



Bi/CNS/NB 150: Neuroscience
Vision I
October 28, 2015
Ralph Adolphs

We emphasize these points from Kandel in Bi/CNS 150

Read

Lecture

Chapter 26 & 27	Vision I (Adolphs)	Overview of the visual system Anatomy: The retina, LGN, V1 Perception: What is seeing? David Marr's three levels of analysis Vision is ubiquitous, but many different types of eyes evolved Visual processing streams originate in the retina Topography: there are maps of visual space in the brain RGCs have center-surround receptive fields	Oct. 28 (today)
Chapter 26	Vision II (Lester)	Phototransduction The brain can detect a single photon: amplification Visual transduction is slow: second messenger pathways Rods and cones hyperpolarize in response to light Retinal ganglion cells send action potentials from retina to brain There is adaptation to bright and dark light levels	Oct. 30
	Discussion section	Midterm Review	Nov. 1
Chapter 25 & 28	Vision III (Adolphs)	High-level vision and object recognition Maps of visual space are topographic but distorted Higher regions synthesize more complex visual representations There are two broad visual processing streams: ventral and dorsal Higher-level visual cortex has functionally specialized regions	Nov. 2

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Synopsis:

Overview
 Perception
 Retina
 Central projections
 LGN
 (Visual Cortex)

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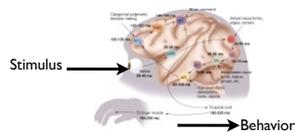
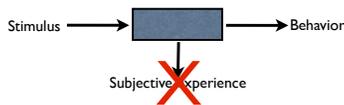
Friday:

More Cortex
 Beyond VI
 Human neuroimaging
 High-level vision

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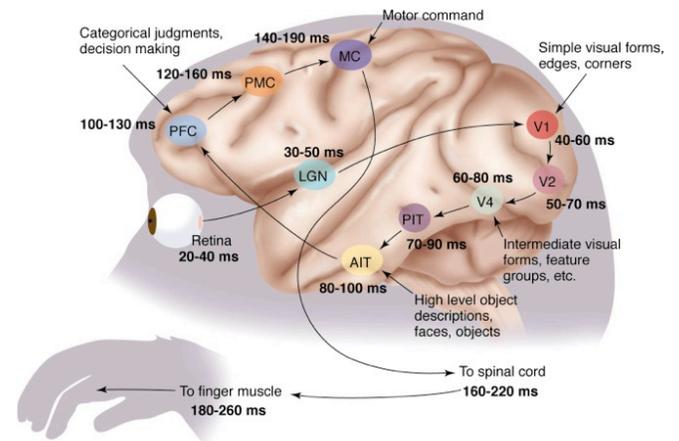
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The Challenge:



Key advances:

- electrophysiology
- neuropsychology
- neuroimaging
- modeling



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Sherrington (1948): senses classified as

- teloreceptive (vision, hearing)
- proprioceptive (limb position)
- exteroceptive (touch)
- chemoreceptive (smell and taste)
- interoceptive (visceral)

VISION

What is seeing?

To know what is where by looking

1. vision involves object identification
2. vision involves localization in visual space
3. vision is active

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Vision as a computational problem

- Vision is the *process* of discovering from images what is present in the world, and where it is.

Cues available for vision

retinal location
luminance
wavelength ratios
change over space
change over time
binocular disparity
surround/context

visual field location
brightness
hue
contrast/spatial frequency/texture
motion
depth
color, illusions

Computational theory

Goal of the computation? Why is it appropriate and what is the logic of the strategy by which it can be carried out?

Representation and algorithm

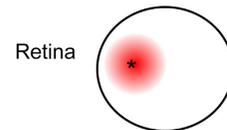
Implementation?
Representation of the input and output?
Algorithm for the transformation?

Hardware implementation

How can representation and algorithm be realized physically?

D. Marr, 1980

Correlation structure



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Stages of Processing

1. Transduction
2. Perception (early)
3. Recognition (late perception)
4. Memory (association)
5. Judgment (valuation, preference)
6. Planning (goal formation)
7. Action

Sensation
Knowledge
Belief
Decision

Tasks

Detection
Discrimination
Categorization
Recognition
Conceptual knowledge
Naming

Disorders

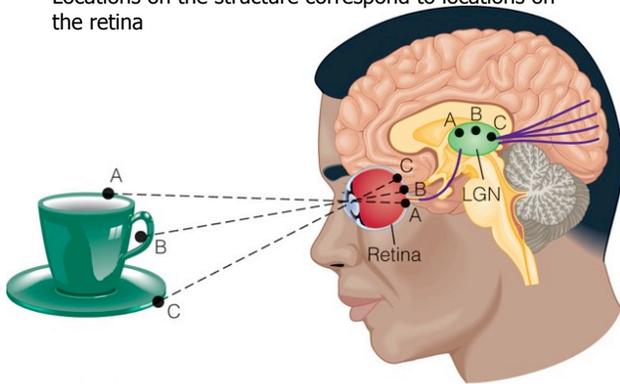
Apperceptive Agnosia
Associative Agnosia
Amnesia
Anomia

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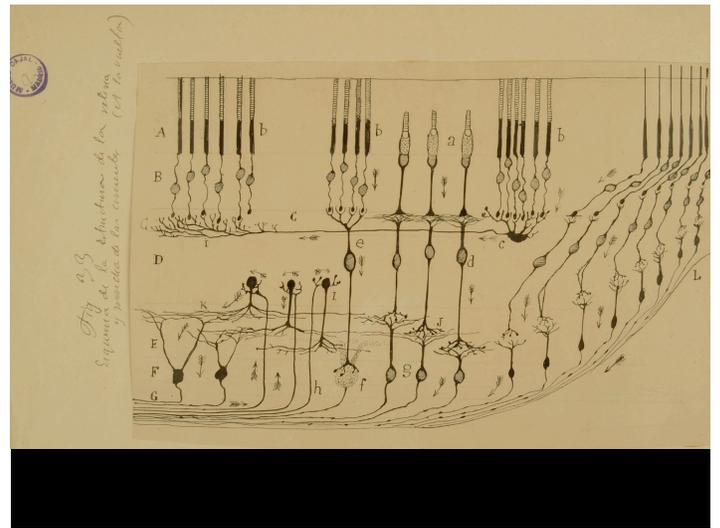
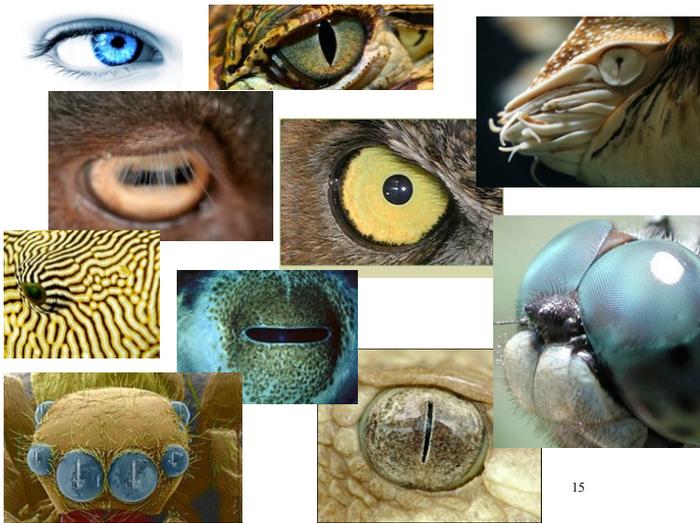
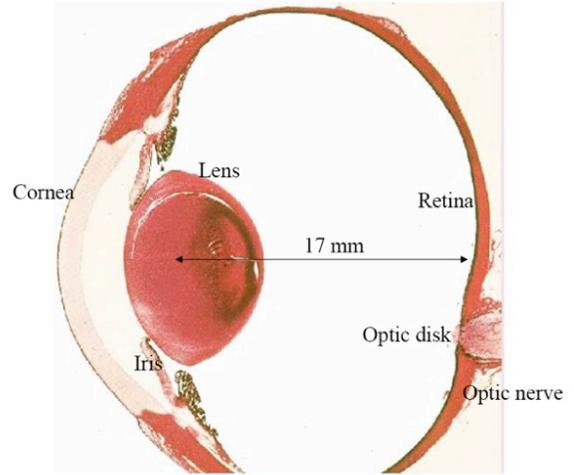
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■ Retinotopic map

- A location map on a structure of the visual system (LGN, V1, SC), in which...
- Locations on the structure correspond to locations on the retina

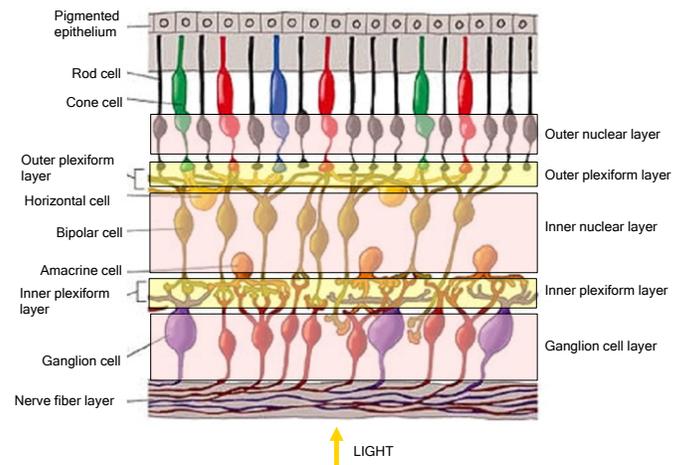
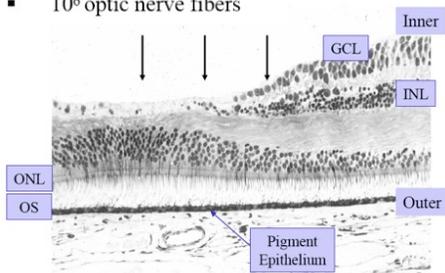
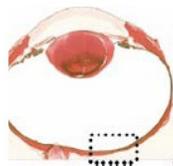


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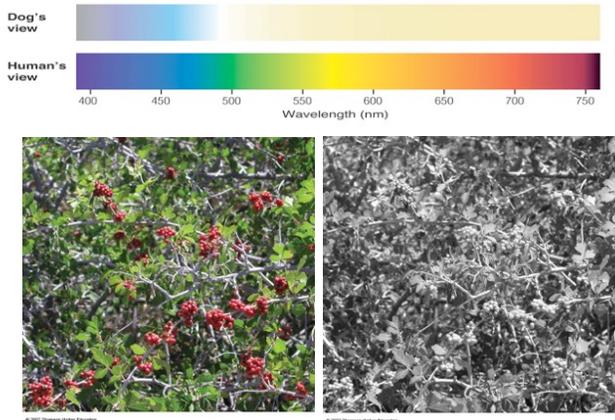


The Retina

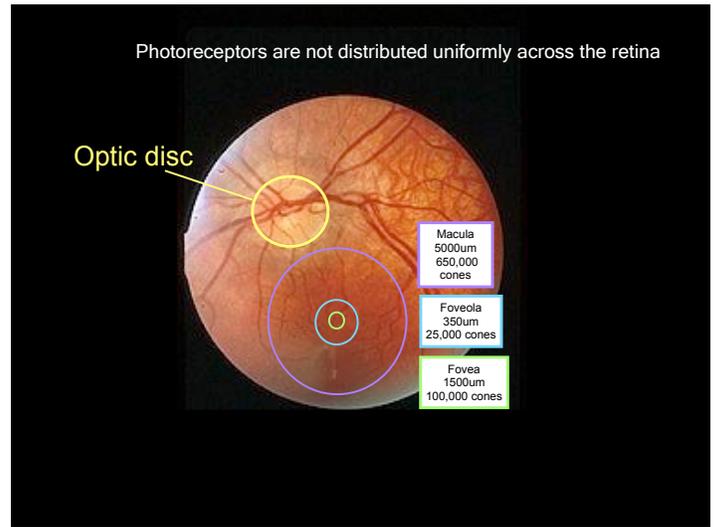
- 5 x 5 cm, 0.4 mm thick
- 5×10^6 cones
- 10^8 rods
- Foveal cone width: 1 μ m
- Contacts per cone: 250
- 10^6 optic nerve fibers



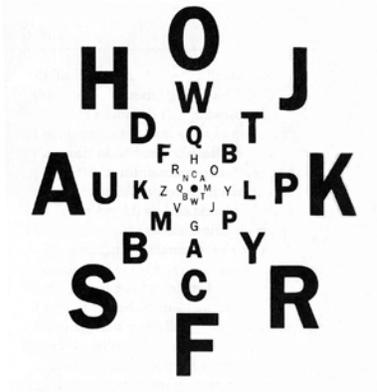
Why see in color?



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Visual Acuity Falls Off with Eccentricity



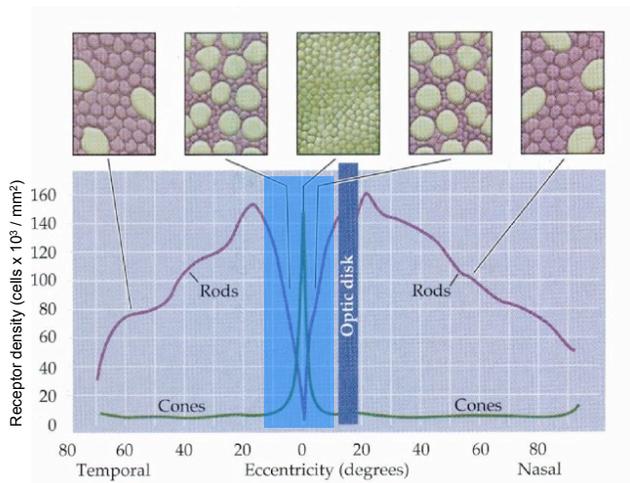
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peripheral detection (coarse)
visual attention
fixate: foveate
central identification

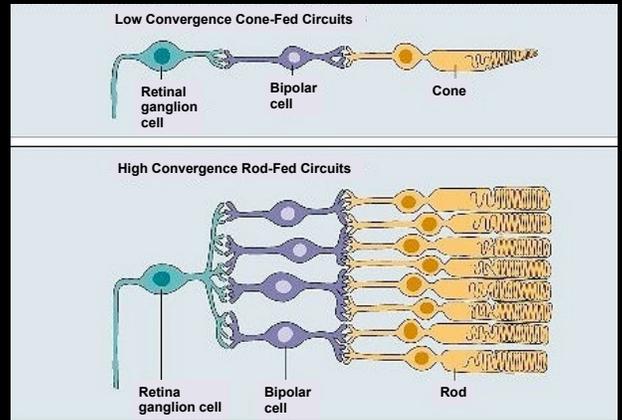
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Information flow in the retina is organized



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Vision solves a specific problem: to know **WHAT** is **WHERE** by **LOOKING**
 Different species implement this in many different ways
 The retina does a lot of complicated processing already
 The only source of visual information to the brain comes from the retina
 There is convergence, divergence, and image compression in the retina
 You fixate what you attend to (you look at what you want to know about)
 Parallel processing streams originate in the retina

From retina to brain

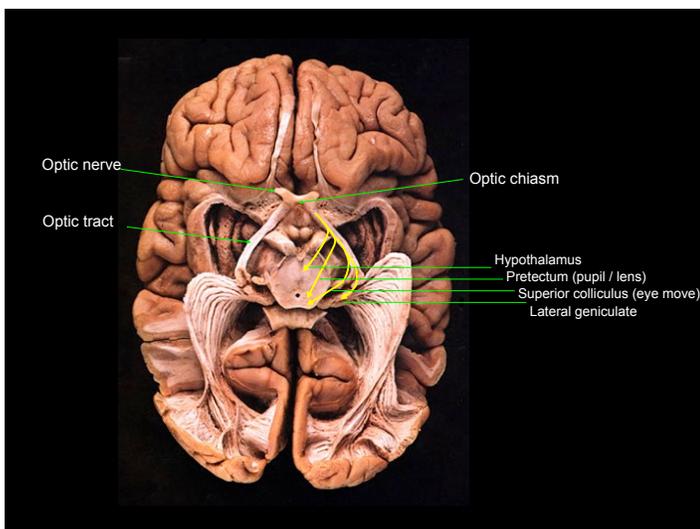
- thalamus
- SC/ optic tectum
- pretectal nuclei
- SCN

-NO feedback from brain to retina

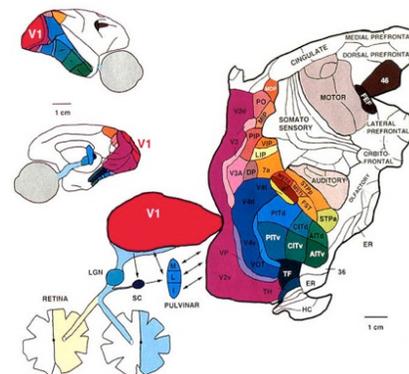
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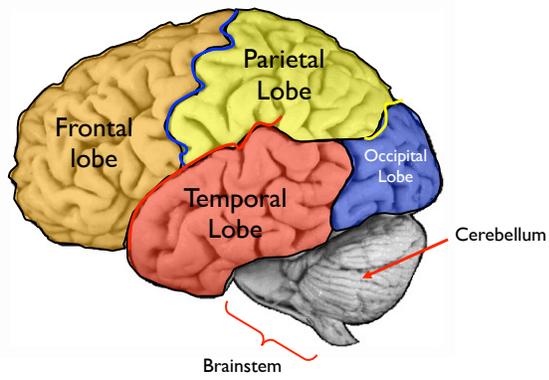
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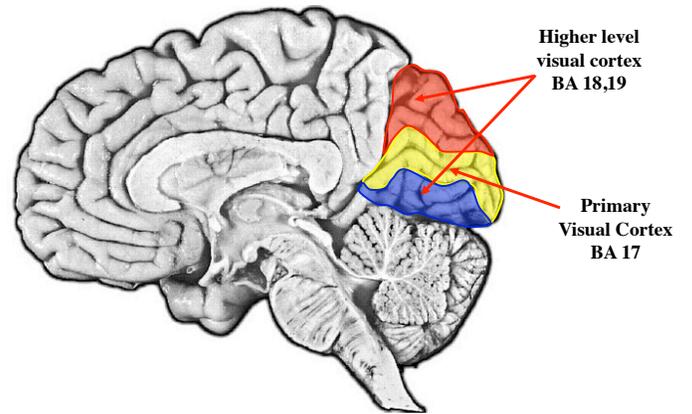
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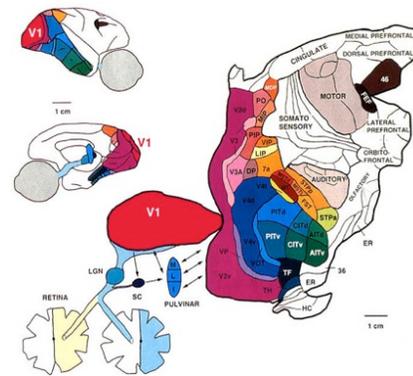


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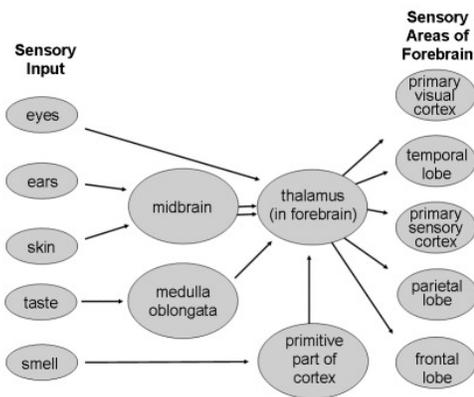
Neocortex is organized into maps

- primary sensory cortices are topographic
- higher-order cortices are next to primary cortices
- there are information processing streams through cortex

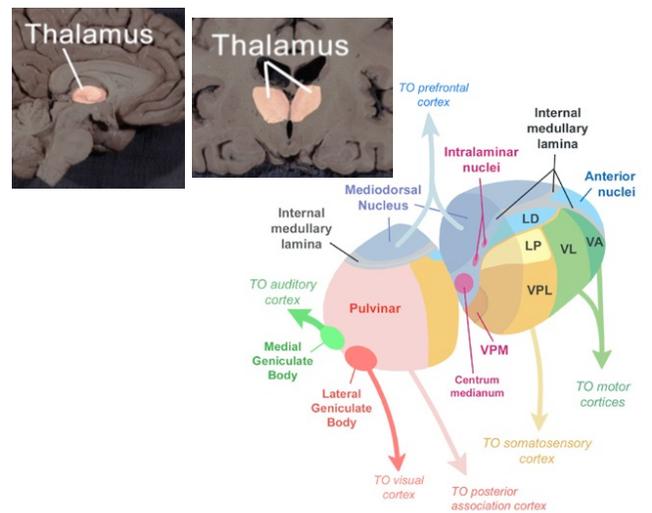
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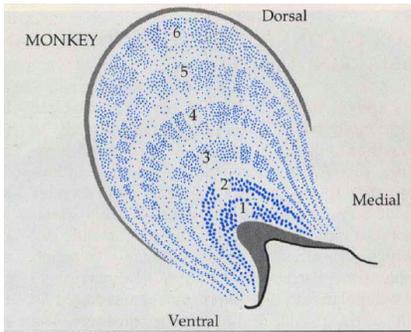
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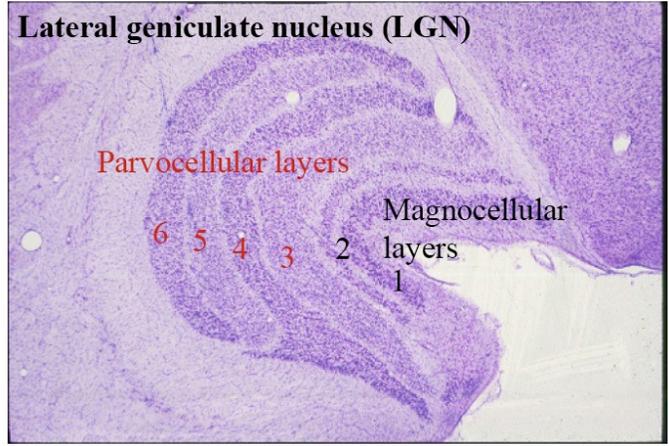
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90% of Optic Nerve Projects to LGN

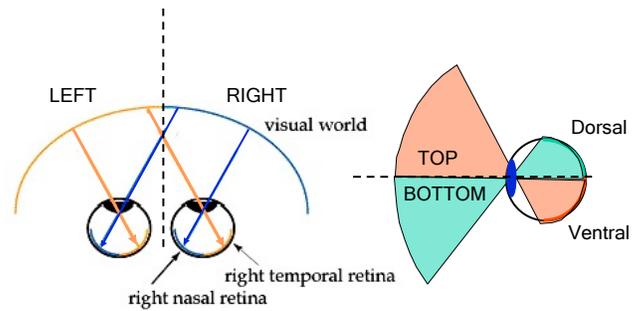
Parvocellular Layers (3-6)



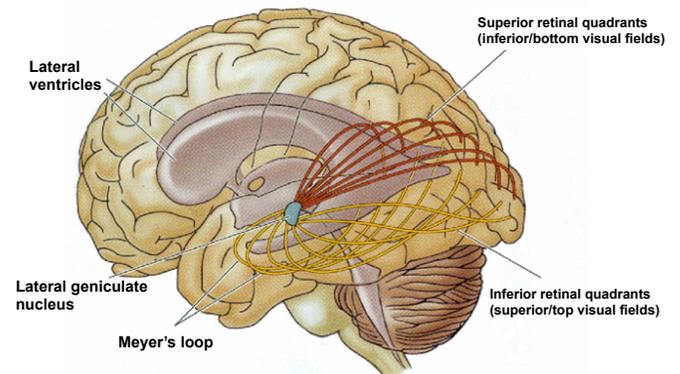
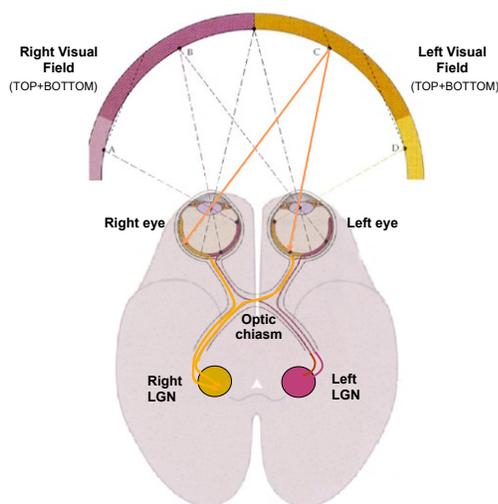
Magnocellular layers 1 and 2

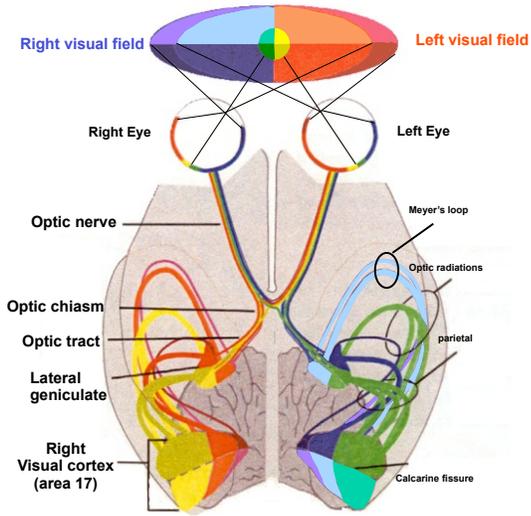


Binocular vision -
Getting information from two eyes to the same neural place



anopia: blindness
contralateral: opposite side
ipsilateral: same side
nasal, temporal





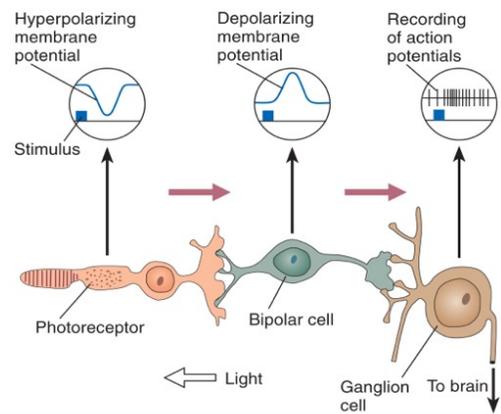
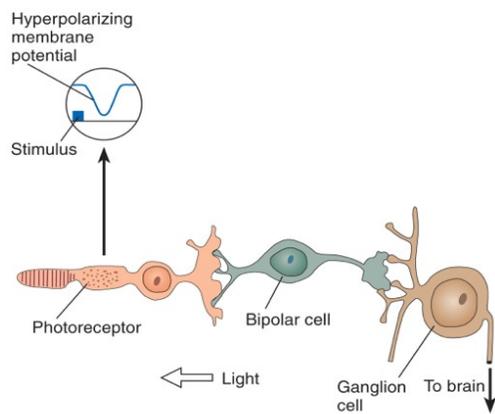
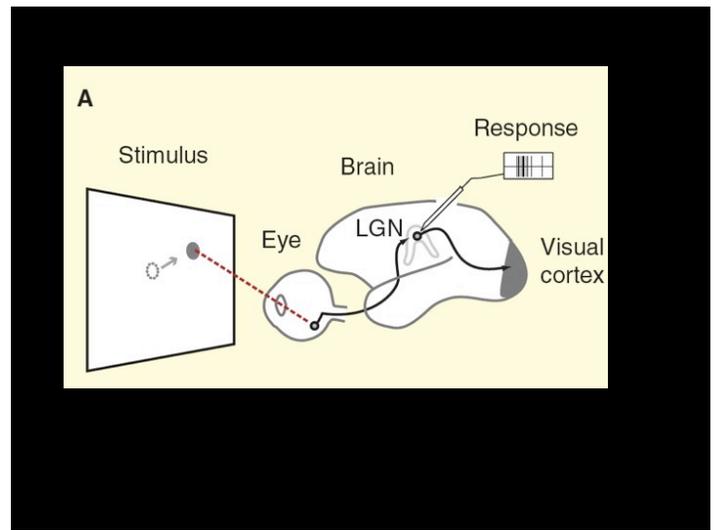
Electrophysiology

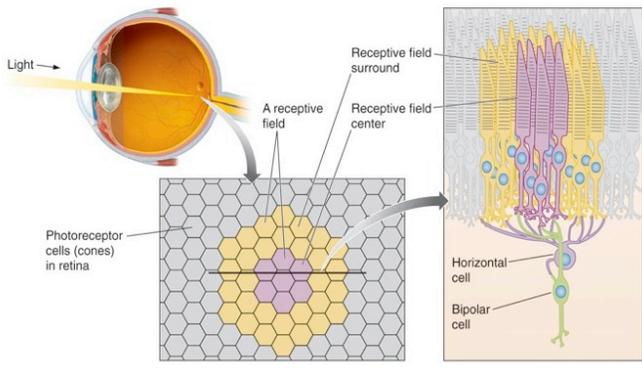
David Hubel
1926 -

Torsten Wiesel
1924 -

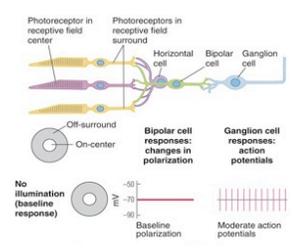
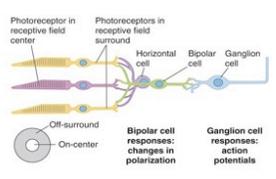
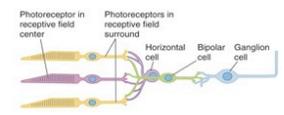
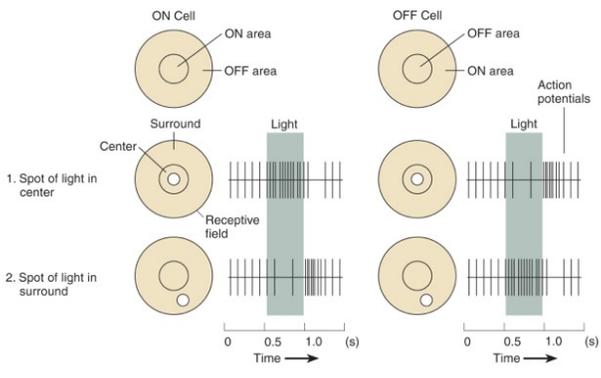
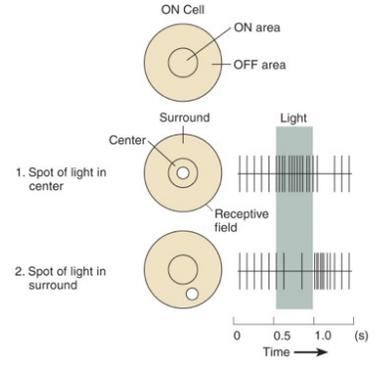
Receptive fields of single neurons in the cat LGN and visual cortex and functional organization of cortex.

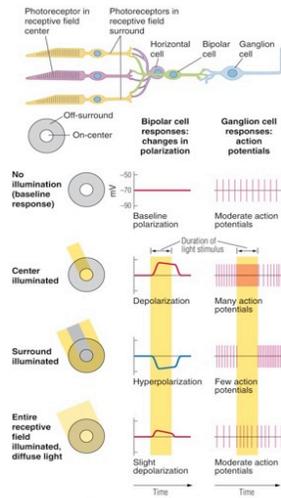
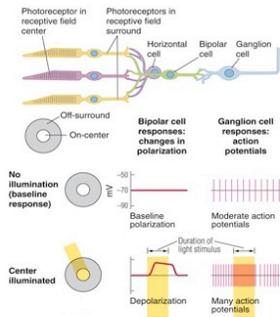
1981 - Nobel prize for work on information processing within the cerebral cortices.





(a) On-Center/Off-Surround Receptive Field of a Bipolar Cell

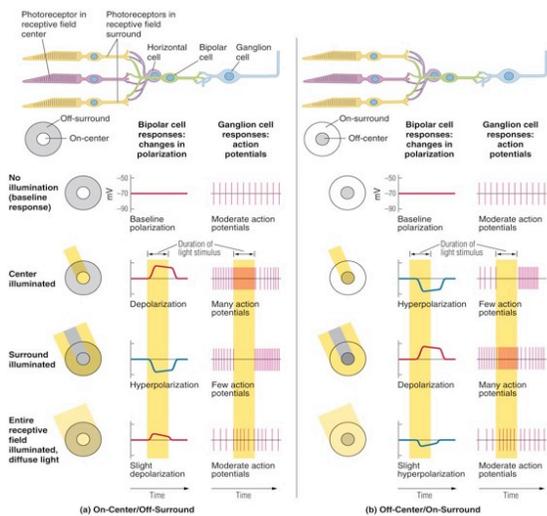




(a) On-Center/Off-Surround

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(a) On-Center/Off-Surround

(b) Off-Center/On-Surround

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