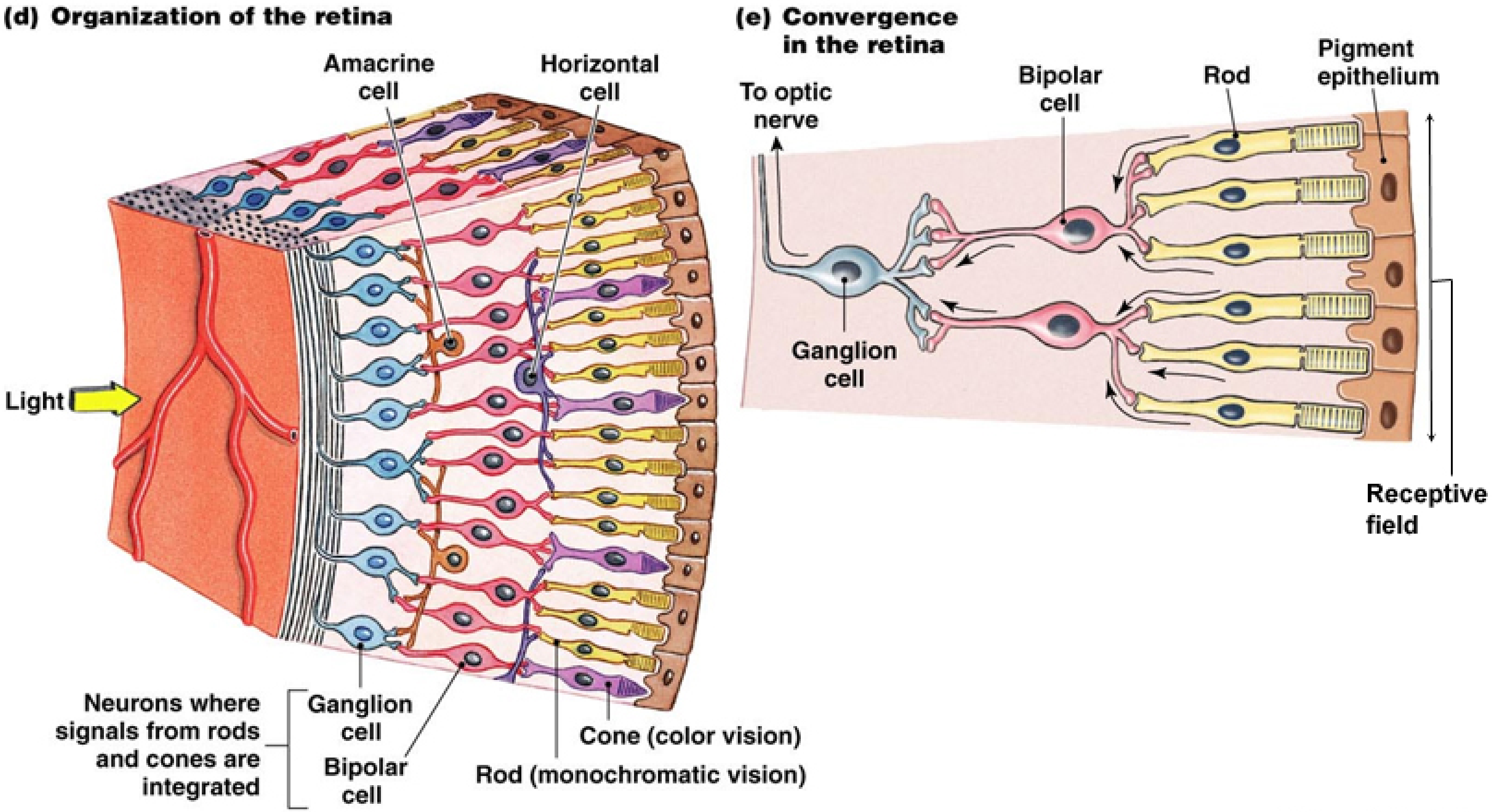
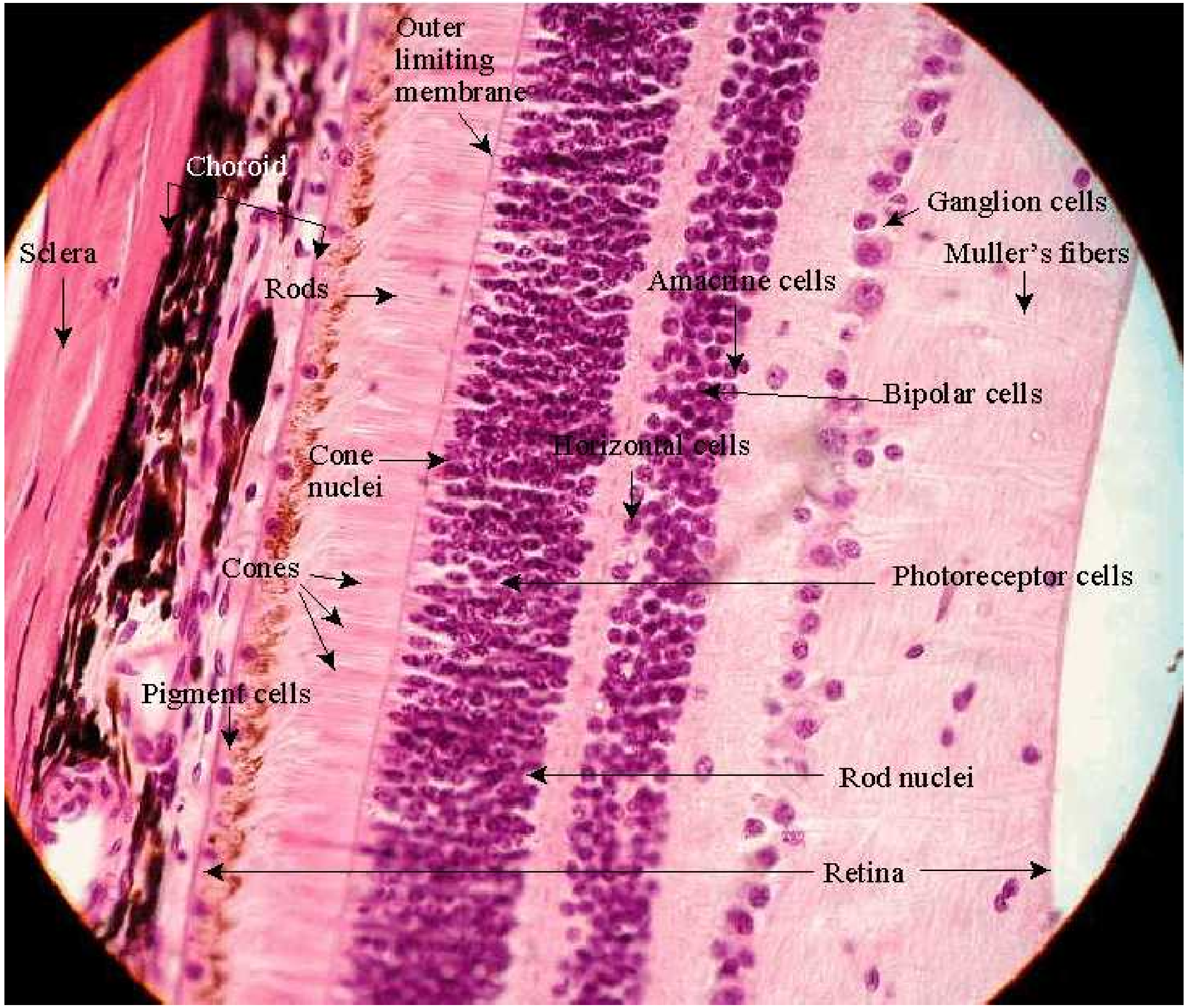





Fig. 10-35

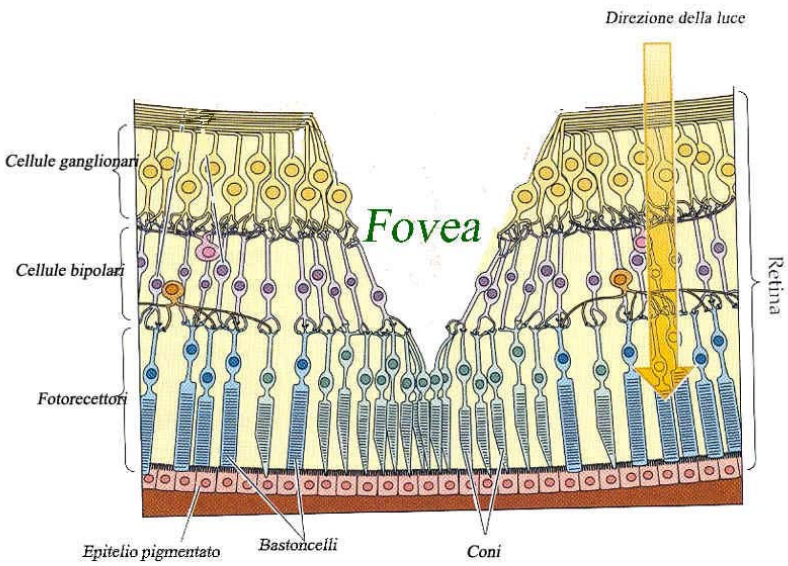
•**rods** - 130,000,000

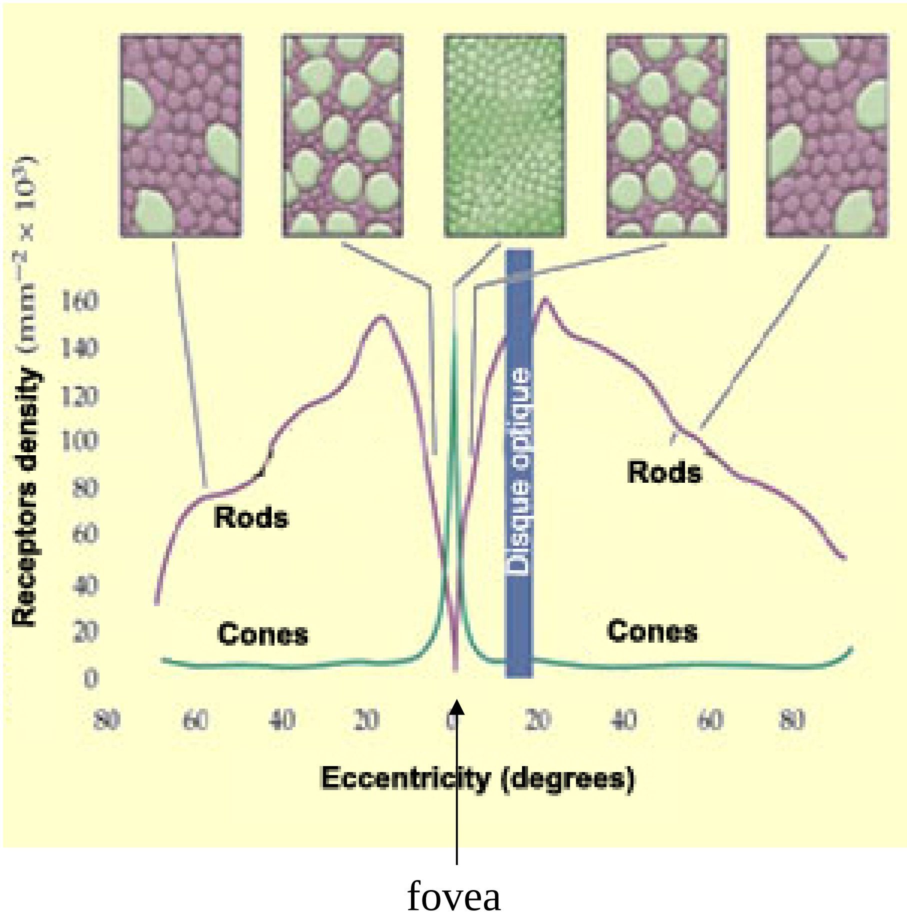
•**cones** - 7,000,000: concentrated in fovea, three types



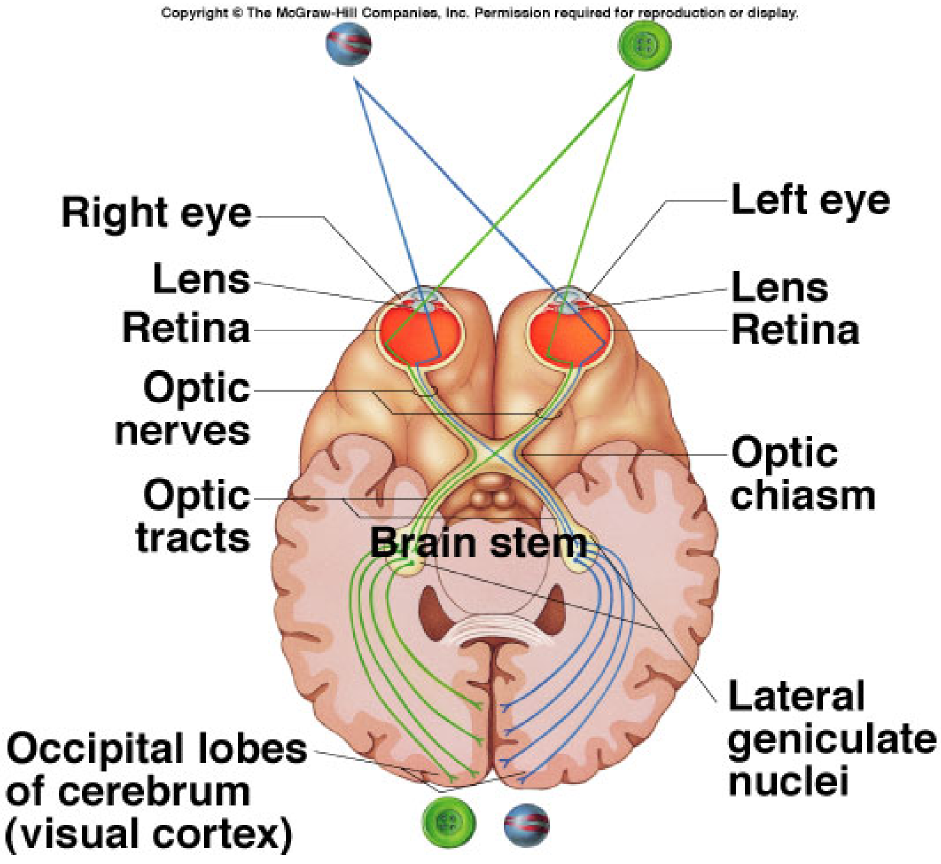

http://www.1800myeyedoc.com/faqaboutus/view.nhtml?profile=faqaboutus&UID=10022

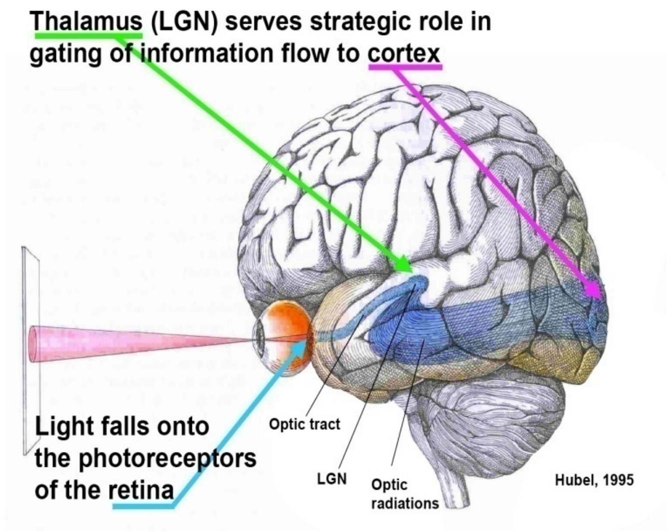
# Distribution of rods and cones in retina

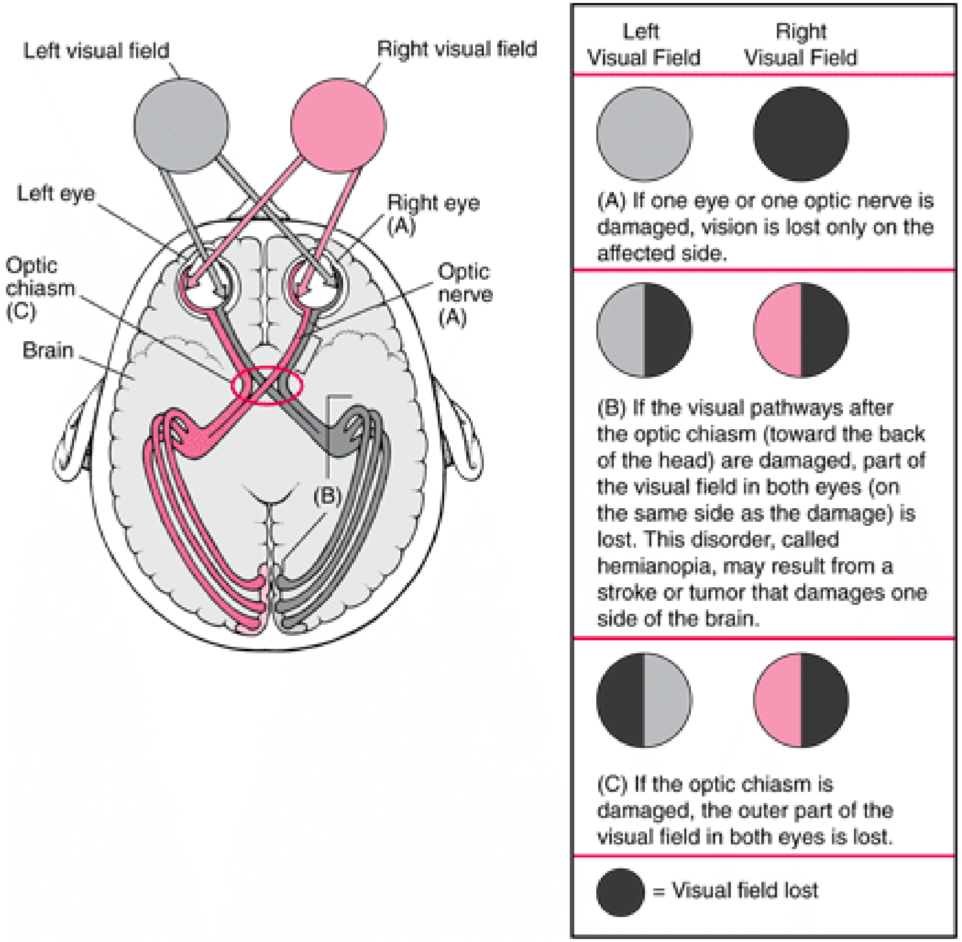


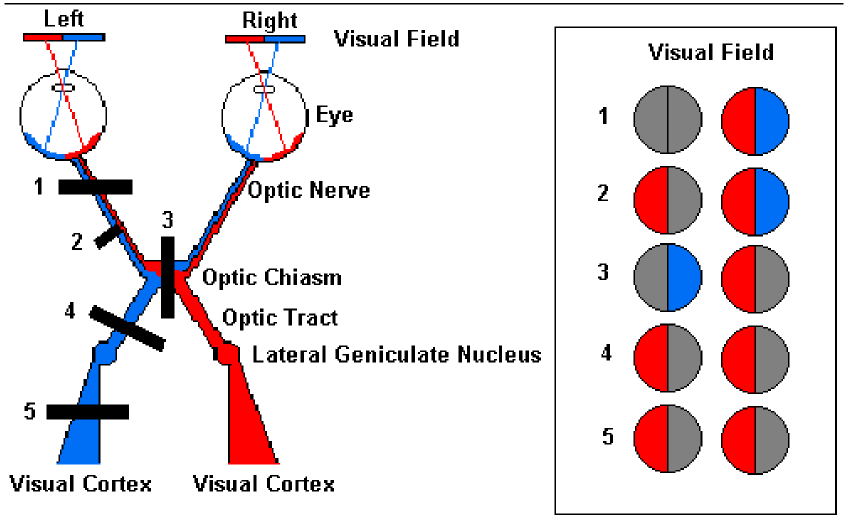



# Pathway of Visual Information





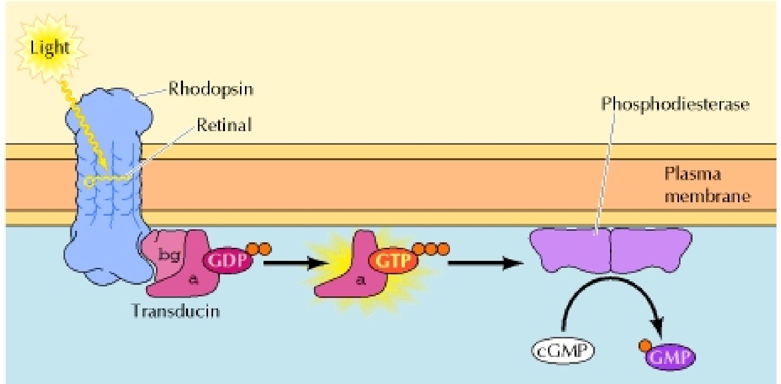




http://www.merck.com/mmhe/sec20/ch225/ch225b.html

http://faculty.washington.edu/chudler/vispath.html

# Photoreceptor cells

Light induced transformation of 11-cis to all-trans retinal
RPE65 protein regenerates 11-cis retinal



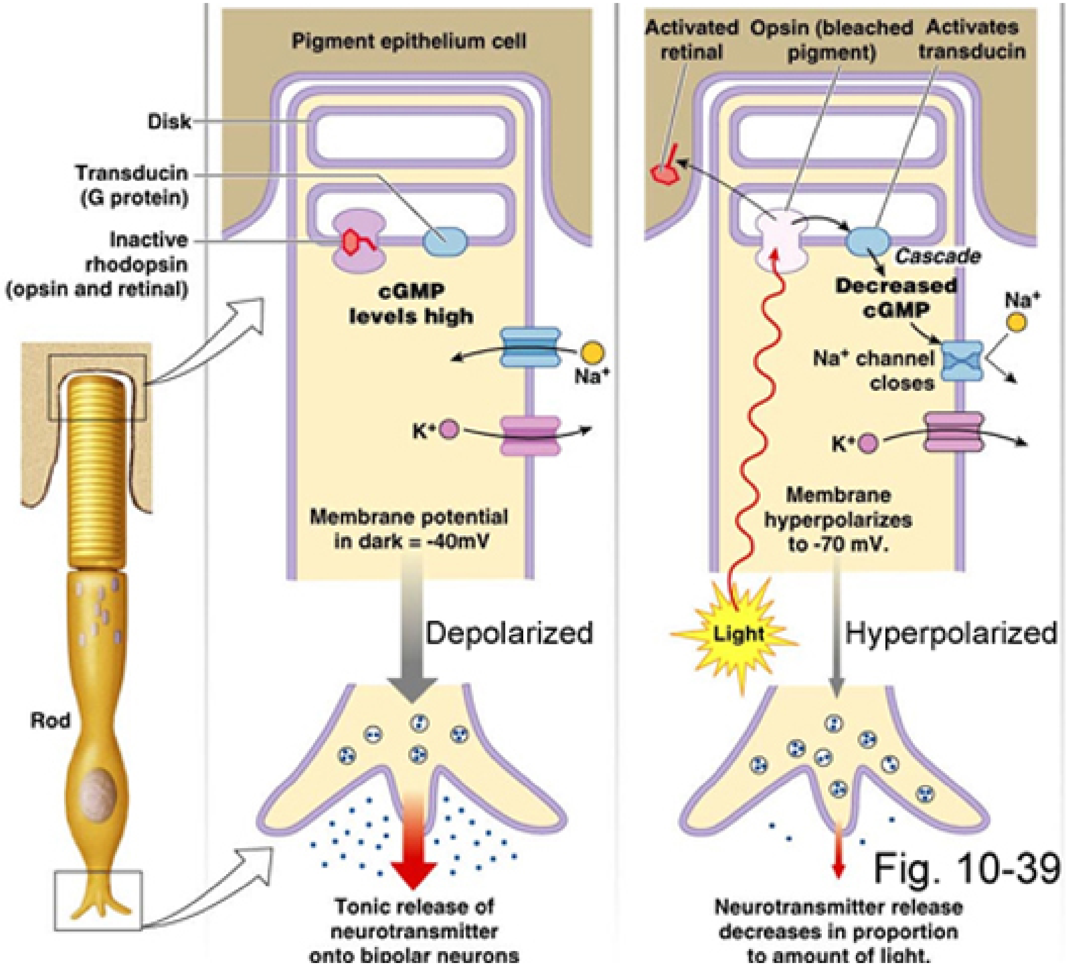
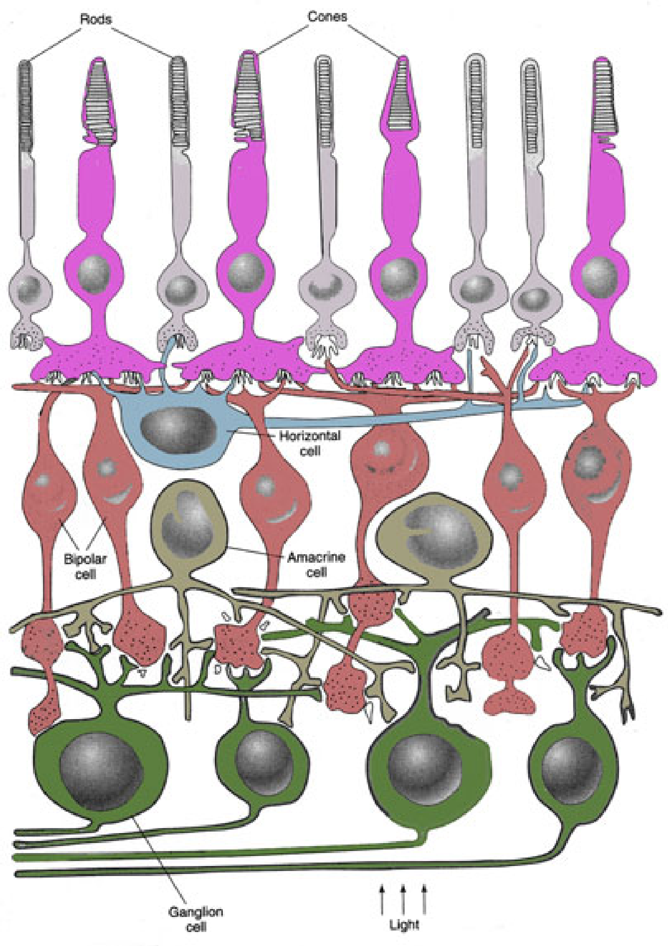




Fig. 10-39

## Horizontal cells

The laterally interconnecting neurons in the outer plexiform layer of the retina of mammalian eyes.
They help integrate and regulate the input from multiple photoreceptor cells. Among their functions, horizontal cells are responsible for allowing eyes to adjust to see well under both bright and dim light conditions.
They span across cones and summate inputs from them all to control the amount of GABA released back onto the photoreceptor cells, which hyperpolarizes them. Their arrangement together with the on-center and off-center bipolar cells that receive input from the photoreceptors constitutes a form of lateral inhibition, increasing spatial resolution at the expense of some information on absolute intensity. The eye is thus more sensitive to contrast and differences in intensity.



**Bipolar cells**

Bipolar cells are so-named as they have a central body from which two sets of processes arise. They can synapse with either rods or cones (but not both), and they also accept synapses from horizontal cells. The bipolar cells then transmit the signals from the photoreceptors or the horizontal cells, and pass it on to the ganglion cells. Unlike many neurons, bipolar cells communicate via graded potentials, rather than action potentials.

Bipolar cells can be categorized into two different groups, ON and OFF, based on how they react to glutamate released by photoreceptor cells. When light hits a photoreceptor cell, the photoreceptor hyperpolarizes, and releases less glutamate. An ON bipolar cell will react to this change by depolarizing. An OFF bipolar cell will react to this decrease in glutamate by hyperpolarizing.

Under dark conditions, a photoreceptor cell will release glutamate, which inhibits the ON bipolar cells and excites (or activates) the OFF bipolar cells. In light, however, light strikes the photoreceptor which causes it to be inhibited, and thus no glutamate to be given off. In this scenario, the ON bipolar loses its inhibition and becomes active, while the OFF bipolar cell loses its excitation and becomes silent.

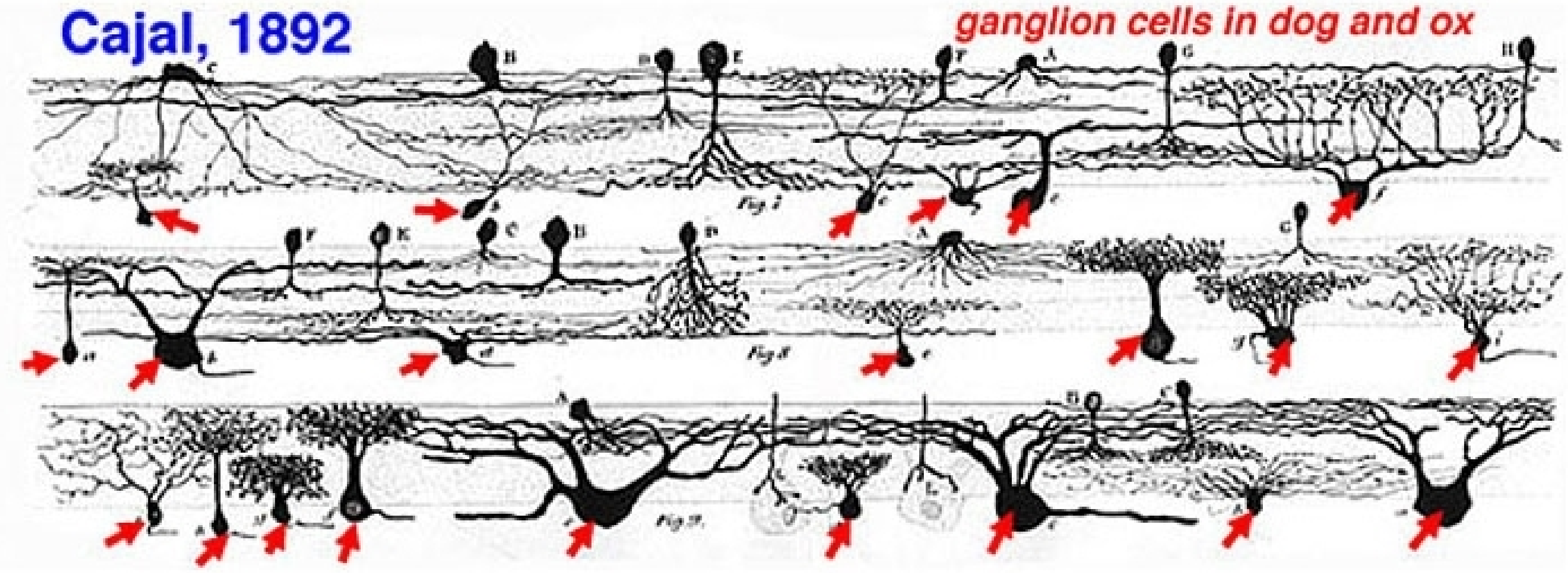
**Amacrine cells**

Amacrine cells are interneurons in the retina. Amacrine cells are responsible for 70% of input to retinal ganglion cells. Bipolar cells, which are responsible for the other 30% of input to retinal ganglia, are regulated by amacrine cells.

There are about 40 different types of amacrine cells, most lacking axons. Like horizontal cells, amacrine cells work laterally affecting the output from bipolar cells, however, their tasks are often more specialized. Each type of amacrine cell connects with a particular type of bipolar cell, and generally has a particular type of neurotransmitter. One such population, AII, 'piggybacks' rod bipolar cells onto the cone bipolar circuitry. It connects rod bipolar cell output with cone bipolar cell input, and from there the signal can travel to the respective ganglion cells.

They are classified by the width of their field of connection, which layer(s) of the stratum in the IPL they are in, and by neurotransmitter type. Most are inhibitory using either GABA or glycine as neurotransmitters.

# Retinal ganglion cells




Based on their projections and functions, there are at least five main classes of retinal ganglion cells:

- Midget cell (Parvocellular, or P pathway; B cells)
- Parasol cell (Magnocellular, or M pathway; A cells)
- Bistratified cell (Koniocellular, or K pathway)
- Other ganglion cells projecting to the superior colliculus for eye movements (saccades)
- Photosensitive ganglion cells

Midget retinal ganglion cells project to the parvocellular layers of the lateral geniculate nucleus.
Parasol retinal ganglion cells project to the magnocellular layers of the lateral geniculate nucleus.
Bistratified retinal ganglion cells project to the koniocellular layers of the lateral geniculate nucleus.

It receives visual information from photoreceptors via two intermediate neuron types: bipolar cells and amacrine cells.
Retinal ganglion cells collectively transmit image-forming and non-image forming visual information from the retina to several regions in the thalamus, hypothalamus, and mesencephalon, or midbrain.
Photosensitive ganglion cell: http://en.wikipedia.org/wiki/Photosensitive_ganglion_cell

# Receptive field

A region of space in which the presence of a stimulus will alter the firing of that neuron. Receptive fields have been identified for neurons of the auditory system, the somatosensory system, and the visual system. If many sensory receptors all form synapses with a single cell further up, they collectively form the receptive field of that cell.

Spatial summation occurs due to the convergence of photoreceptors onto ganglion cells. This convergence of photoreceptors form a receptive field thus stimulating different photoreceptor within this receptive field would result in one signal. Receptive field sizes vary with eccentricity.

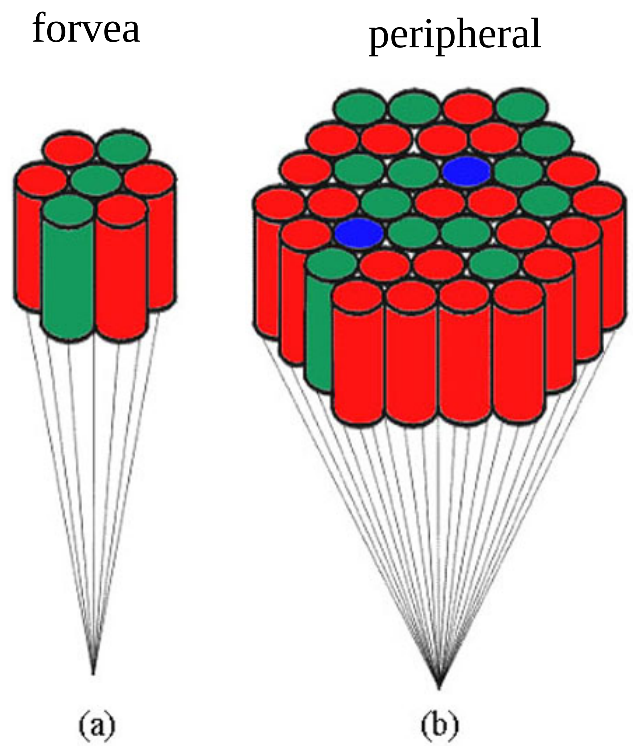
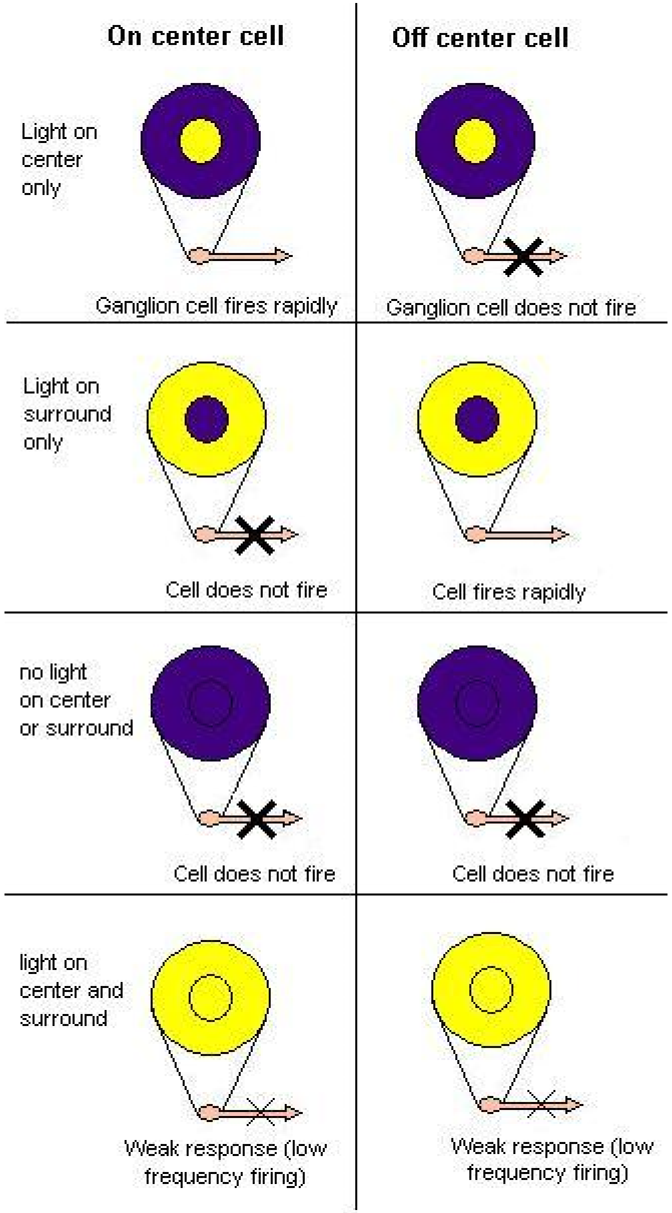



*Figure 26. Schematic illustration of the size of receptive fields in (a) the parafoveal region ($7^{o}$ eccentricity) and in (b) the peripheral retina ($35^{o}$ eccentricity).*

http://webvision.med.utah.edu/KallSpatial.html




On center and off center retinal ganglion cells respond oppositely to light in the center and surround of their receptive fields. A strong response means high frequency firing, a weak response is firing at a low frequency, and no response means no action potential is fired.

The retina uses contrast rather than absolute light intensity for better detection of weak stimuli

http://www.answers.com/topic/receptive-field-jpg-1

# Projection to visual cortex

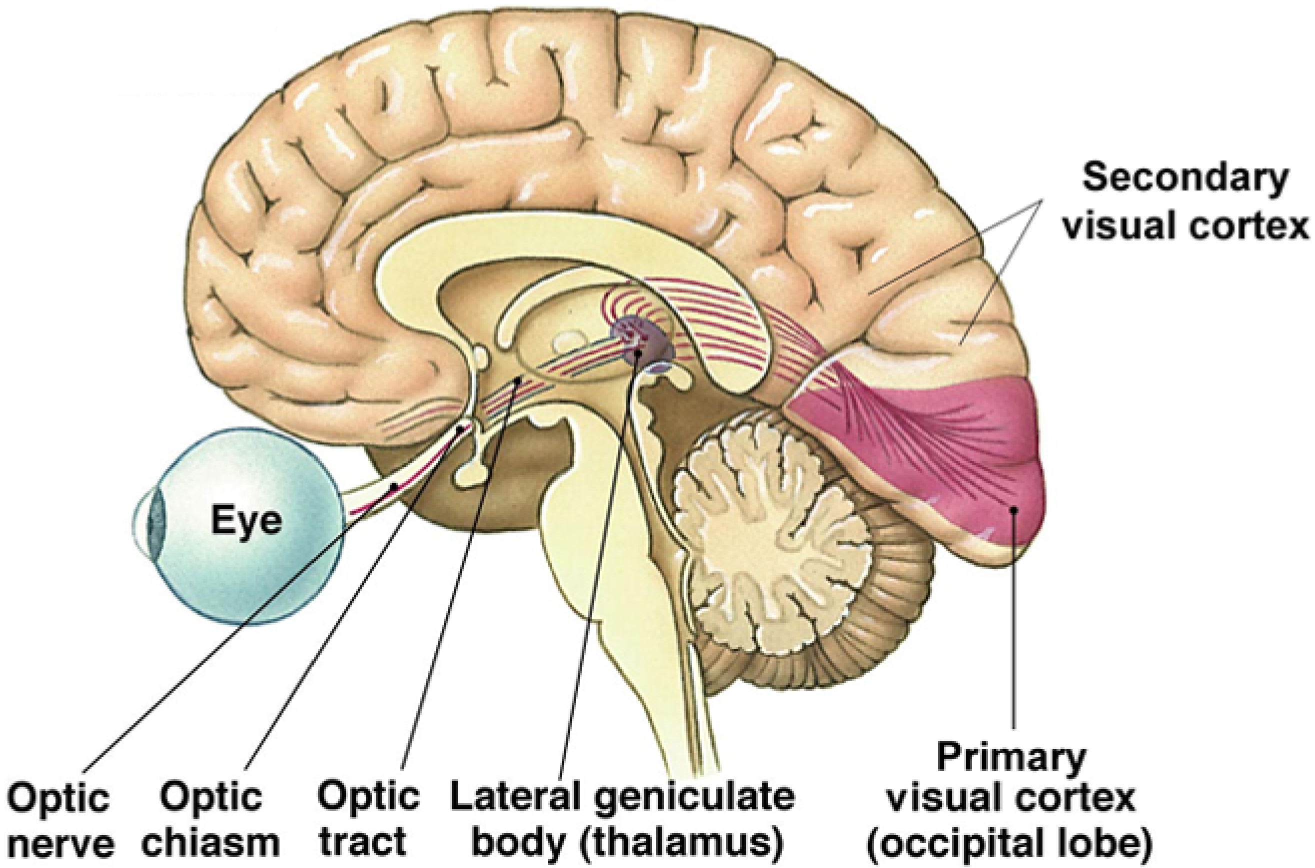
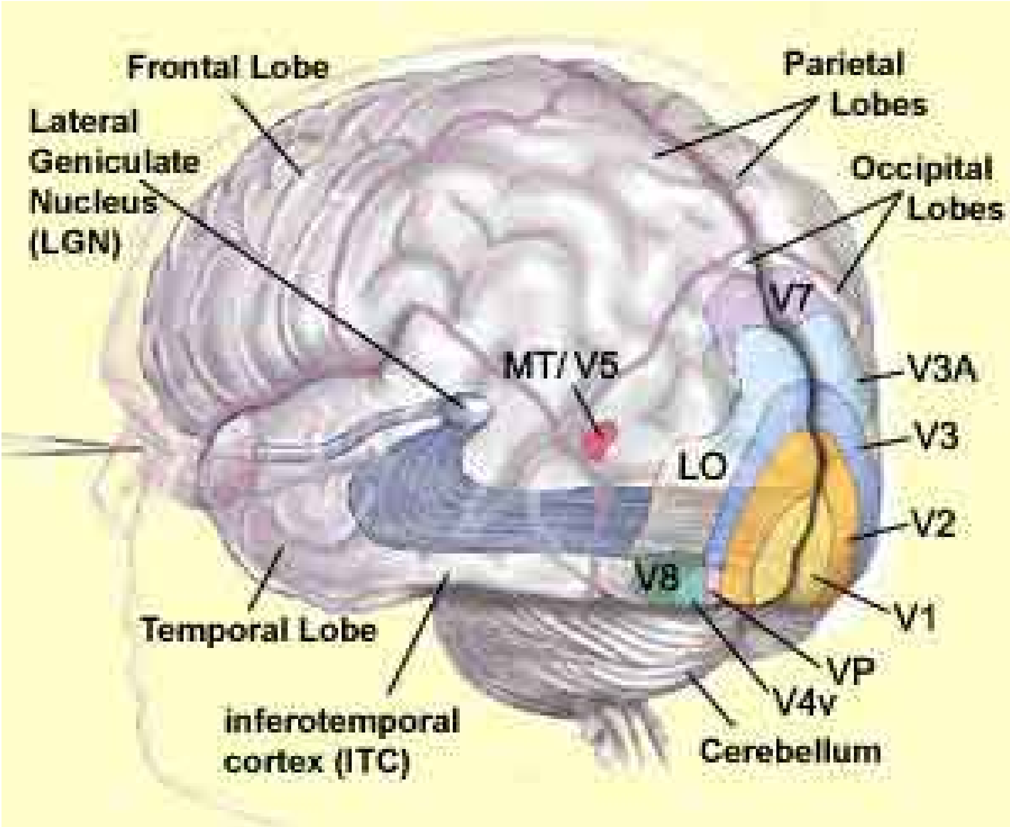
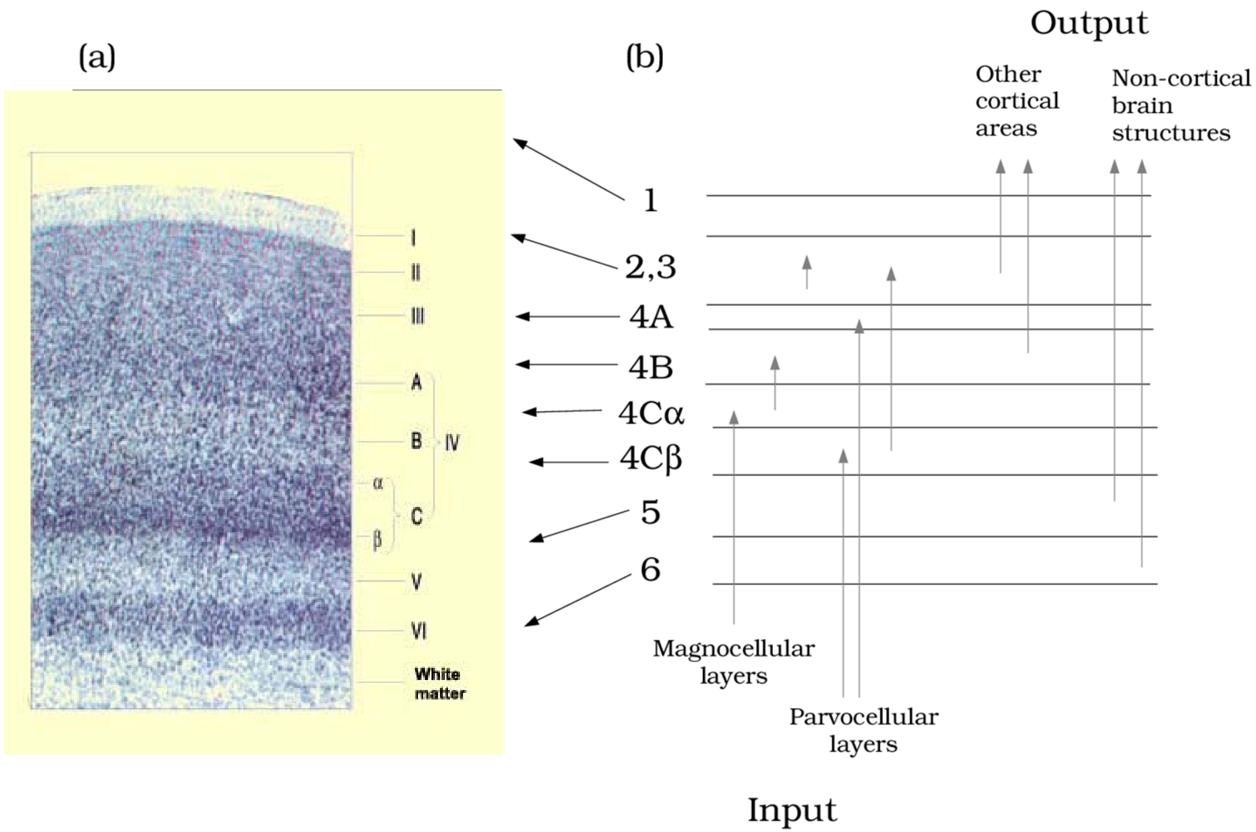




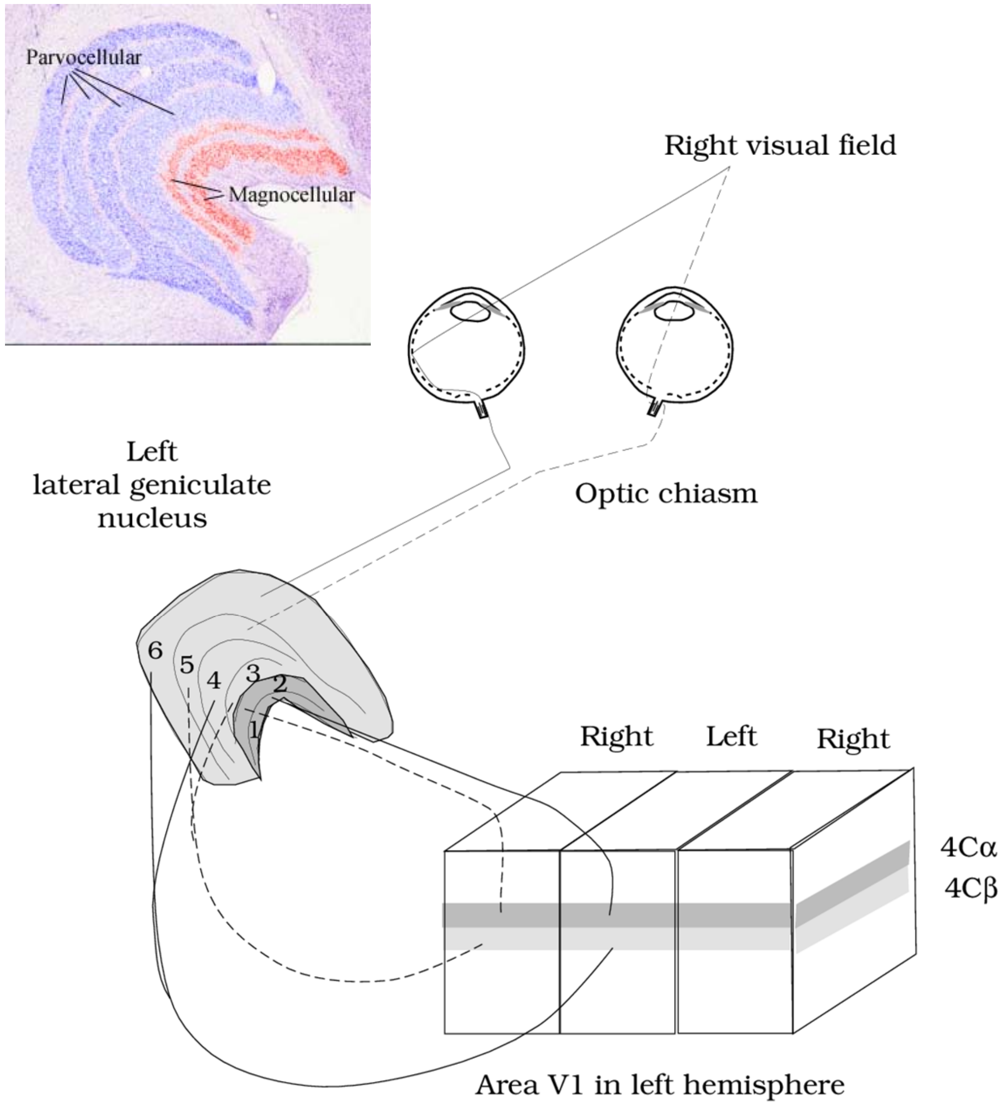

Figure 10-29

Visual cortex





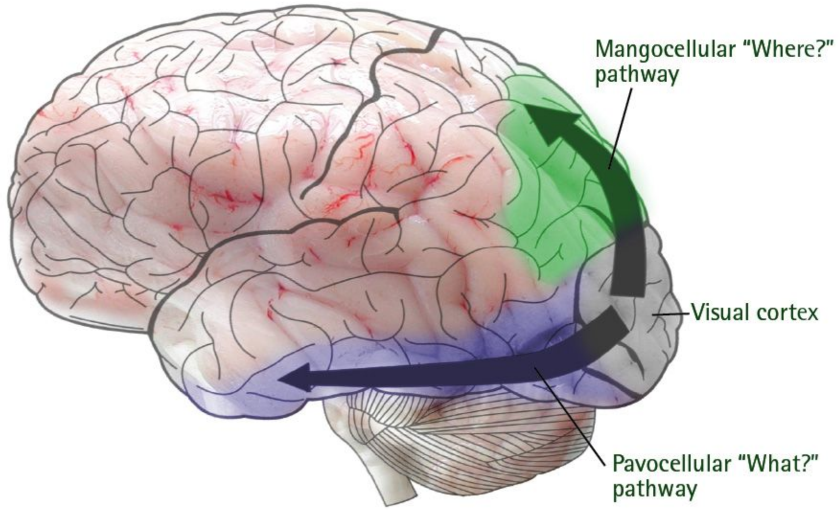

Area V1 is a layered structure}. (a) A stained cross-section of the visual cortex in macaque shows the individual layers. Each layer has a different proportions of cell bodies, dendrites and axons and may be distinguished by the density of the staining and other properties. The light areas are blood vessels. (Source: J. Lund, personal communication). (b) The organization of the neural inputs and outputs to area V1 are shown. The parvocellular and magnocellular inputs make connections in layer 4C. The intercalated neurons make connections in the superficial layers. The outputs are sent to other cortical areas, back to the lateral geniculate nucleus and other subcortical nuclei.

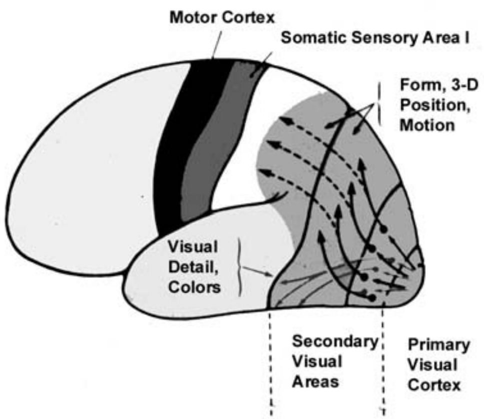


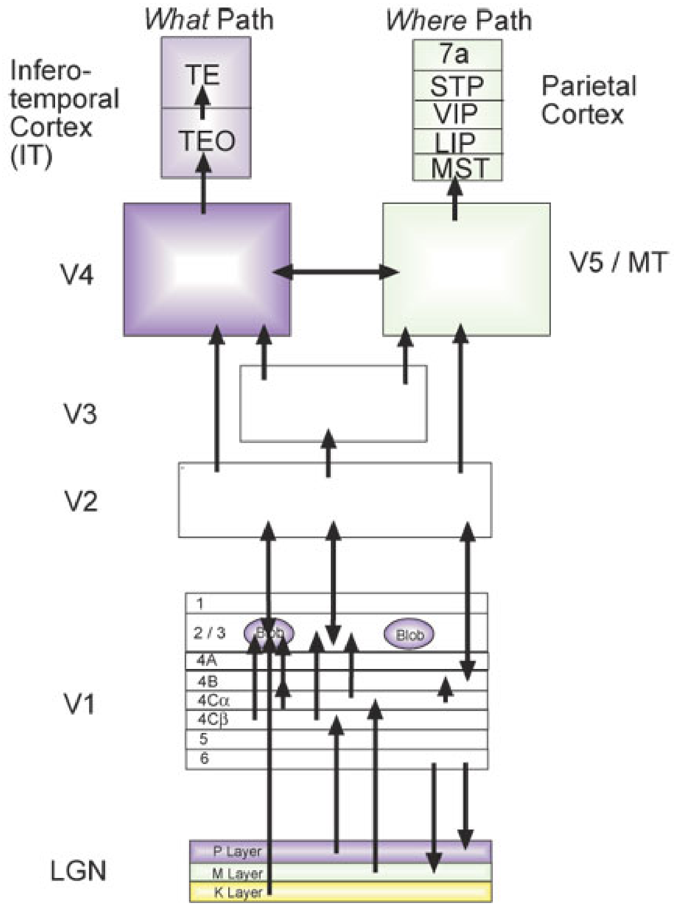

The signals from the two retinae are communicated to area V1 via the lateral geniculate nucleus. Points in the right visual field are imaged on the temporal side of the left eye and the nasal side of the right eye. Axons from ganglion cells in these retinal regions make connections with separate layers in the left lateral geniculate nucleus. Neurons in the magnocellular and parvocellular layers of the lateral geniculate send their outputs to cortical layers 4C alpha and 4C beta, respectively. The signals from each eye are segregated into different bands within area V1. Signals from these bands converge on individual neurons in the superficial layers of the cortex.

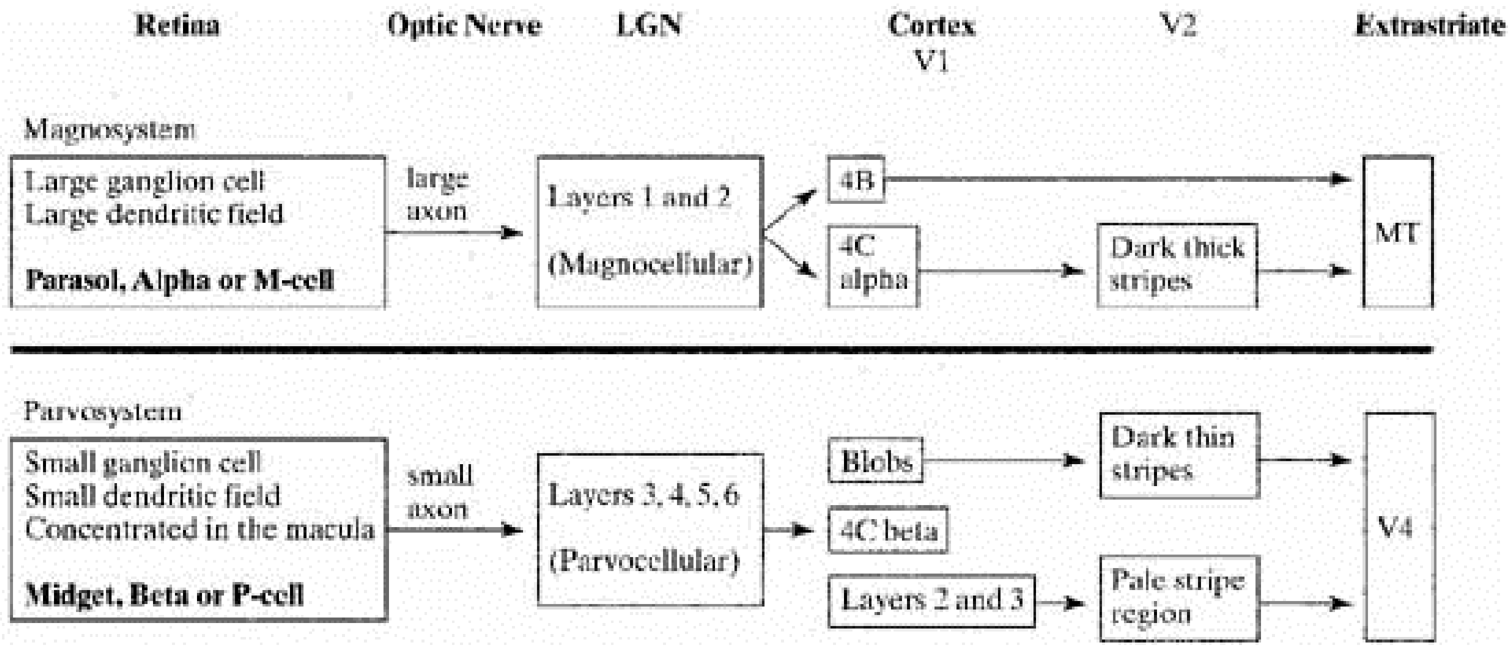
https://www.stanford.edu/group/vista/cgi-bin/FOV/chapter-6-the-cortical-representation/

# Two streams hypothesis

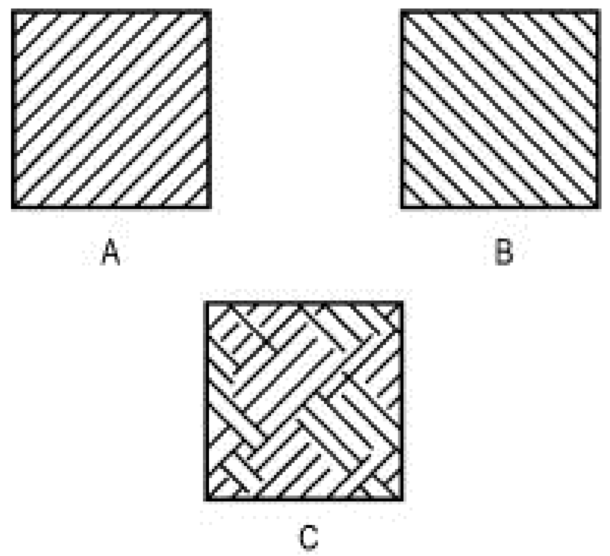



Retina
Optic Nerve
LGN
Cortex
V1
V2
Extrastriate
Magnosystem
Large ganglion cell
Large dendritic field
Parasol, Alpha or M-cell
large
axon
Layers 1 and 2
(Magnocellular)
4B
4C
alpha
Dark thick
stripes
MT
Parvosystem
Small ganglion cell
Small dendritic field
Concentrated in the macula
Midget, Beta or P-cell
small
axon
Layers 3, 4, 5, 6
(Parvocellular)
Blobs
4C beta
Layers 2 and 3
Dark thin
stripes
Pale stripe
region
V4

Binocular rivalry is a visual phenomenon that occurs when dissimilar monocular stimuli are presented to corresponding retinal locations of the two eyes. Rather than perceiving a stable, single amalgam of the two stimuli, one experiences alternations in perceptual awareness over time as the two stimuli compete for perceptual dominance. Binocular rivalry is a compelling example of multistable perception wherein physically invariant stimulation leads to fluctuations in perception. It is also one of a few psychophysical phenomena that have been usefully exploited to study visual processing outside of awareness; other such phenomena include metacontrast masking, motion induced blindness, and flash suppression.



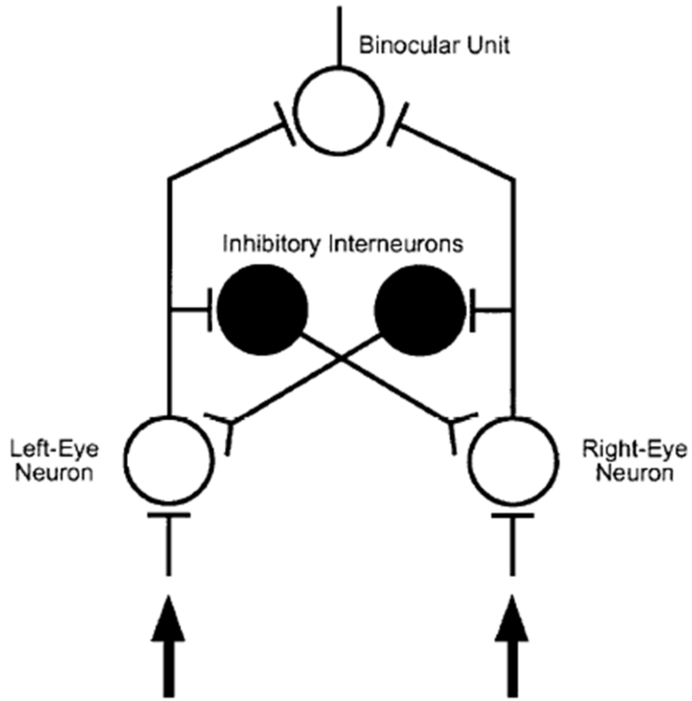
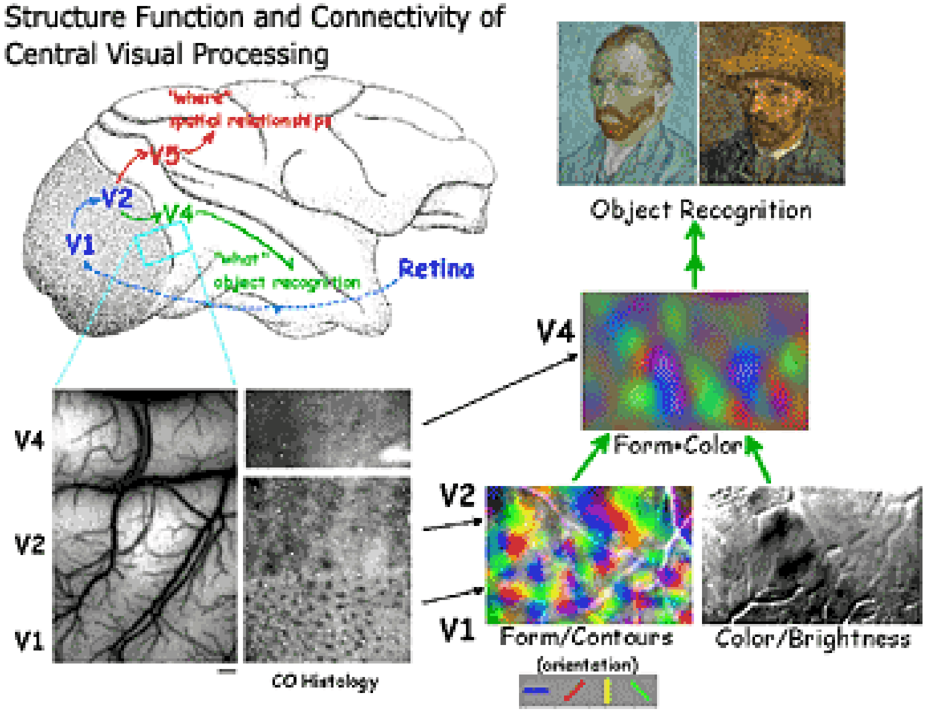
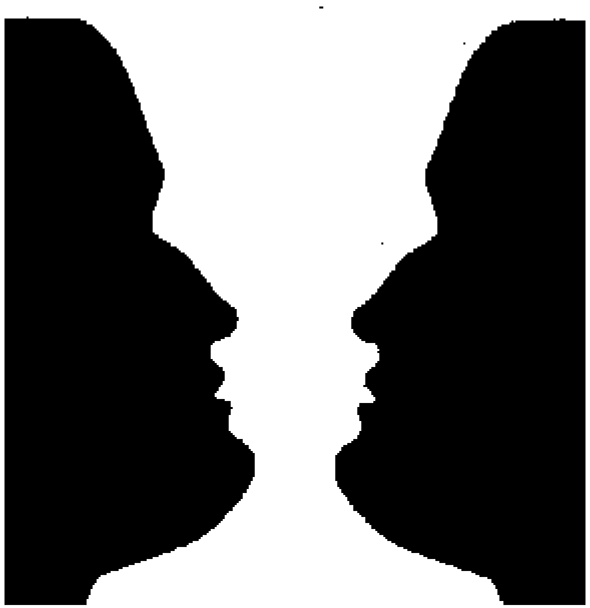




*Figure 2.* Example of a neural network model of binocular rivalry (adapted from Lehky, *Perception*, 1988). Reciprocal inhibition occurs between left-eye and right-eye neurons as a result of inhibitory interneuronal connections. As a consequence, left-eye versus right-eye inputs are alternately suppressed during binocular rivalry. These competitive interactions take place prior to binocular convergence.

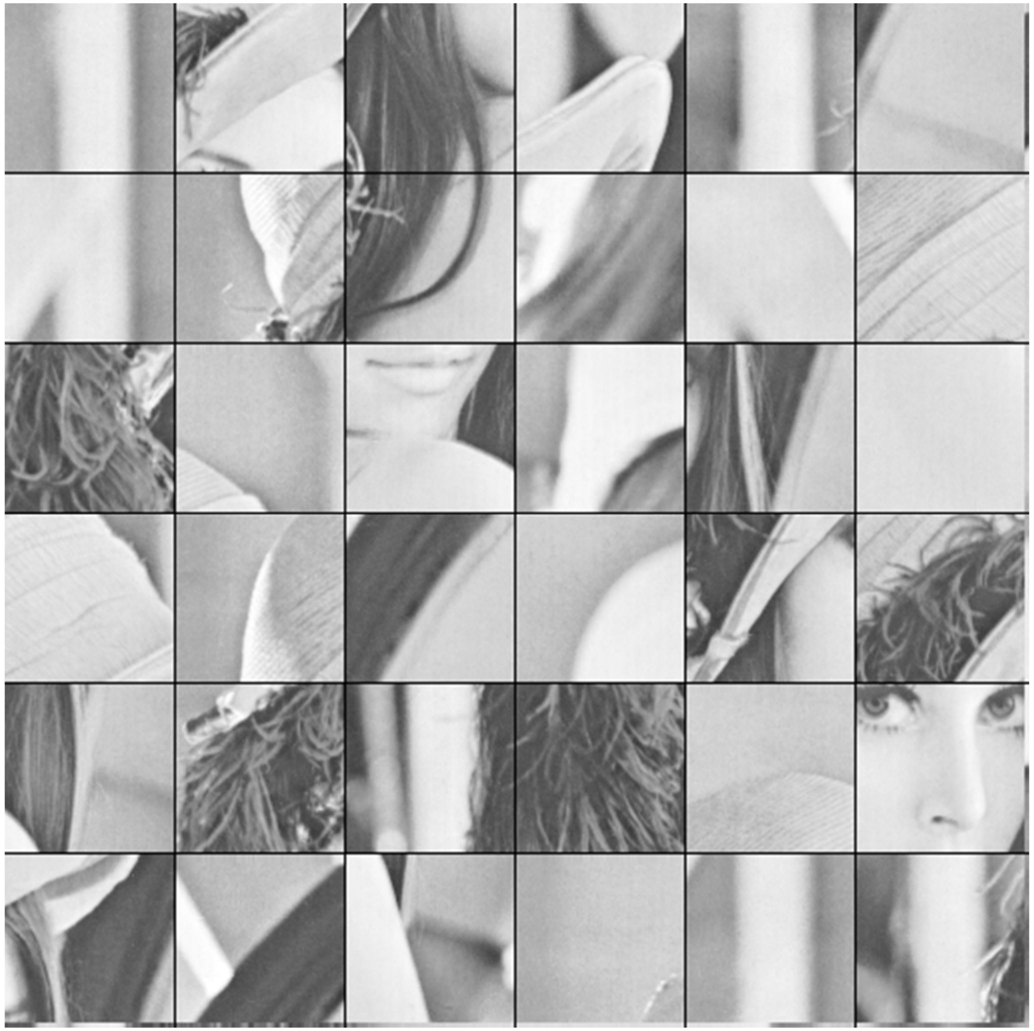
Structure Function and Connectivity of Central Visual Processing



# Visual perception

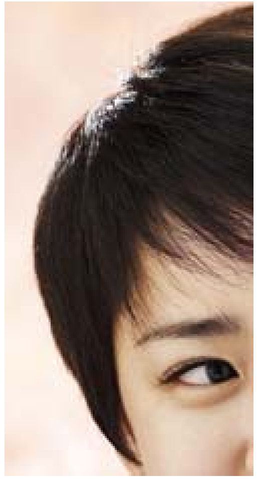


# Relationship as a whole



Aoccdring to rscheearch at Cmabrigde Uinervtisy, it deosn’t mttaer in wihhc odrer the ltteers in a word are, the olny iprmoatnt thing is that the frist and lsat ltteer be at the rghit pclae. This is bcuseae the hmaun mind deos not raed ervey lteter by istlef, but the word as a wlohe.

According to research at Cambridge University, it doesn't matter in which order the letters in a word are, the only important thing is that the first and last letter be at the right place. This is because the human mind does not read every letter by itself, but the word as a whole.

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http://www.ibric.org/myboard/read.php?id=266173&Page=&Board=news