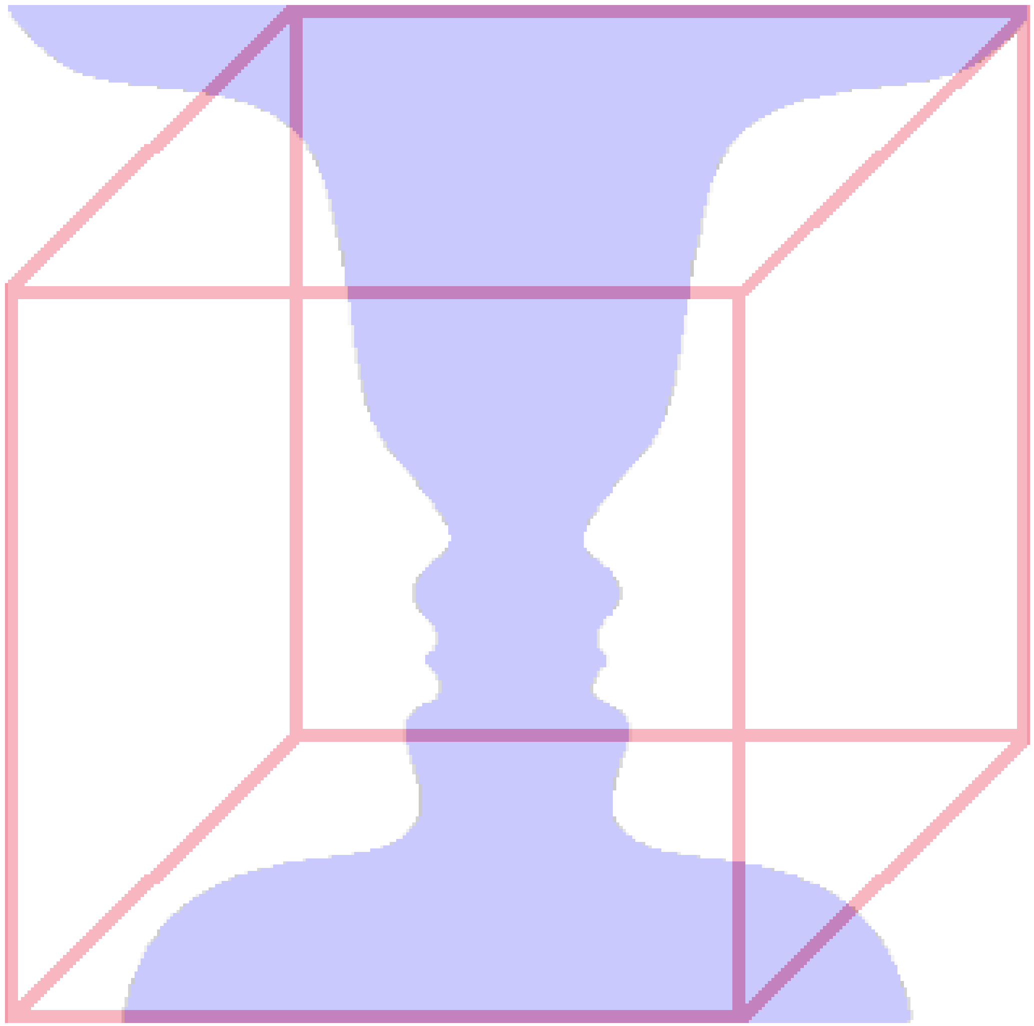
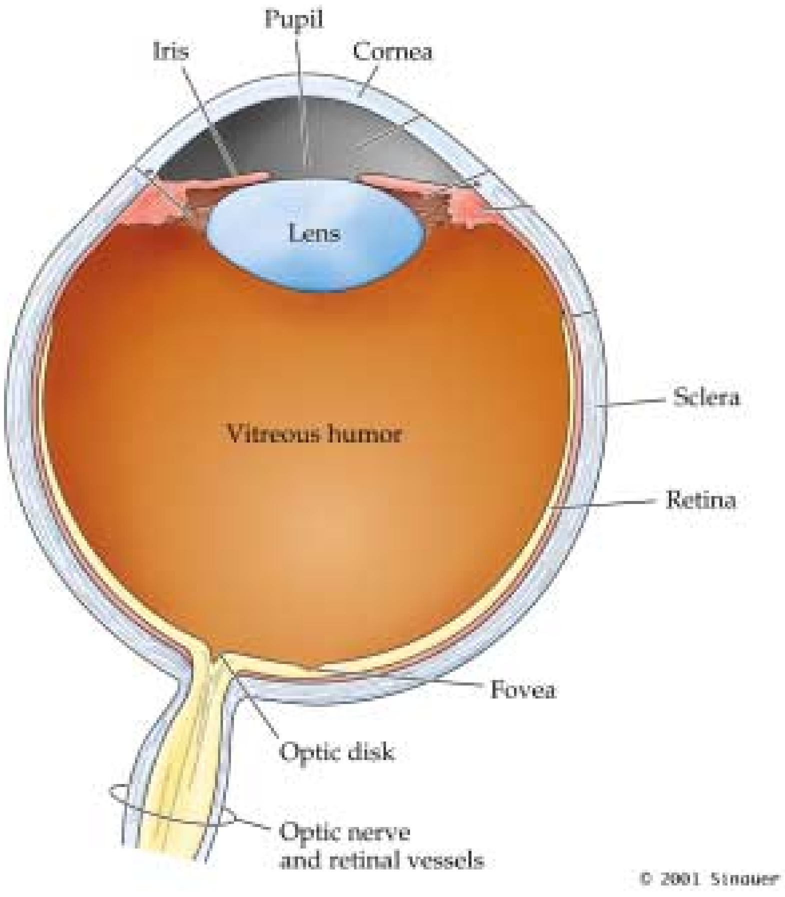
Lecture 2

Brain and Perception

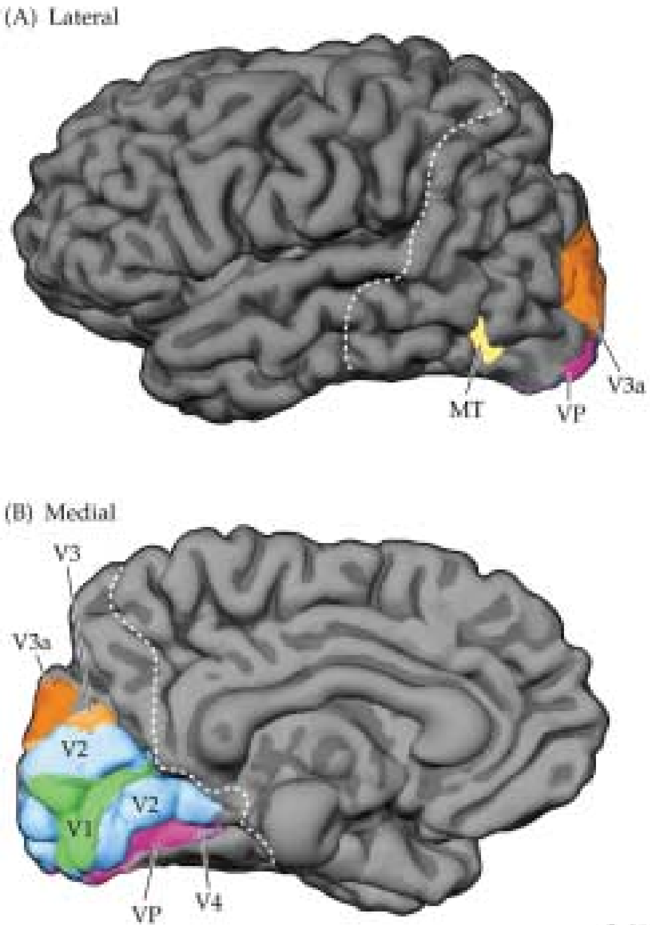


How does the visual system capture information in the environment?

- Photoreceptors are specialized neurons that convert light into electrical signals that are used to form a sensory representation of the world .

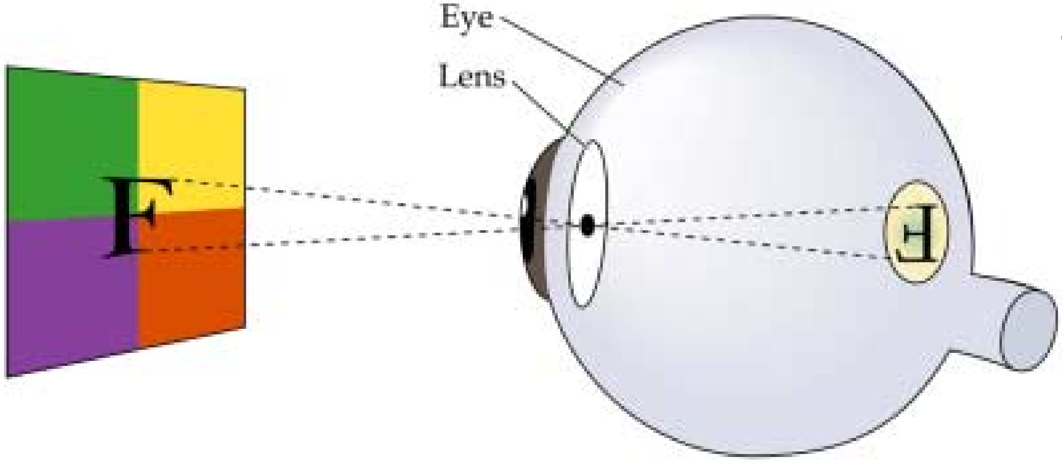


How does the visual system process and represent light?

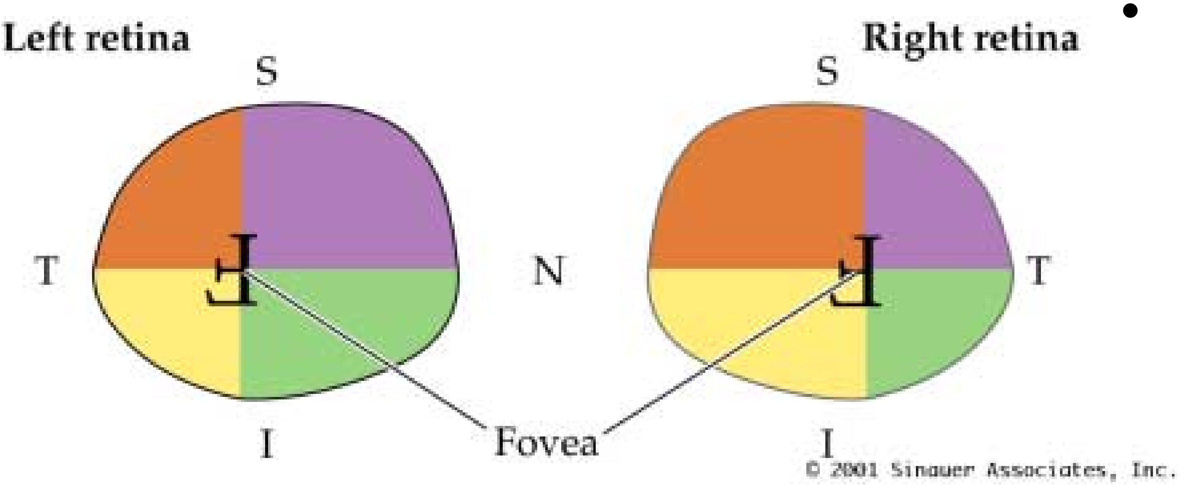


- Sensory areas in the cerebral cortex interpret the signals generated by receptors and determine:
  - *(1) where it is*
  - *(2) what it is*
  - *(3) how strong it is*

How does the visual system determine WHERE light comes from?

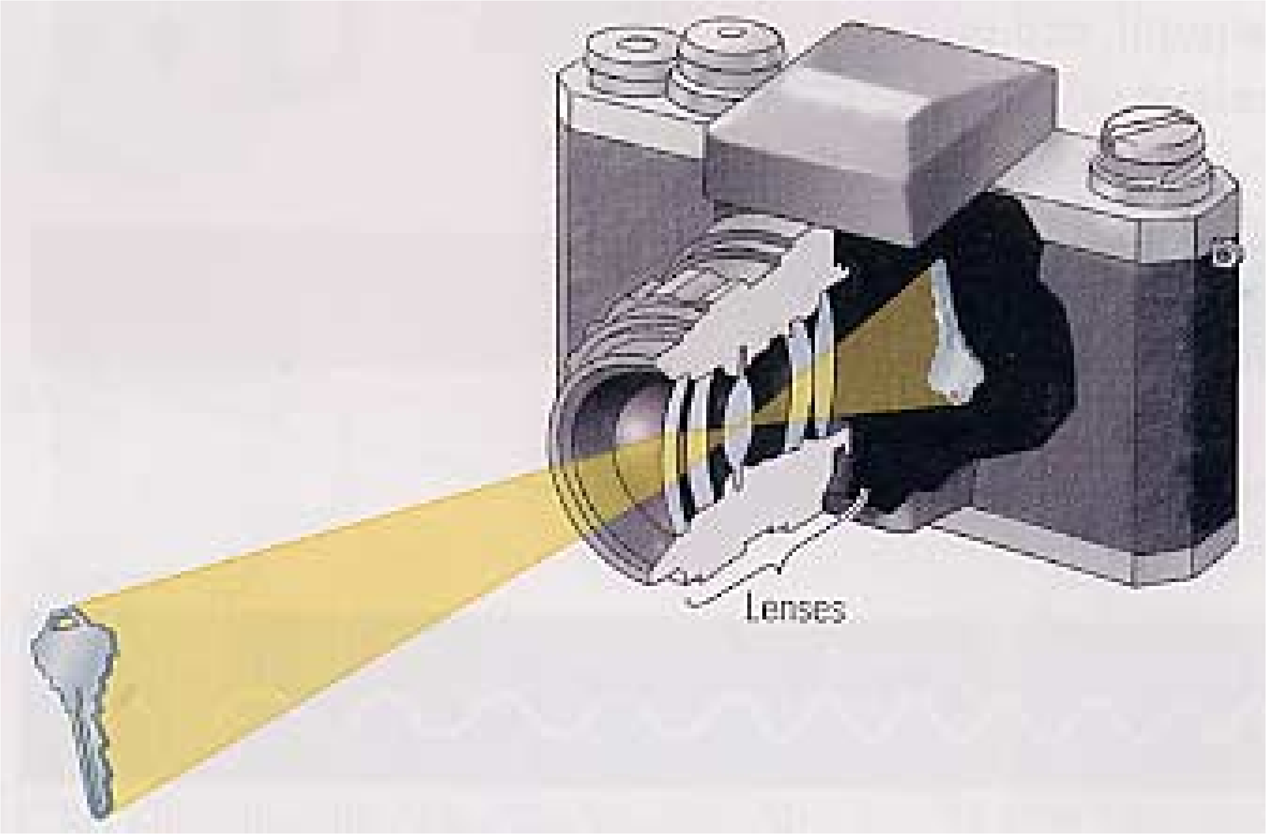


- Different parts of the visual scene project to different parts of the retina
  - the retinotopic map is inverted in the two eyes.



- Therefore, neurons in different parts of the retina respond to WHERE objects are in the visual scene.

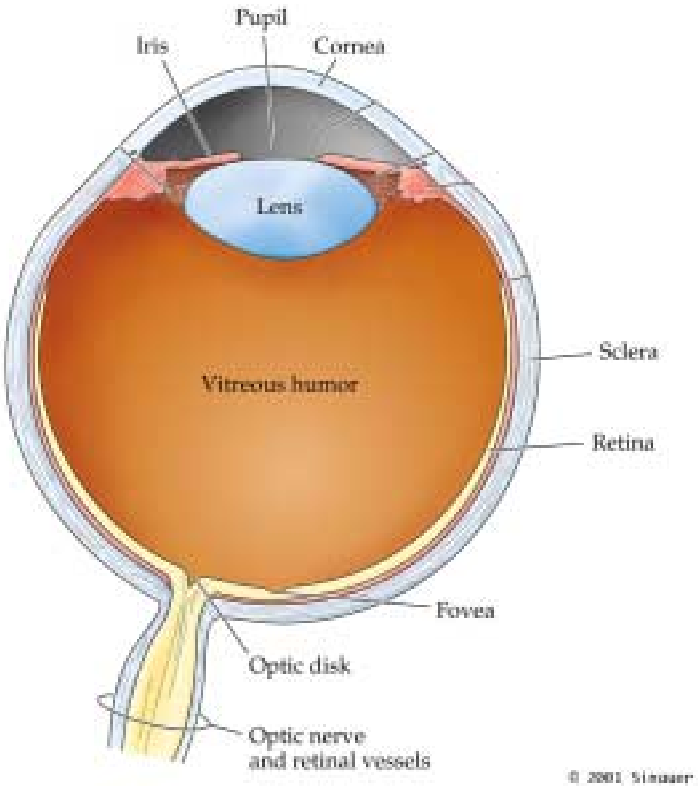
How does the visual system determine WHERE light comes from?



The blind spot

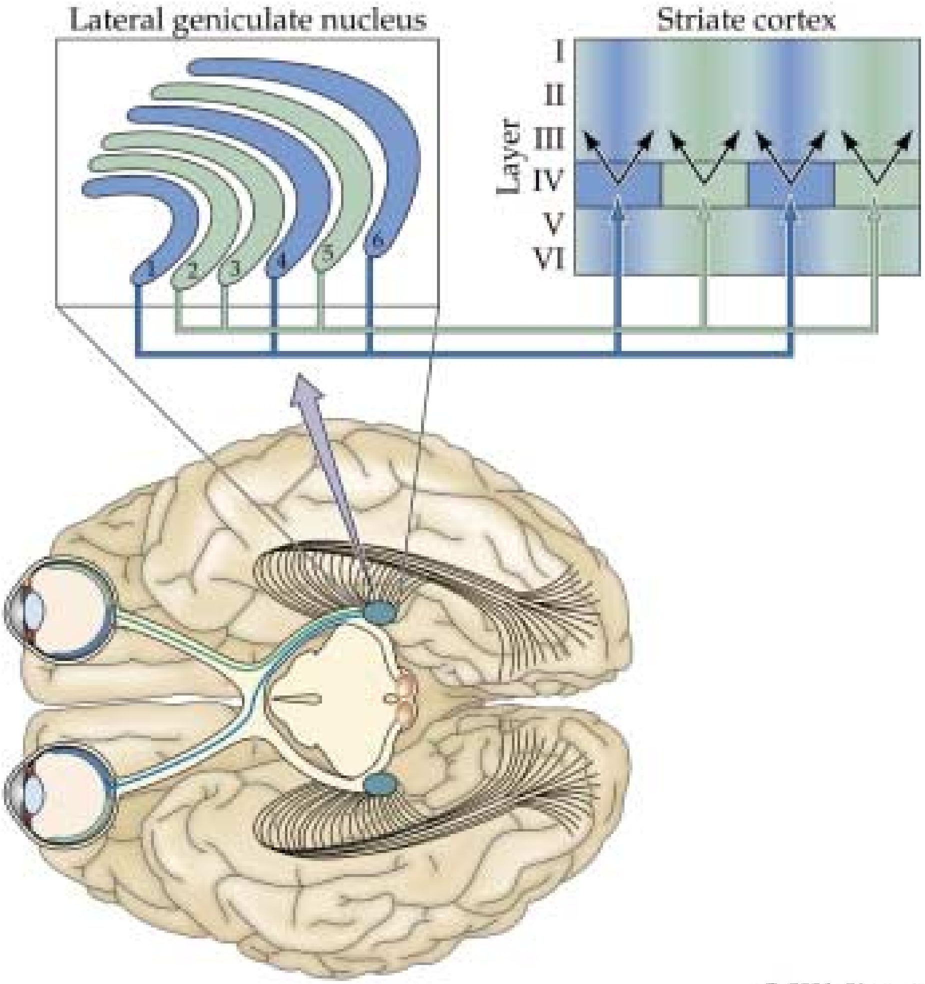
- Axons from retinal ganglion cells exit at the optic disc

- The optic disc is insensitive to light (the blind spot).



X

Ganglion cells project to the lateral geniculate nucleus (LGN)

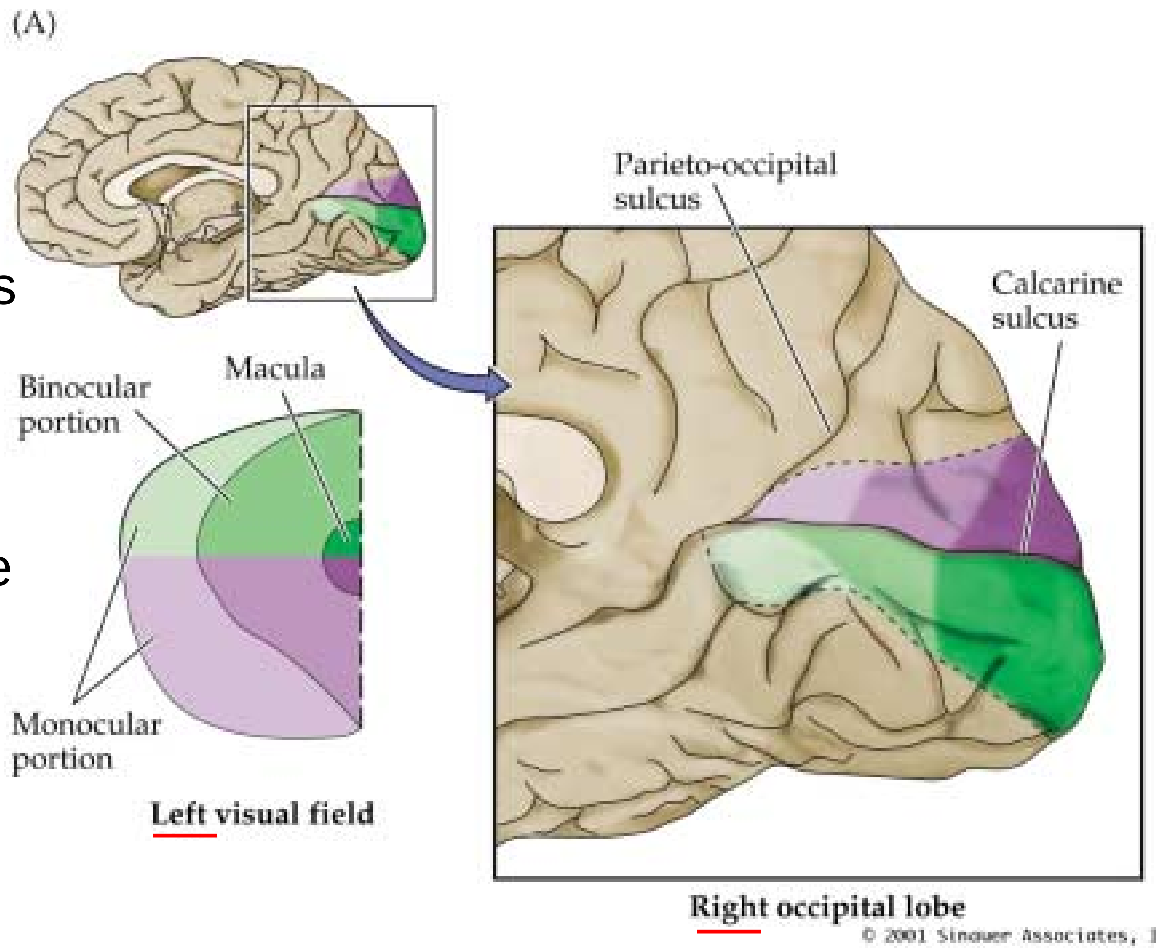


- Retinal ganglion cells project to the LGN
- The LGN is segregated into 6 layers
- The LGN project to primary visual cortex (striate cortex)

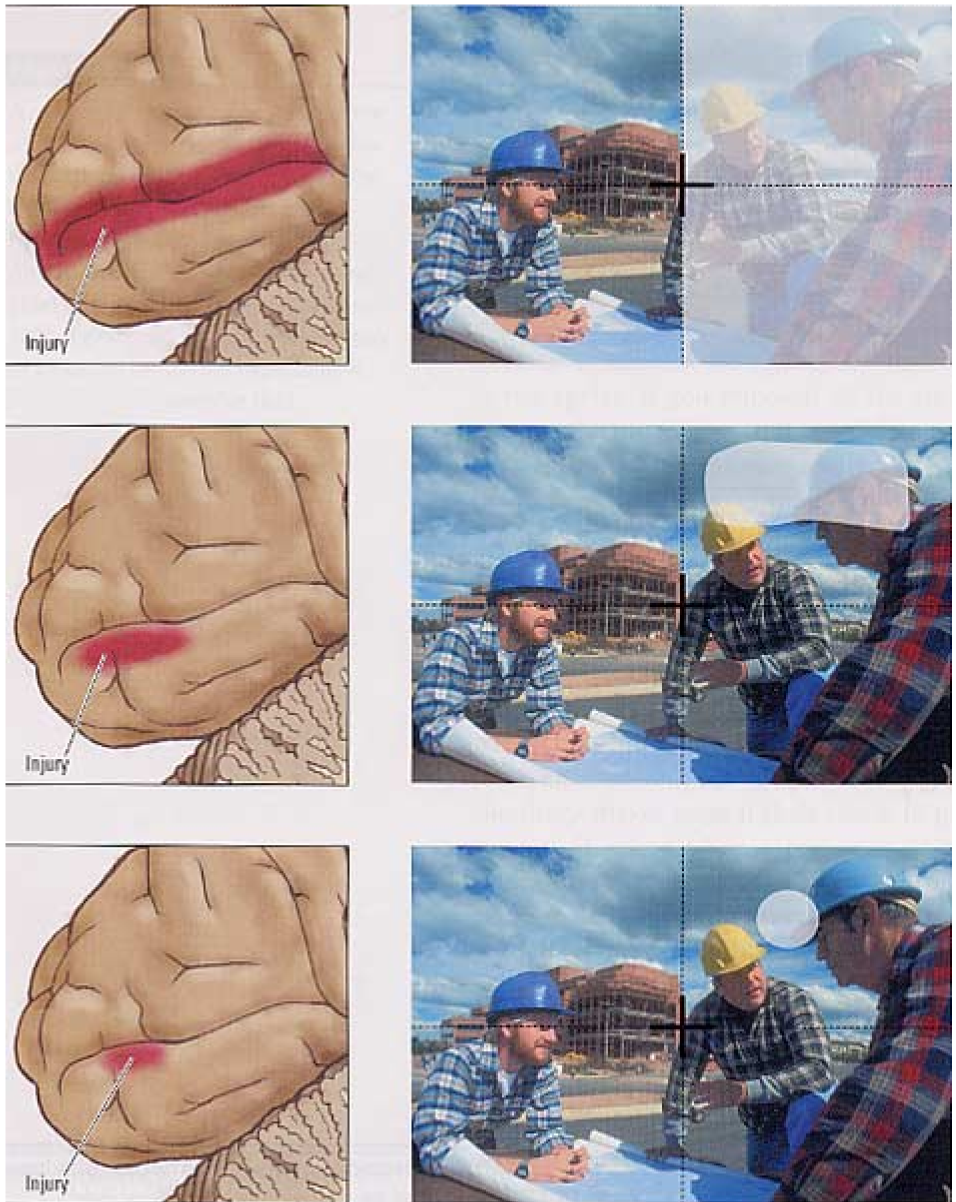
Neurons in different parts of primary visual cortex detect WHERE an object is.

- The right hemisphere detects objects in the left visual field and the left hemisphere detects objects in the right visual field.

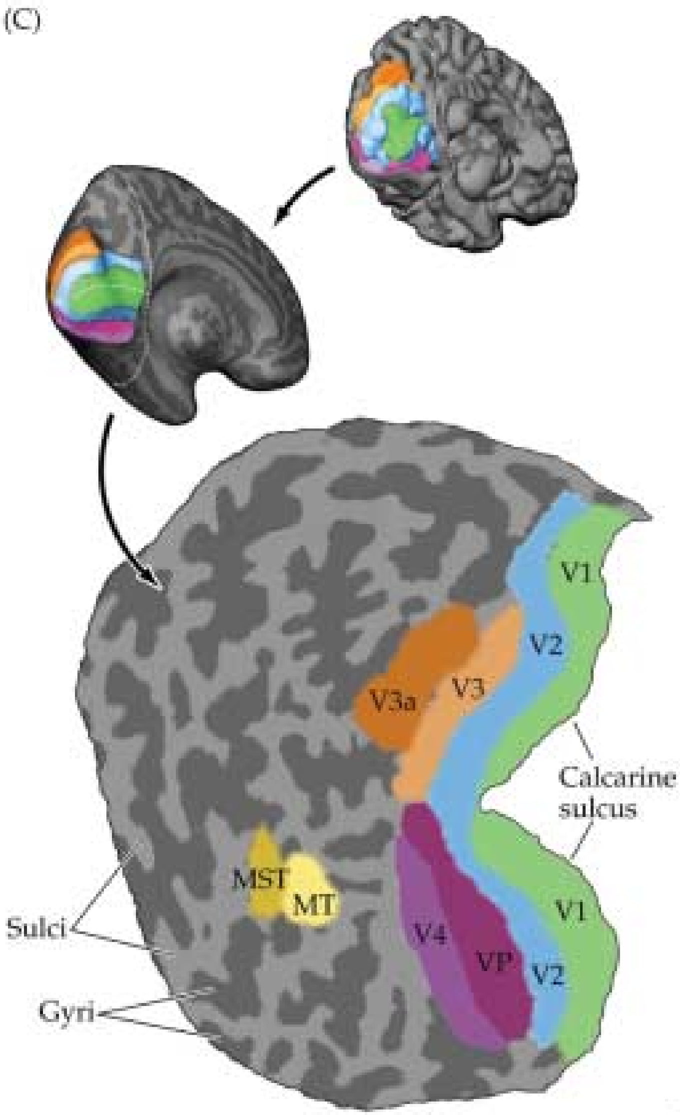
- Neurons in different parts of primary visual cortex are responsive to different parts of the visual field (retinotopic map).



Neurons in different parts of primary visual cortex detect WHERE an object is.

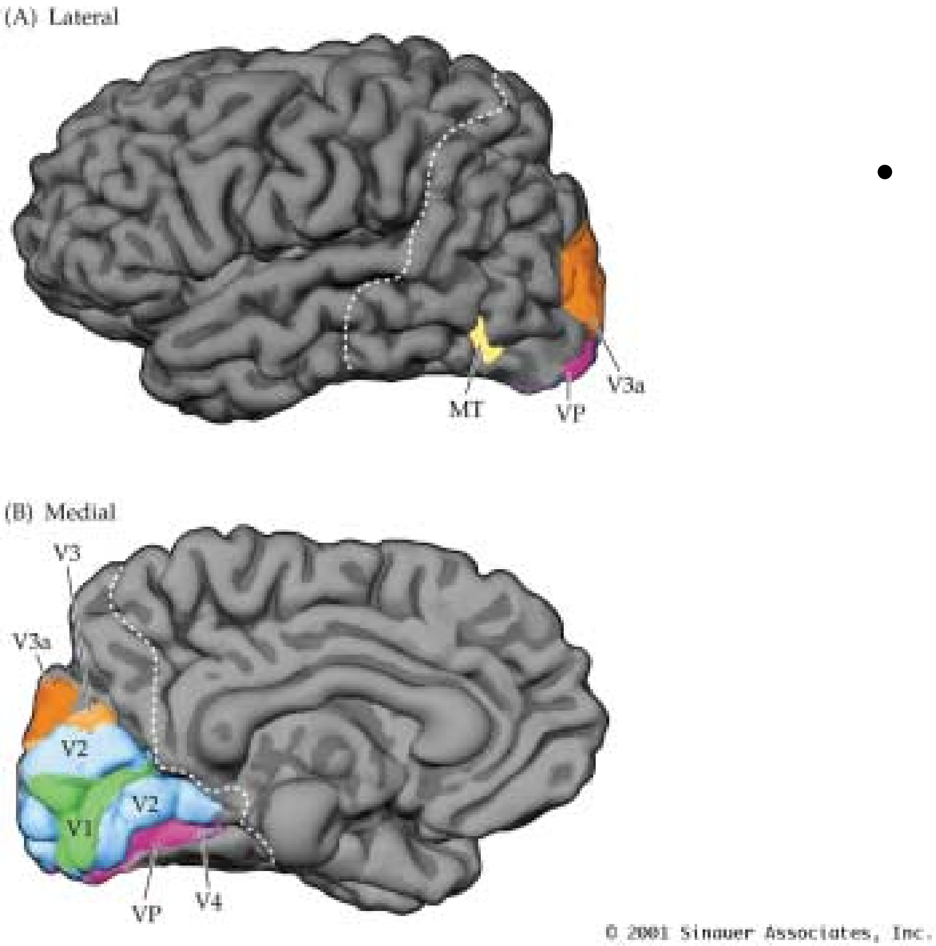


Primary visual cortex projects to other visual areas



- Visual cortex is composed of many areas.
- Like primary visual cortex (V1), other visual areas contains a map of the visual field (retinotopic map).

How does the visual system process and represent light?



- Sensory areas in the cerebral cortex interpret the signals generated by receptors and determine:
  - *(1) where it is*
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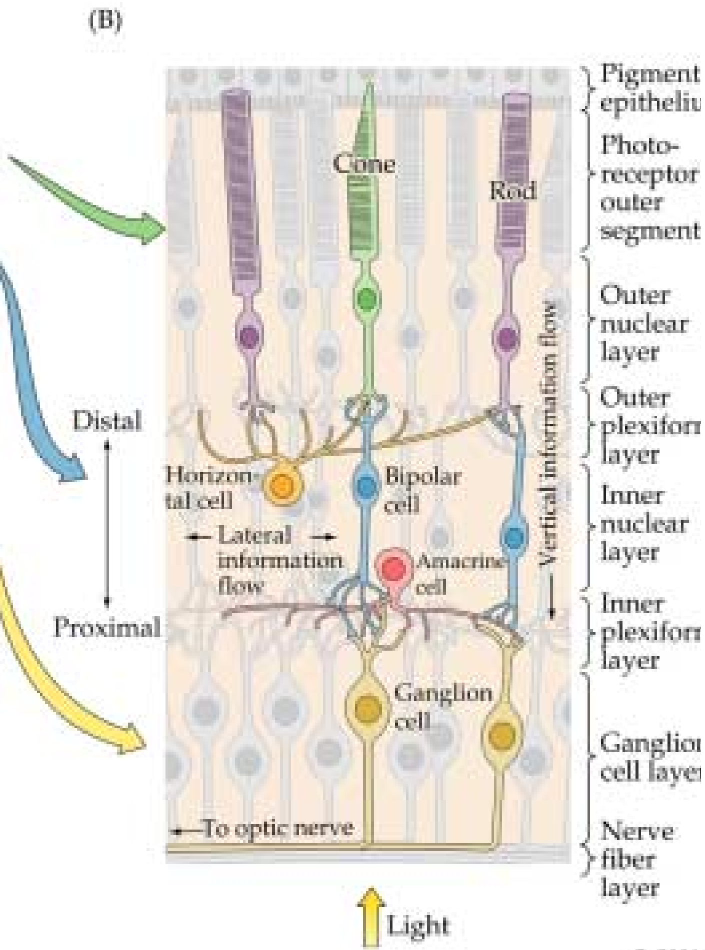
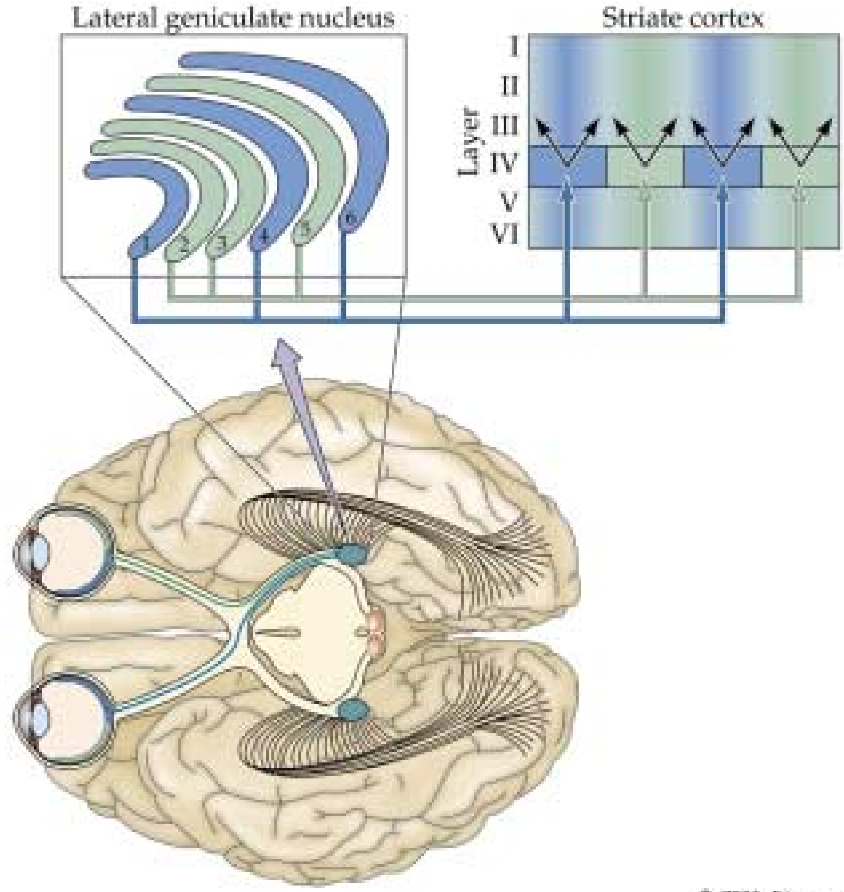
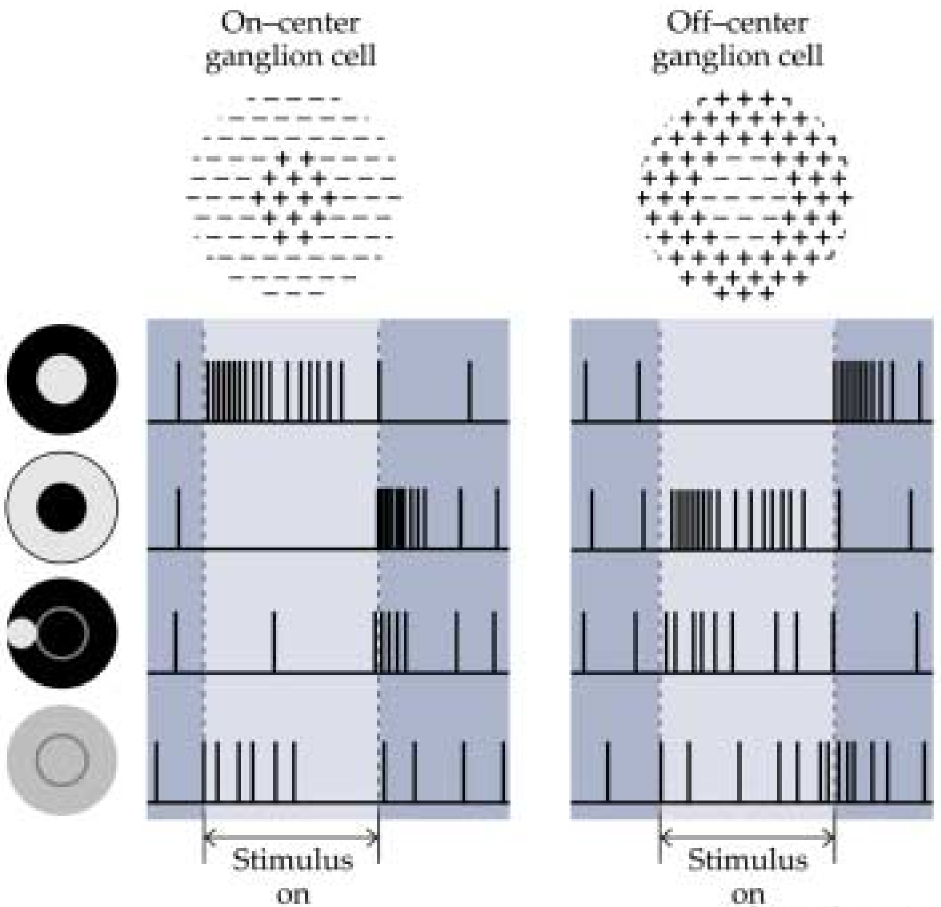
Retinal ganglion cells project to the LGN





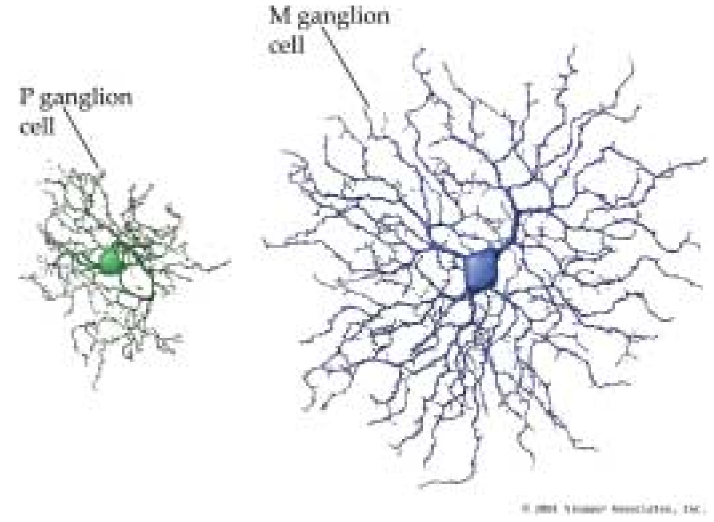
What do retinal ganglion cells and LGN cells respond to?

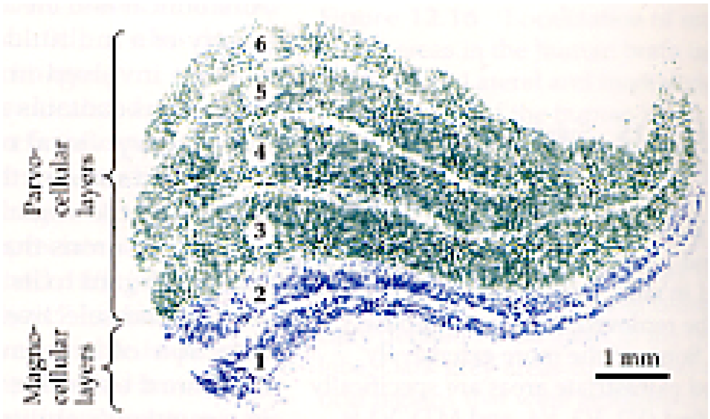


- Retinal ganglion cells and LGN cells respond to spots of light (WHAT) from specific areas of the visual scene (WHERE).
- The combination of WHAT and WHERE is referred to as the receptive field of the ganglion cell
  - Each neuron has a centre and an antagonistic surround.

Magnocellular and parvocellular pathways convey different information to visual cortex.

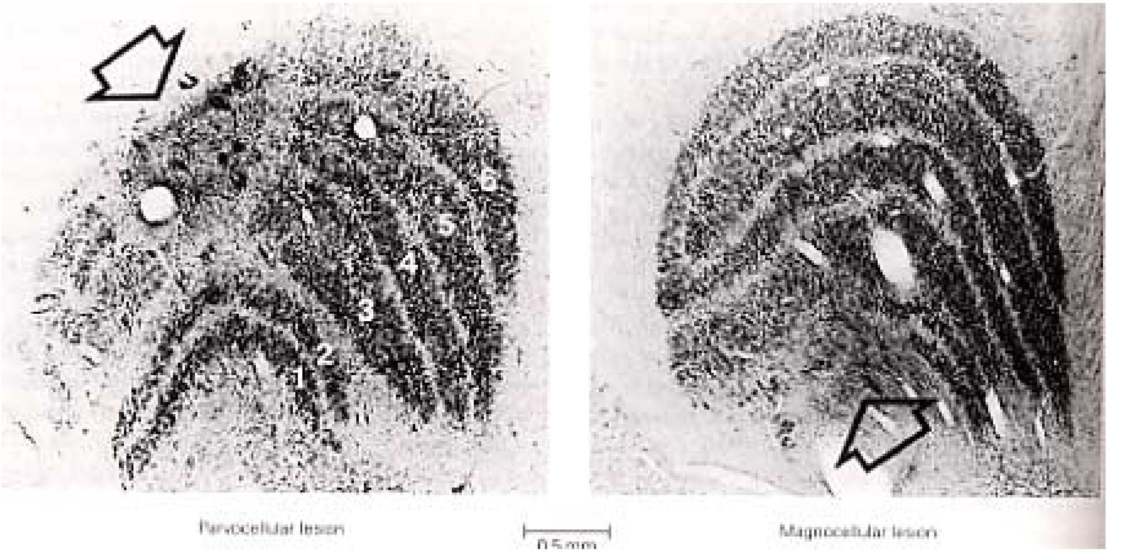
	Magnocellular	Parvocellular
Colour	No	Yes
Receptive field	Large	Small
Responsivity	Fast	Slow





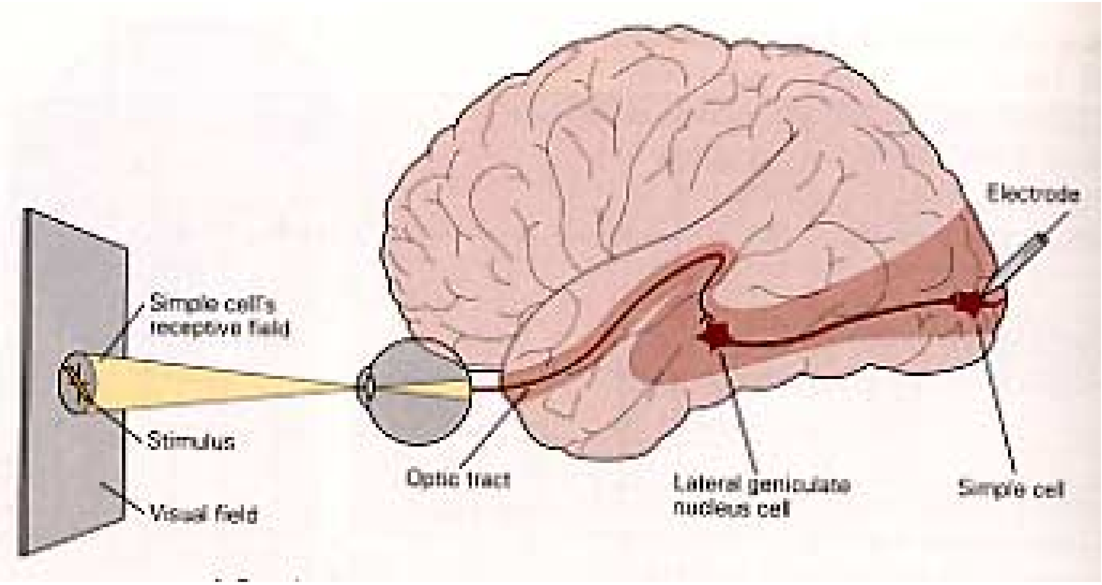
Lesions to different layers of the LGN affect different aspects of visual perception

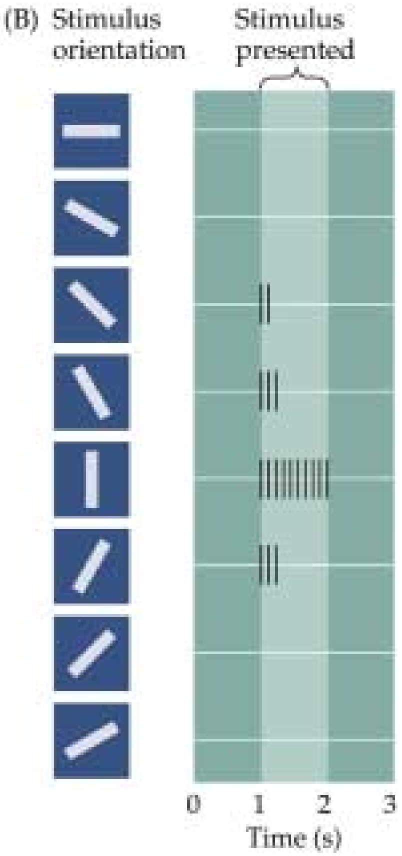
- Lesions to magnocellular layers affect *motion* perception
- Lesions to parvocellular affect *form and colour* perception



WHAT does primary visual cortex respond to?

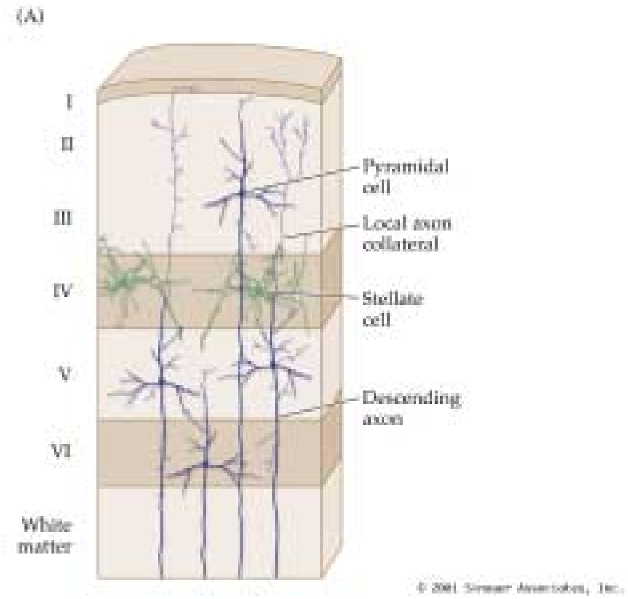
- Neurons in primary visual cortex respond selectively to oriented edges.
  - different neurons respond to different orientations.

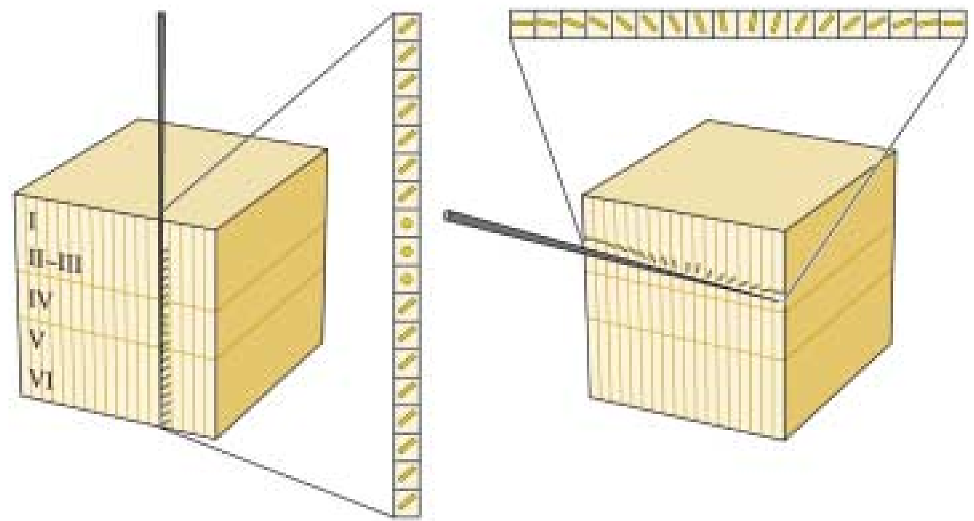




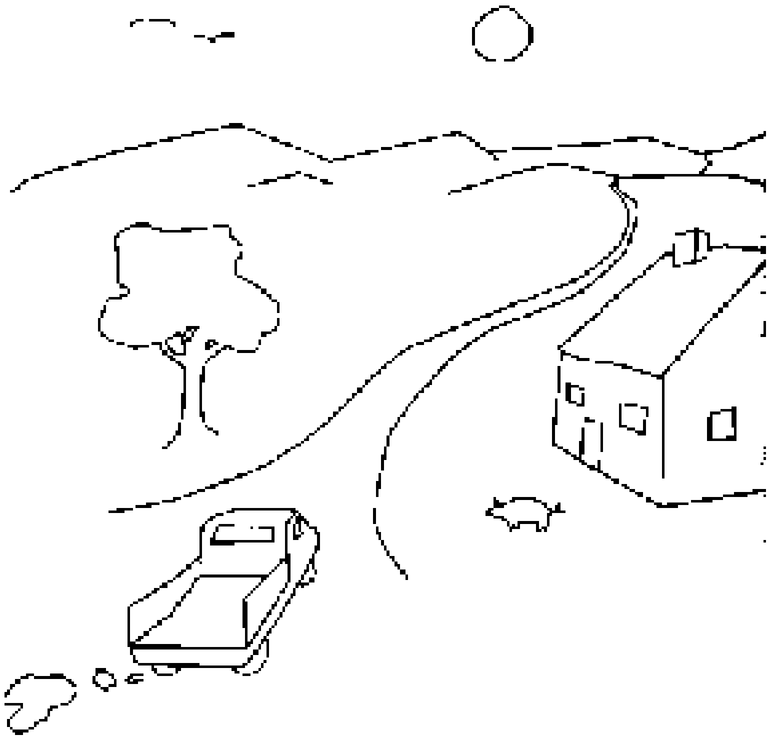
Orientation columns in primary visual cortex

- Neurons in primary visual cortex are organized into columns.
- In each column, neurons have the same orientation preference.
- Adjacent columns respond to slightly different orientations.



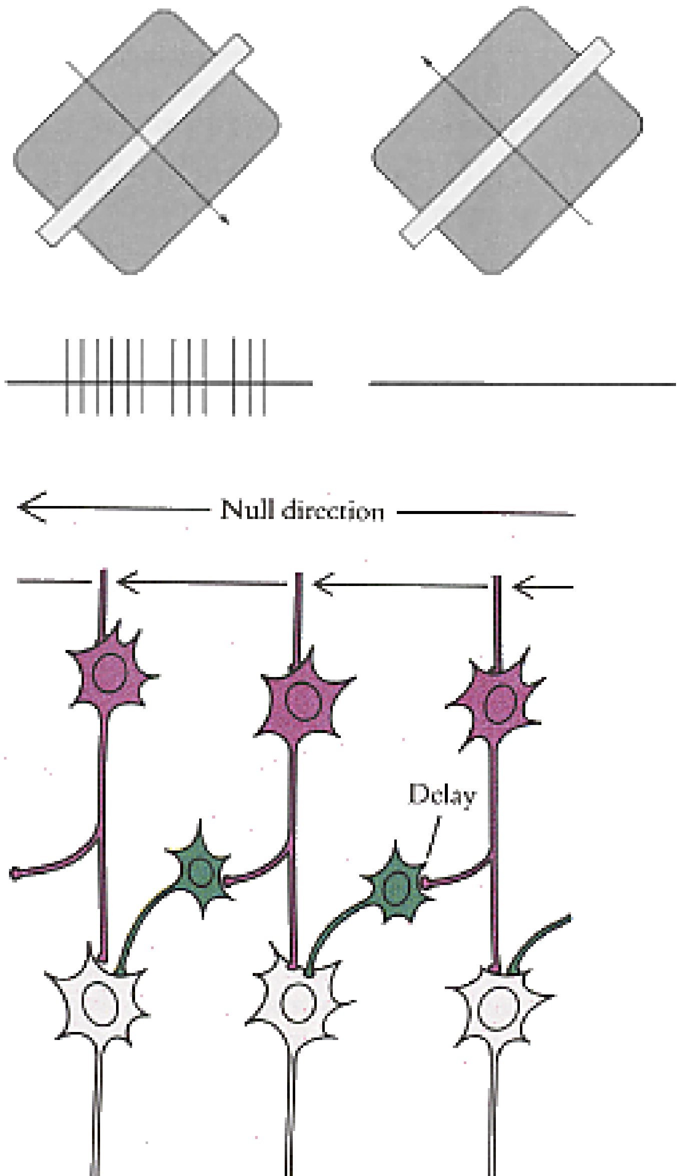


The importance of contours in perception



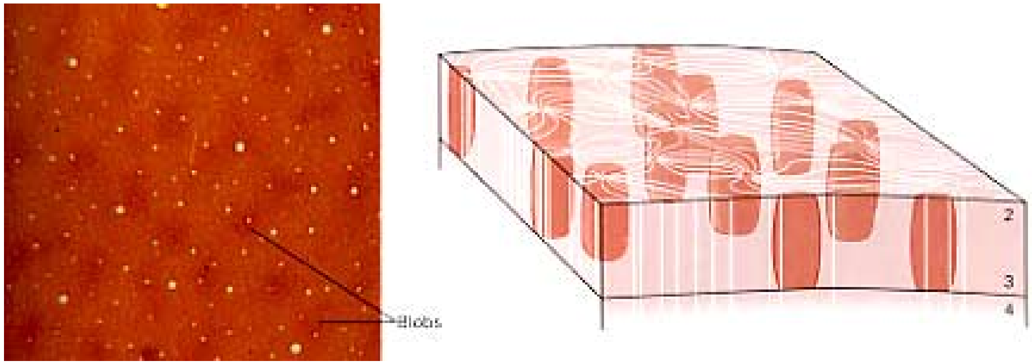
- An outline drawing, typical of children’s drawings, has clearly recognizable objects because edges are powerful cues for the perceptual system.

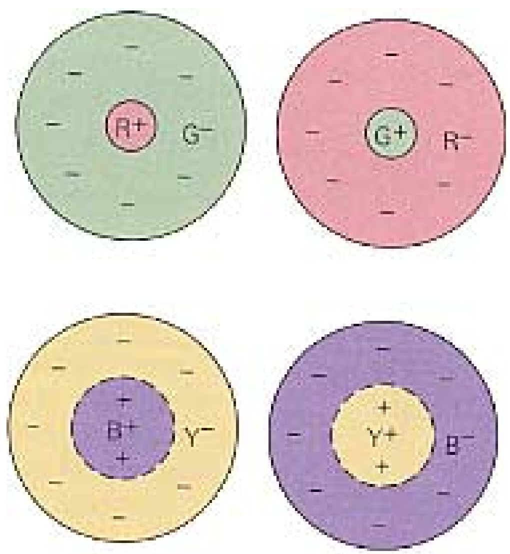
Other neurons respond to the direction of motion



- A proportion of neurons in primary visual cortex respond to one direction of motion.
- A simple inhibitory circuit could explain this pattern of activity.

Colour selectivity in primary visual cortex



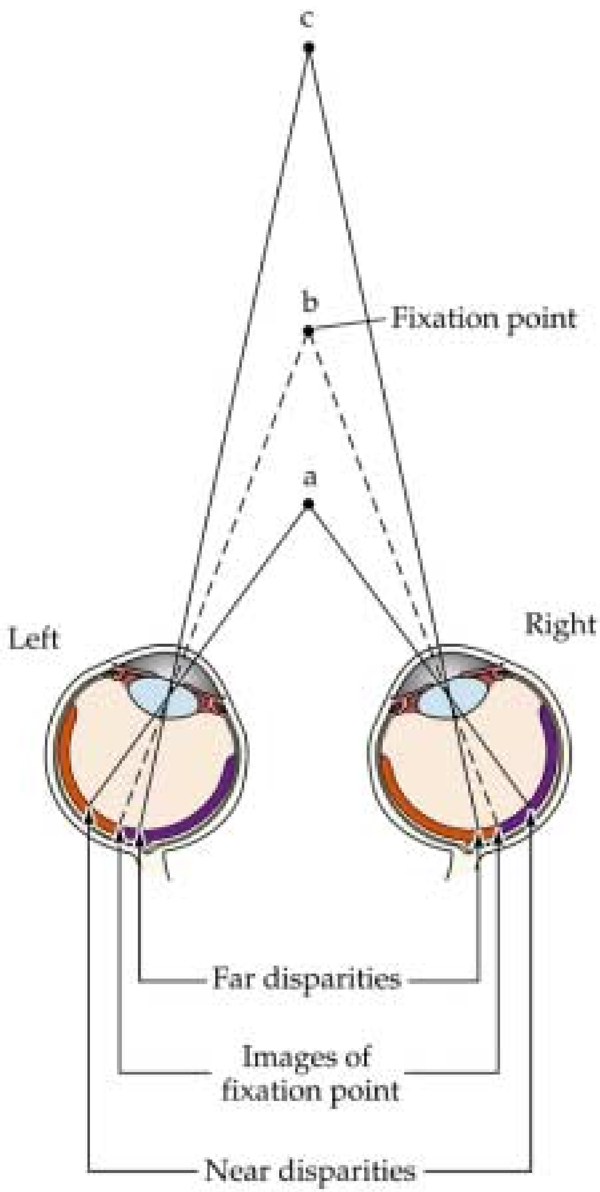


- Blobs are groups of cells in layer II-III of primary visual cortex.
- Cells in blobs are not orientation selective, but respond to *colour*.

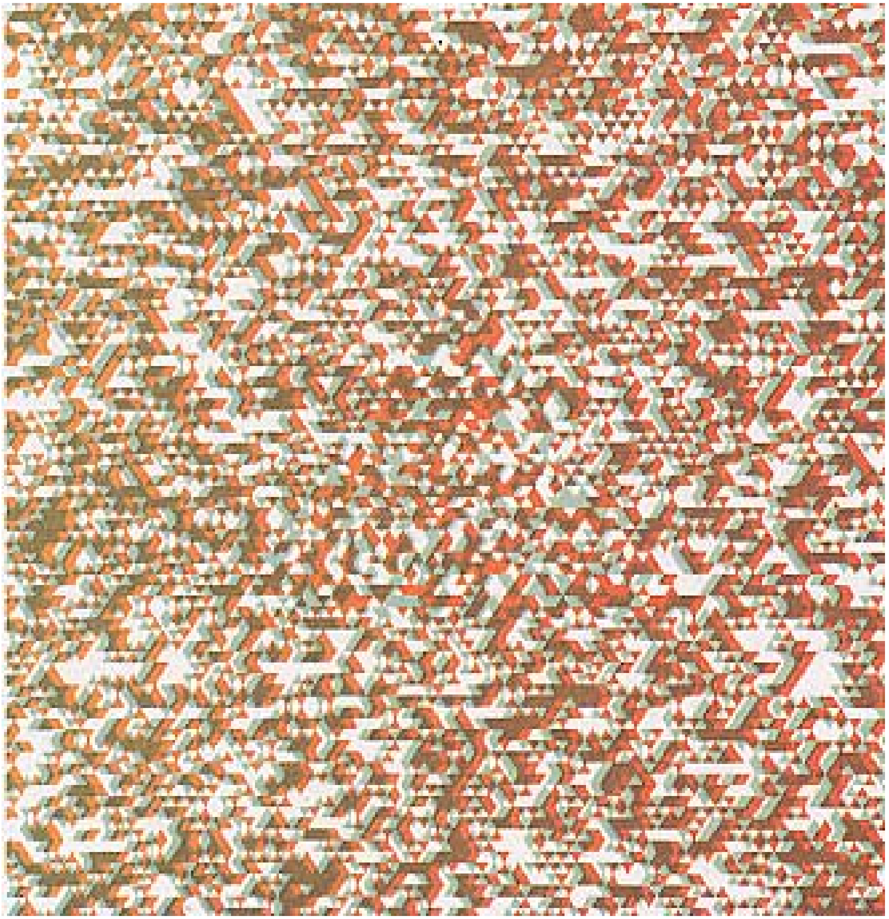
How does the visual system process depth?

- Some cells in primary visual cortex are sensitive to differences in the images in the two eyes (binocular disparity).

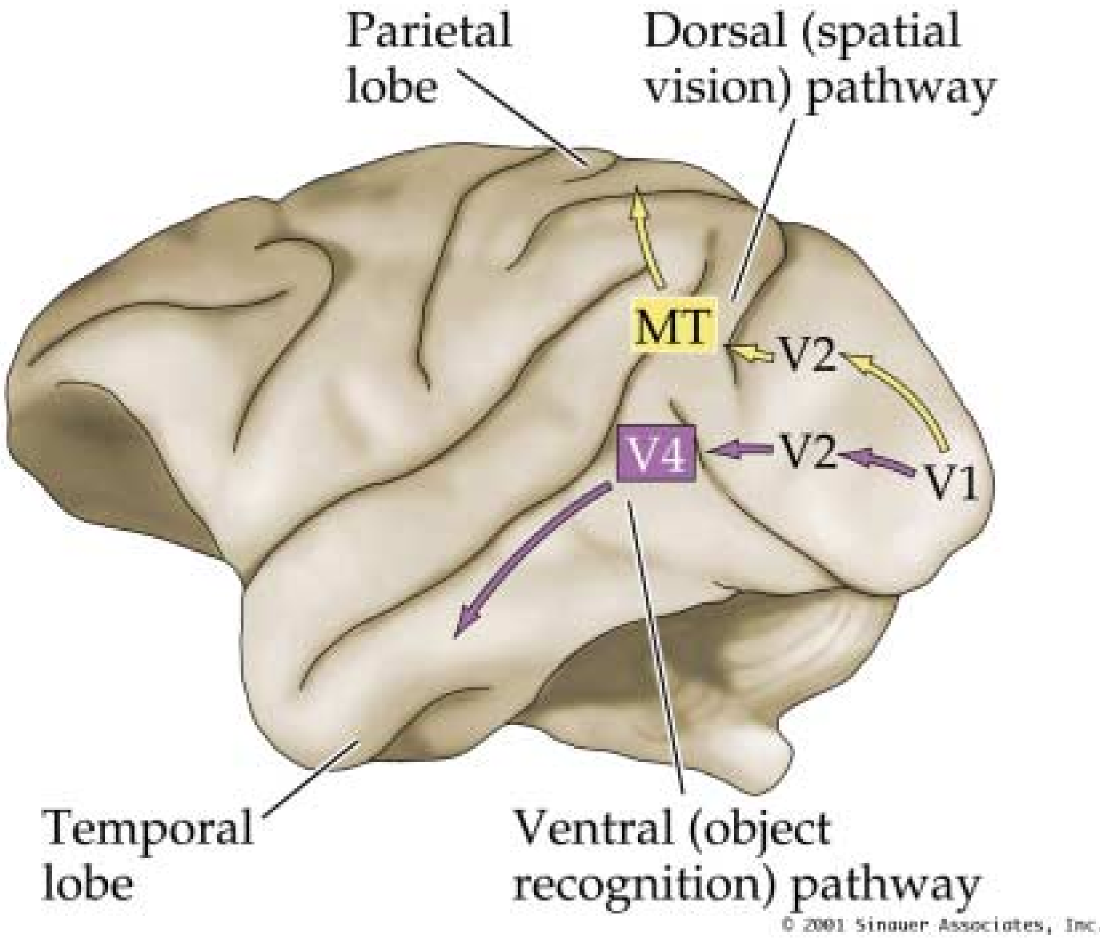
- These cells are involved in our perception of depth.



How does the visual system process depth?

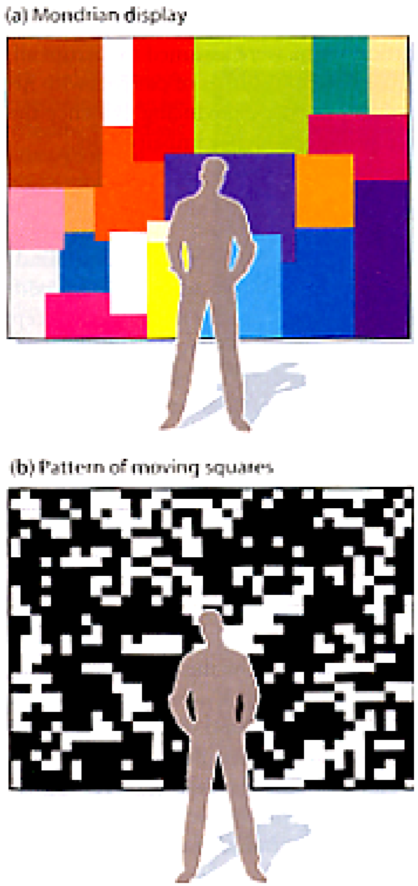


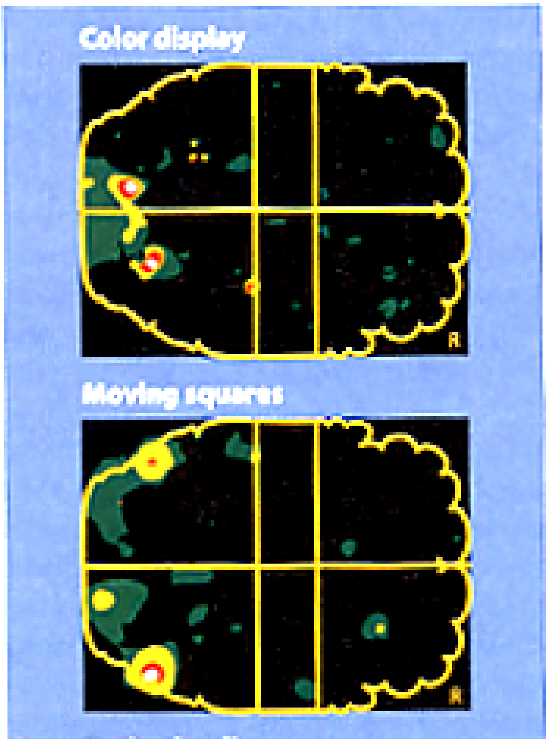
Neurons in V1 project to other visual areas



Different visual areas are specialized to analyse different aspects of the same visual scene

- Colour (V4)
- Motion (MT/V5)





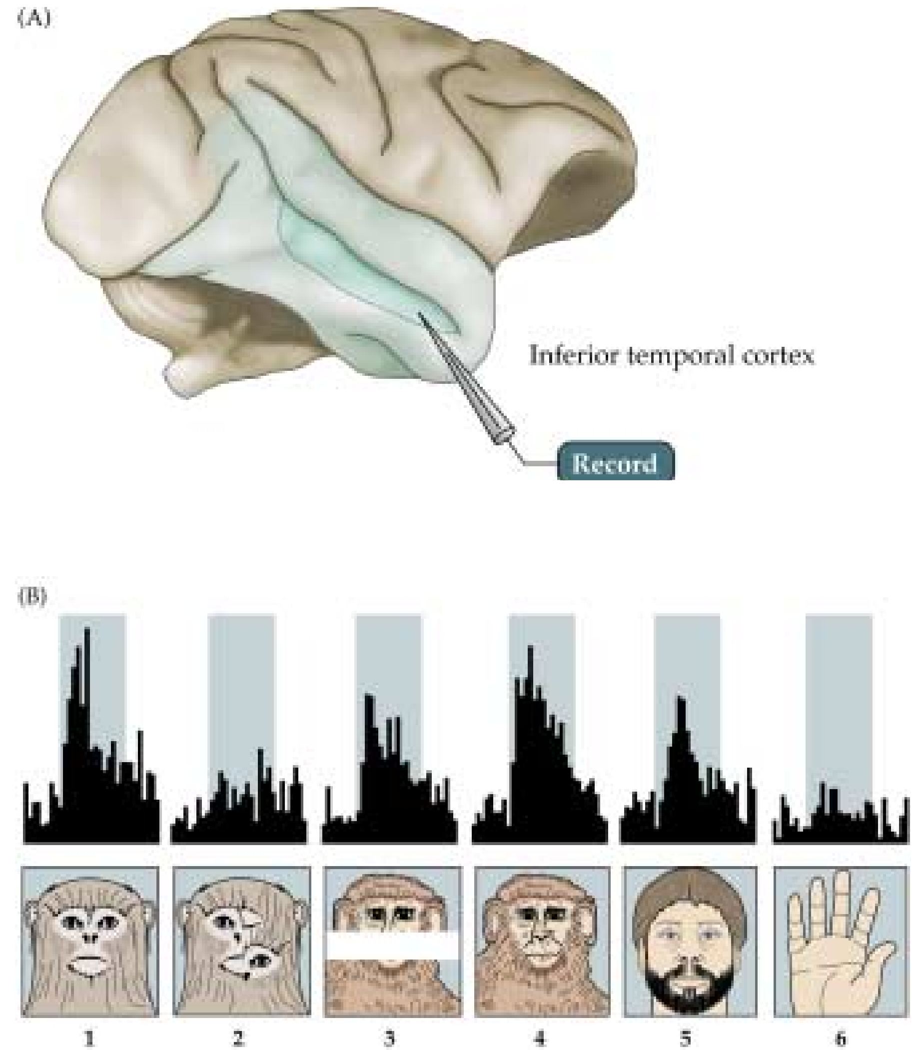
Lesions to different visual areas result in specific deficits in perception.

- *lesions to V4 affect colour perception*

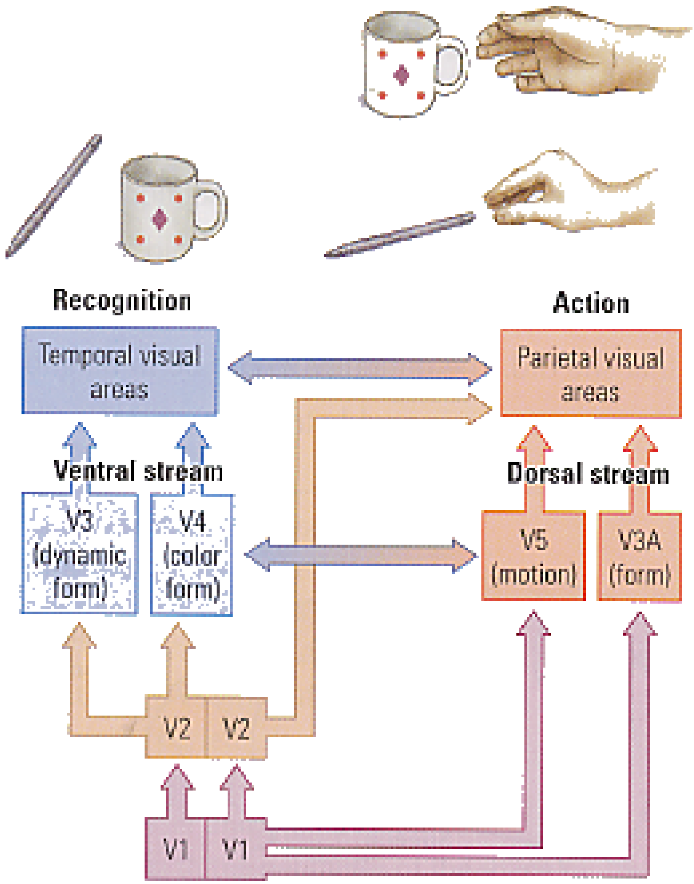
- *lesions to MT affect motion perception*

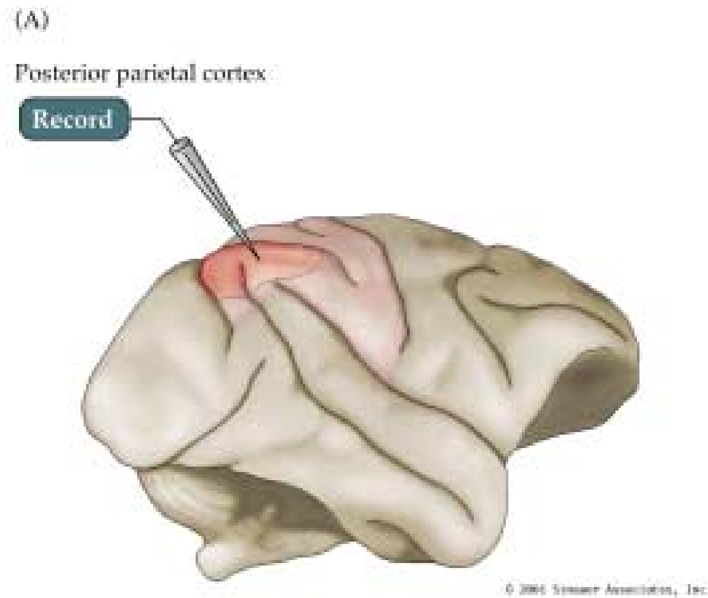
Neurons in the temporal lobe (ventral stream) respond to complex objects

- Lesions to these areas result in agnosias - deficit in object recognition.



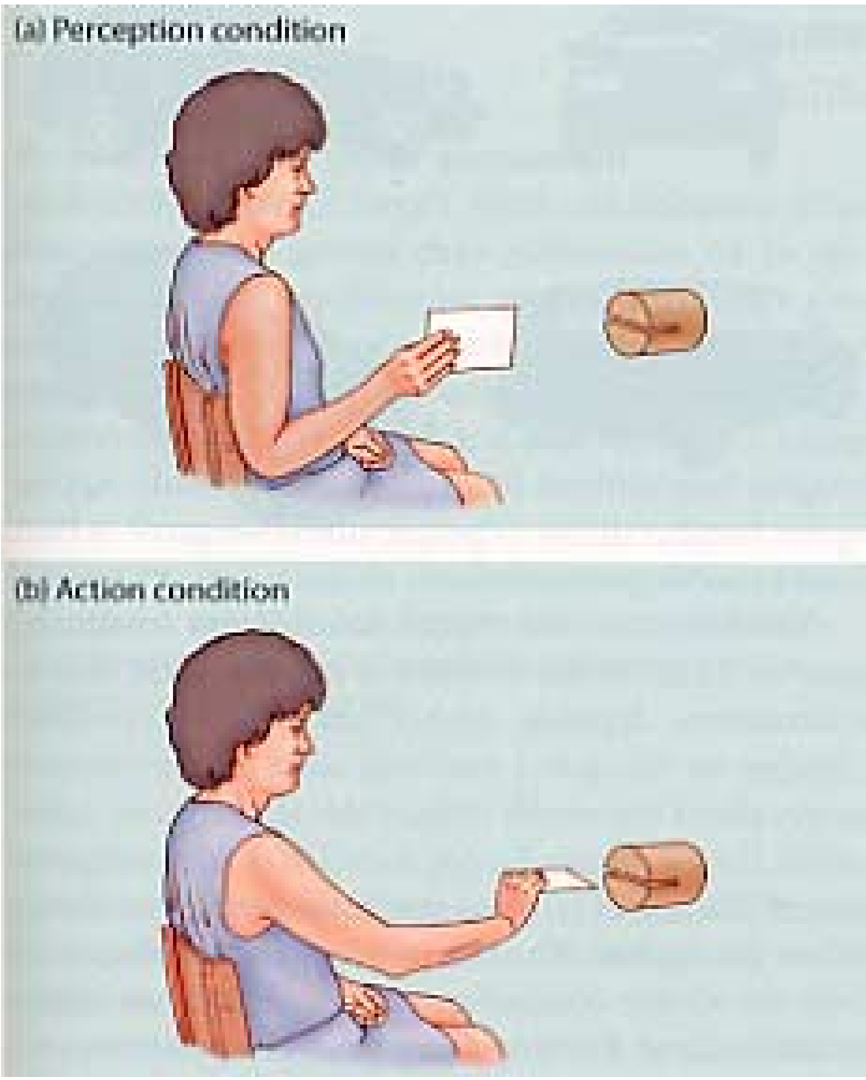
Lesions to the parietal lobe (dorsal stream) affect visually guided behaviour





- *Optic ataxia: deficit in the visual control of reaching and other movements*

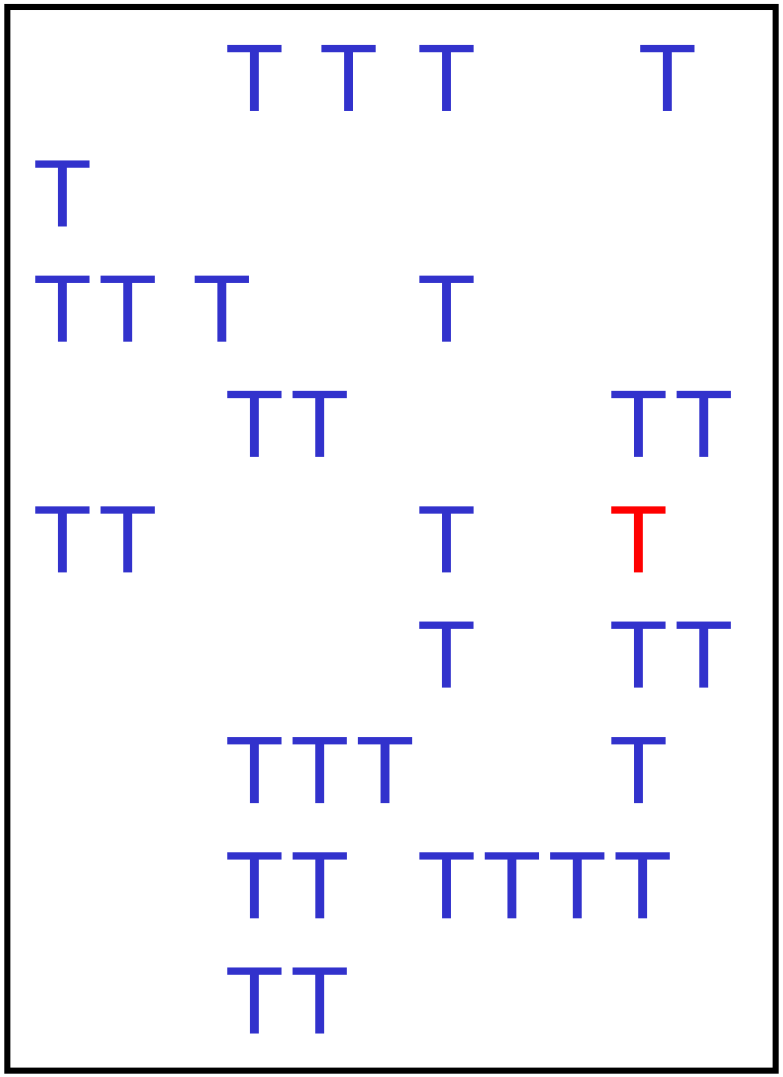
A patient with a lesion to the ventral pathway



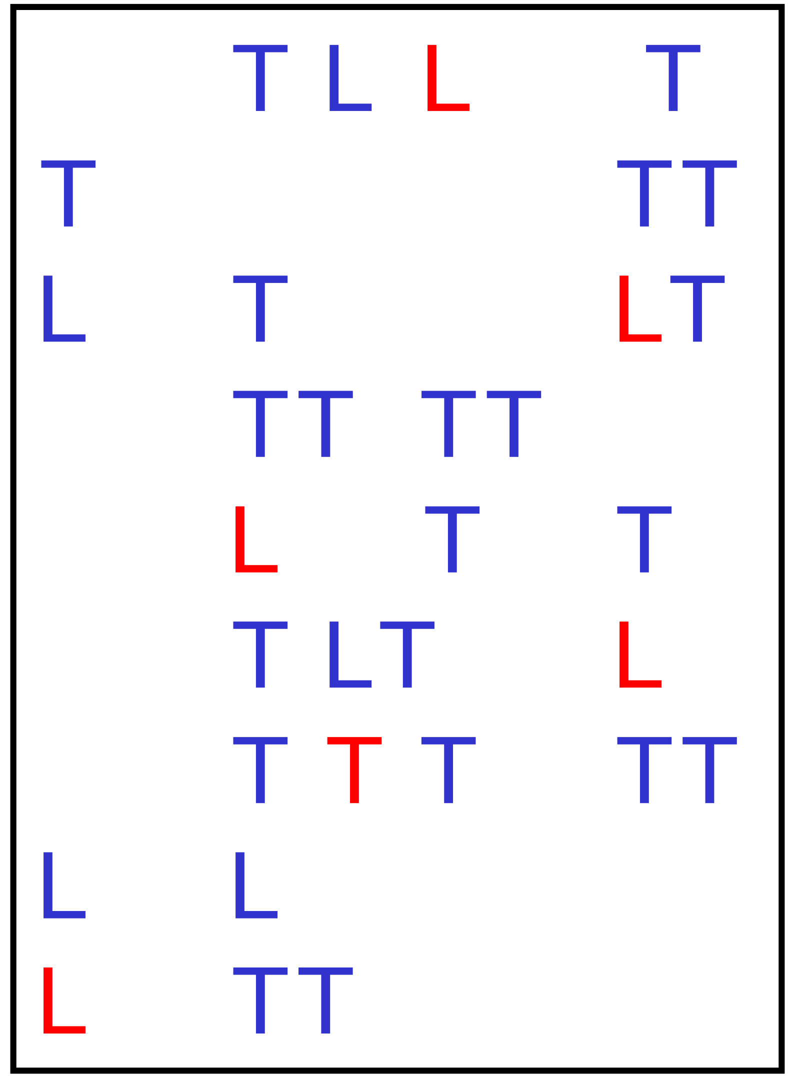
- The patient is unable to *perceive* the correct orientation, but is able to produce the correct *action* when instructed.

Visual search

Pop-out



Conjunction Search

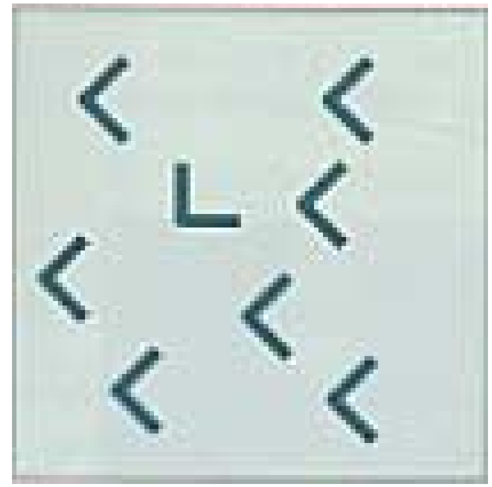


A perceptual demonstration of parallel processing

- Pop out occurs for different features of the visual scene (color, form, depth, motion, brightness)

- These results are consistent with the finding that these features are processed in separate areas of the visual system.

- In the conjunction-search task, reaction time increases because we have to combine information from different visual areas.



The binding problem

- The discovery of parallel processing inevitably leads to the question of how these areas interact to provide us with a unified image of the visual world - *the binding problem*.

Solving the binding problem

- Convergence
  - This theory is based on the idea that neurons coding for different aspects of an object such as its color, form etc converge on a single neuron that detect that combination of features. This theory is often referred to as the 'Grandmother cell' theory because it implies that we have a neuron for every object we recognise - even Granny!
- Temporal synchrony
- Population coding
- Feature integration theory