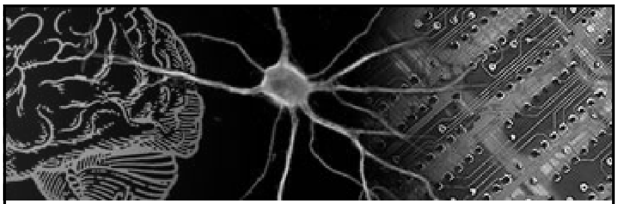

PSYC305-08A

Applied Cognition & Neuroscience

Mātai hinengaro whaipainga

Lect 13. Neuroscience: Visual Pathways

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Psychology Dept.
The University of Waikato

Central Visual Pathways

- •Retinal ganglion cells
- •Lateral geniculate nucleus
- •Segregation of information
  - -Parvocellular neurons
  - -Magnocellular neurons
- •Primary visual cortex (striate cortex)

Essential reading: Livingstone & Hubel article.
Extra reading: 6th Edition, pp 77-115 or 7th Ed pp 72-78
Physiology textbook: Carlson, Foundations of Physiological Psychology. Ch. 6)

The first part of the lecture will consist of an explanation of the terminology in the Livingstone and Hubel article.

Figures used to explain terminology can be found in L & H article, Goldstein and these lecture notes.

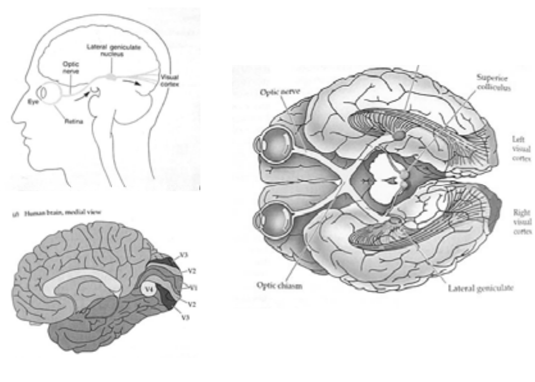
Terminology in Livingstone & Hubel article:

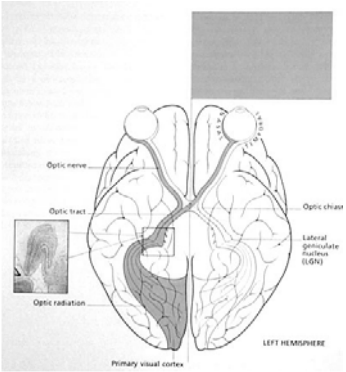
	Page
Lateral Geniculate bodies	740,741
Superior colliculus	740
Equiluminance	740
6 topographic maps	741
Retinal ganglion cells, Center-surround opponency	741
Spectral sensitivity curves	741
Acuity, Speed, Contrast	741
4cα	742
Mitochondrial enzyme cytochrome oxidase stain	742
Orientation selective	742
Depth from parallax (see video clips on last slide)	743
End-stopped	743
Higher visual areas (e.g., middle temporal lobe, MT)	744

The following slides are used to illustrate the terminology in the Livingstone and Hubel article.

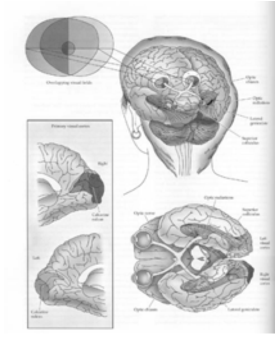
They won't make a lot of sense on their own and are designed to be used as an accompaniment to the lecture.

The primary visual pathway





From: Biological Psychology. Rosenzweig, Leiman and Breedlove



Cross-section of the lateral geniculate nucleus

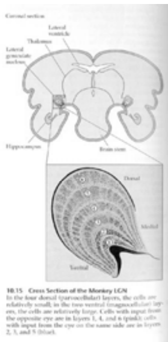


Figure 1. from Livingstone and Hubel article (coloured version).

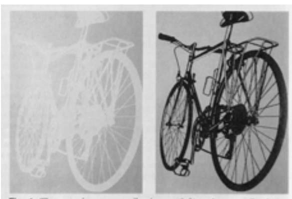


Fig. 1. The same image at equiluminance (left) and non-equiluminance (right). Depth from perspective, spatial organization, and figure/ground segregation are diminished in the equiluminant version. To convince yourself that the left version does indeed contain the same information as the other, look at it through a piece of blue cellophane or glass. These two colors may not be close enough to your equiluminance point to be effective. Changing the light source may help.

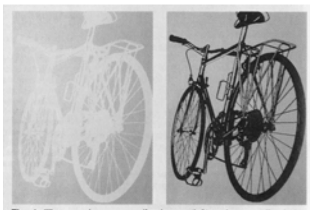
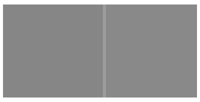
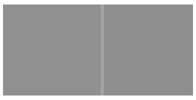


Fig. 1. The same image at equiluminance (left) and non-equiluminance (right). Depth from perspective, spatial organization, and figure/ground segregation are diminished in the equiluminant version. To convince yourself that the left version does indeed contain the same information as the other, look at it through a piece of blue cellophane or glass. These two colors may not be close enough to your equiluminance point to be effective. Changing the light source may help.

Example of equiluminant patches

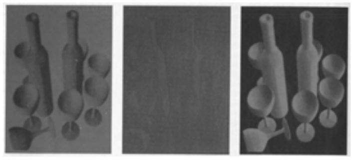


Different wavelengths
Same intensities

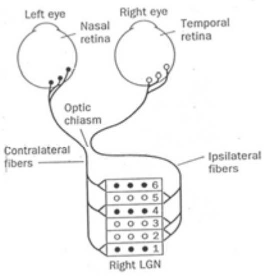


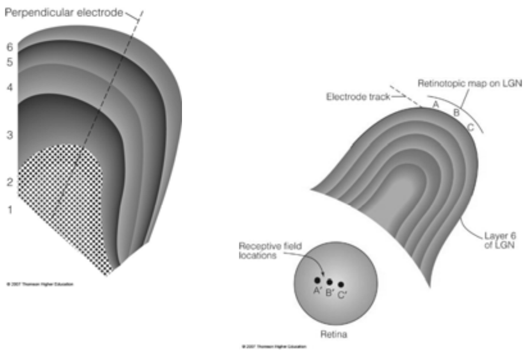
No wavelength (colour) information

Figure 7 from Livingstone and Hubel article (coloured version)

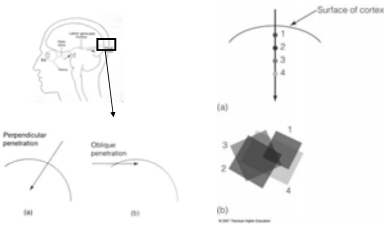


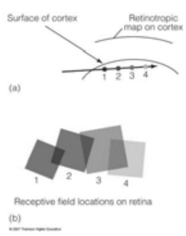
Topographic maps





Locations on the retina are also mapped in an orderly way on the cortex (retinotopic mapping).

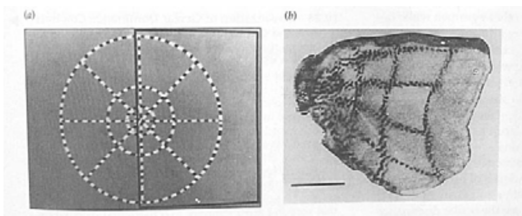




An electrode that penetrates the cortex perpendicularly, encounters neurons which have overlapping receptive fields (a). If the electrode penetrates obliquely, the neurons near each other in the cortex have receptive fields near each other on the retina (b).

Locations on the retina are also mapped in an orderly way on the cortex (retinotopic mapping).

However much more of the cortex is dedicated to the central visual field (fovea) than to the periphery.



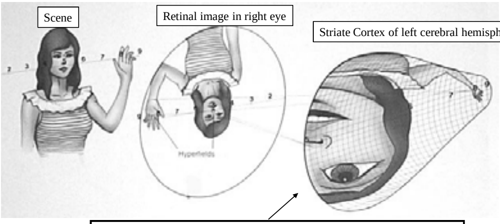
Screen in front of monkey Monkey's cortex

From Tootell et al., 1988.

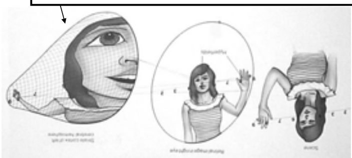
Scene

Retinal image in right eye

Striate Cortex of left cerebral hemisphere



Approximation of the spatial distortion that results from the mapping of the retinal image onto the cortex.

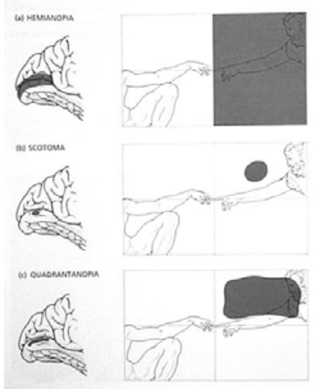


The consequences of lesions in the striate cortex.

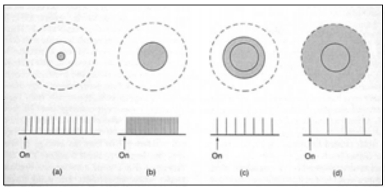
Lesion affecting all of V1 in left hemisphere

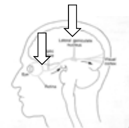
Small lesion in the lower lip of the left area of V1

Larger lesion affecting the lower lip of the left area of V1



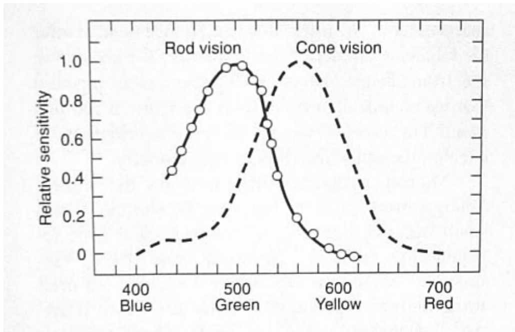
Retinal ganglion cells and neurons in the Lateral Geniculate Nucleus have circular shaped receptive fields.



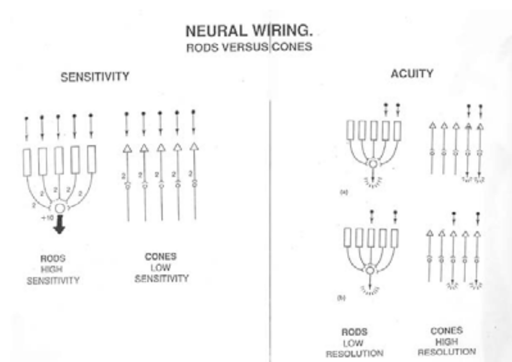


Excitatory-centre-inhibitory-surround receptive field

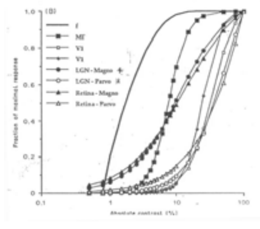
See CD-ROM demo



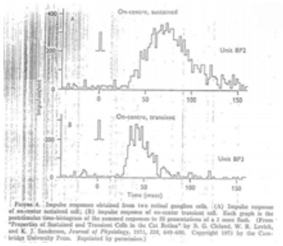
Examples of spectral sensitivity curves.



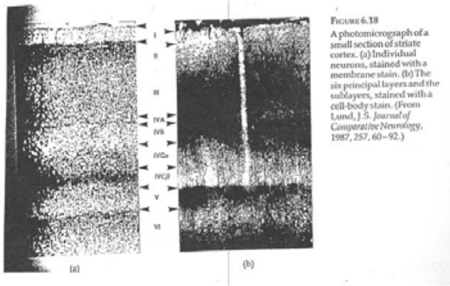
From Goldstein textbook



Contrast response



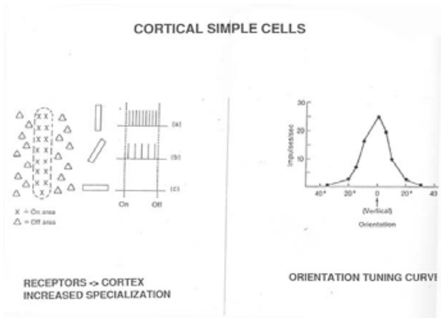
‘Speed’ of response



Layers in V1

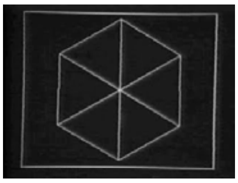
Fig. 5 area V1 and V2, blobs and interblobs.

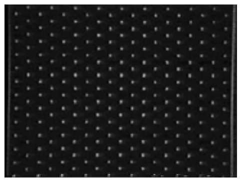
Stained with mitochondrial enzyme cytochrome oxidase stain

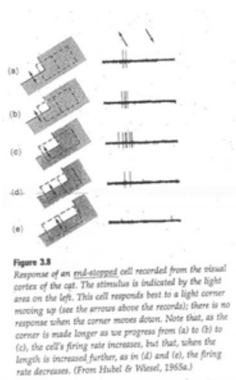


From Goldstein text book

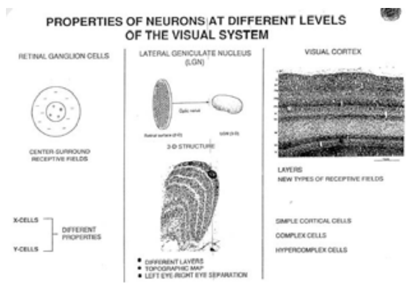
Examples of depth from parallax (motion)

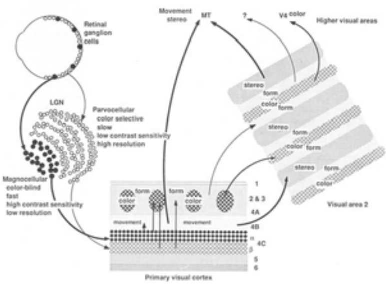


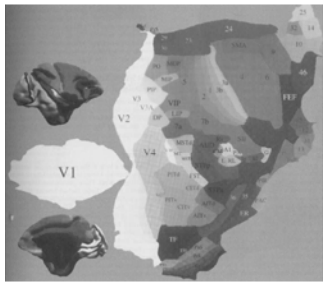




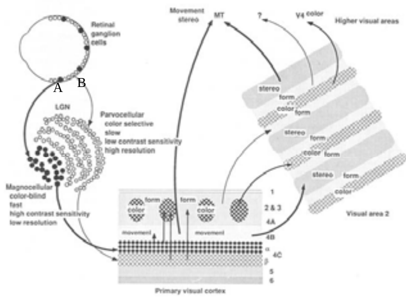
From Goldstein text book







You don't need to know this!



"The primate lateral geniculate body is a six-layered structure, with two obviously different subdivisions: the four dorsal, small-cell (parvocellular) layers and the two ventral, large-cell (magnocellular) layers; these two subdivisions differ both anatomically and physiologically".

Page 741.

These receive inputs from two types of retinal ganglion cells:
Type A which project to Magnocellular layers of LGN
Type B which project to Parvocellular layers.

The Parvocellular and Magnocellular neurons have different physiological properties.
See pp 741, 742 and table for different responses to:

Colour
Acuity
Speed (of response)
Contrast

TABLE 8-1 Properties of parvocellular and magnocellular cells in the Lateral Geniculate Nucleus.

	Parvo	Magno*
Retinal input	Type B (or P)	Type A (or M)
Spatial summation	linear	M, linear, M, nonlinear
Field size	small	M, small, M, large
Response timing	sustained (for pure colors)	more transient
Layers in LGN	3, 4, 5, 6	1, 2
Axon conduction velocity	slow	fast
Sensitivity to contrast	poor	good, but saturates
Sensitivity to color	many cells	none
Projection to V1 (layers)	4A, 4Cβ	4Cα

*Magnocellular cells may be further subdivided as X-like (M,) or Y-like (M,), but most magno cellular properties apply to both subtypes (or they have not been separately tested).

Continuation of the magno and parvo subdivisions in visual area 1 (Primary visual cortex, V1)

Cells in magnocellular geniculate layers project to layer 4cα which then projects to 4B and then onto V2 and cortical area MT (Middle Temporal).

Magno ⟹ 4cα ⟹ 4B

Parvocellular project to different layers of V1 and then onto V2.

Parvo ⟹ 4Cβ ⟹ layers 2 and 3 (blobs and interblobs)

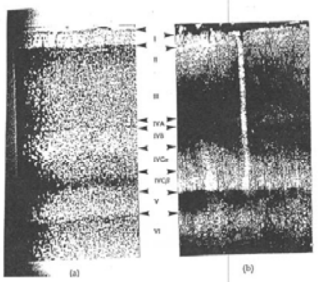
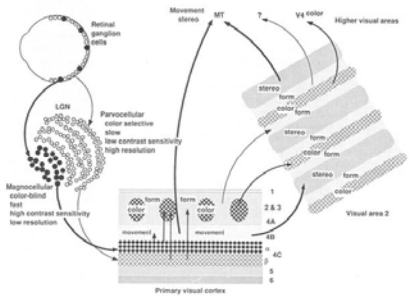


FIGURE 6.18
A photomicrograph of a small section of striate cortex. (a) Individual neurons, stained with a membrane stain. (b) The six principal layers and the sublayers, stained with a cell-body stain. (From Lund, J.S. *Journal of Comparative Neurology*, 1987, 257, 60–92.)

Layers in V1

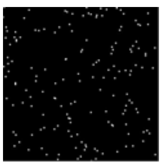


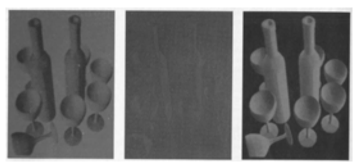
Human Perception

Can differences in LGN neuron (magno and parvo) responses be detected in conscious human visual perception?

Yes. (see list of examples pp 746)

e.g., Effect of equiluminance upon motion and stereo displays.





The magno system seems to be more primitive than the parvo system and possibly has the same origin as the entire visual system of nonprimate mammals. If so, it should not be surprising that the magno system is capable of what seems to be the essential functions of vision for an animal that uses vision to navigate in its environment, catch prey, and avoid predators.

The parvo system, which is well developed only in primates, seems to have added the ability to scrutinize in much more detail the shape, color, and surface properties of objects, creating the possibility of assigning multiple visual attributes to a single object and correlating its parts (visual identification and association).

Summary of Livingstone & Hubel, p 748.