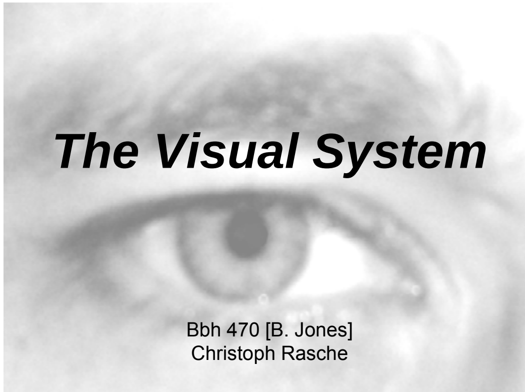


The Visual System

Bbh 470 [B. Jones]
Christoph Rasche

Goal

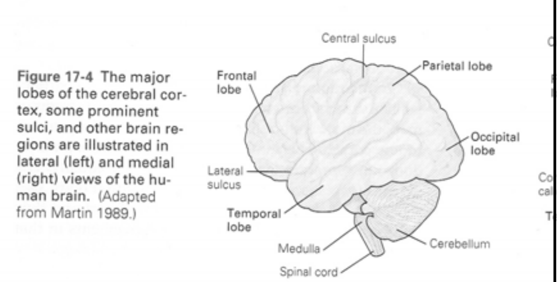
- To familiarize with rough anatomy, structure and function of the visual system
- Basis: chapters 25-28 of Kandel et al
- To be done in two lectures

Jobs of the Visual System

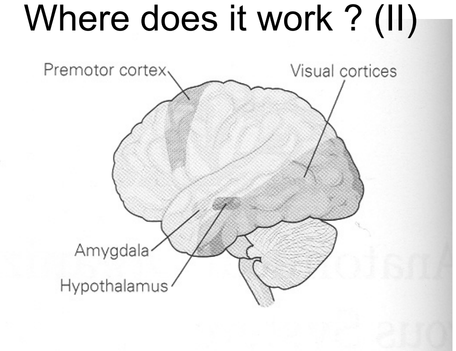
- To make sense of the structures/shapes/forms in our visual environment ≈ object categorization)
- To detect & follow motion
- To analyze/investigate/interpret the image in detail (depth, color)

→ many, many functions!

Where does it work?



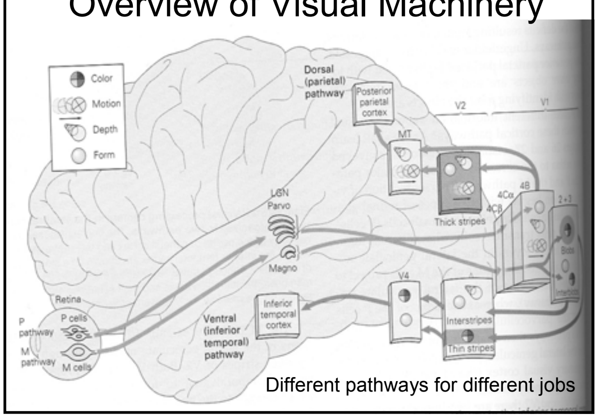
Where does it work ? (II)



- it's not only the eye, but half of the brain

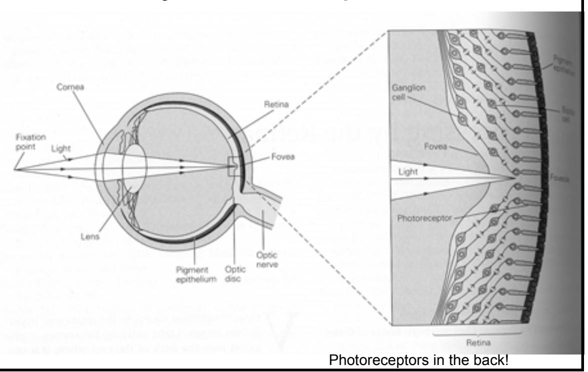
Outline brain
Legend 4 pathways

Overview of Visual Machinery



Different pathways for different jobs

The Eye – The Input Device



Photoreceptors in the back!

Two Types of Photo-receptors: Rods and Cones

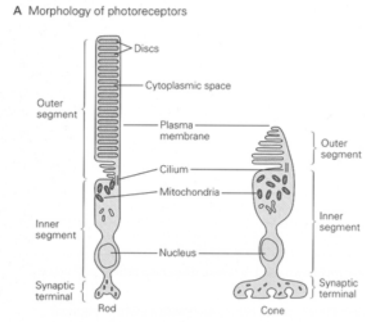


Figure 26-2 The two types of photoreceptors, rods and cones, have similar structures. (Adapted from O'Brien 1982 and Young 1970.)

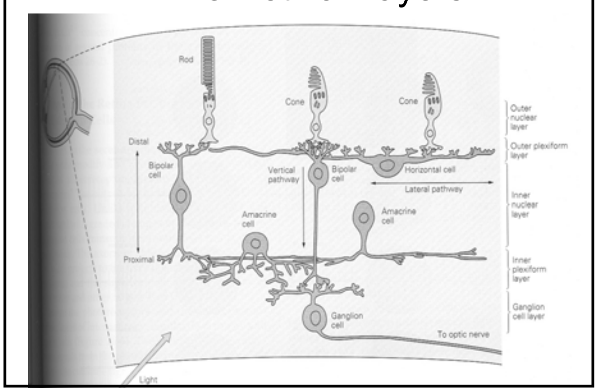
A. Both rod and cone cells have inner and outer segments connected by a cilium. The inner segment contains the cell's nucleus and most of its biosynthetic machinery. The outer segment contains the light-transducing apparatus.

Rods for Night, Cones for Day (Color)

Table 26-1 Differences Between Rods and Cones and Their Neural Systems

Rods	Cones
High sensitivity to light, specialized for night vision	Lower sensitivity, specialized for day vision
More photopigment, capture more light	Less photopigment
High amplification, single photon detection	Lower amplification
Low temporal resolution: slow response, long integration time	High temporal resolution: fast response, short integration time
More sensitive to scattered light	Most sensitive to direct axial rays
Rod system	**Cone system**
Low acuity: not present in central fovea, highly convergent retinal pathways	High acuity: concentrated in fovea, dispersed retinal pathways
Achromatic: one type of rod pigment	Chromatic: three types of cones, each with a distinct pigment that is most sensitive to a different part of the visible light spectrum

The Retinal Layers



Vertical Pathway

- Parallel pathways:
  Off: responds to offset
  On: responds to onset

- analog to 'digital' conversion

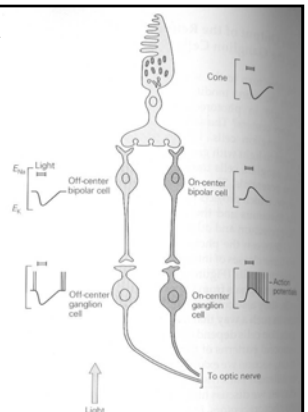
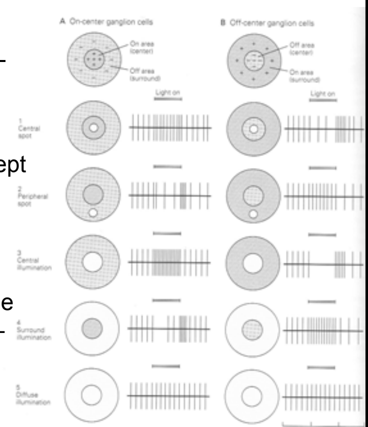


Figure 26-9 On-center and off-center bipolar cells establish

Ganglion Cell Responses – A Systematic Investigation

- receptive field concept
- circular stimulation works best

- bipolar cells have the same response pat-terns just without spikes



How are Receptive Fields Created?

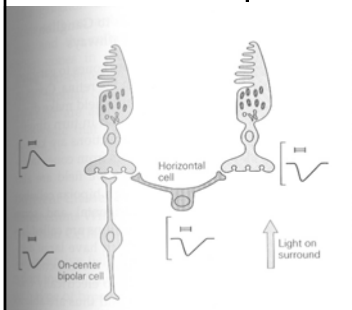


Figure 26-10 Signals from cones in the surround of a bipolar cell's receptive field are mediated by horizontal cells. Center-surround antagonism is illustrated here for an on-center bipolar cell. The horizontal cell receives input from a cone in the surround of the on-center bipolar cell and also

- Center determined by Photoreceptors (narrow area)
- Surround determined by Horizontal Cells (broad area)
- Read from right to left

→ center-surround antagonism

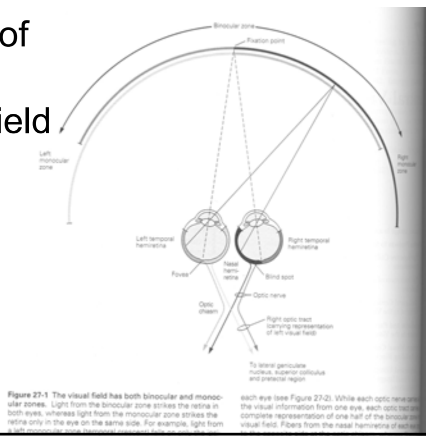
Ganglion Cells: M and P

Table 27-1 Differences in the Sensitivity of M and P Cells to Stimulus Features

	Sensitivity	
Stimulus feature	M cells	P cells
Color contrast	No	Yes
Luminance contrast	Higher	Lower
Spatial frequency	Lower	Higher
Temporal frequency	Higher	Lower

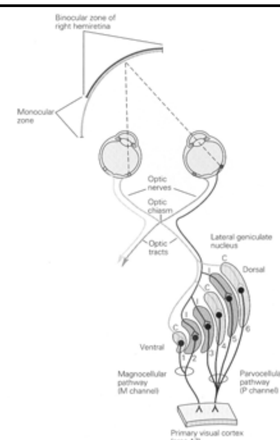
- Starting point of motion (magnocellular) and object (parvocellular) pathways

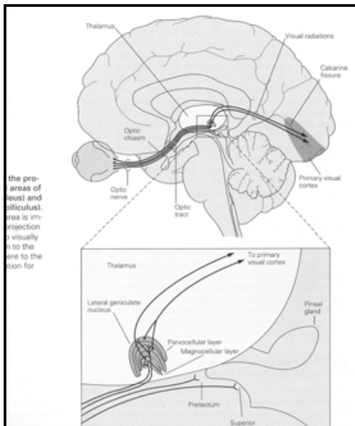
Zones of the Visual Field



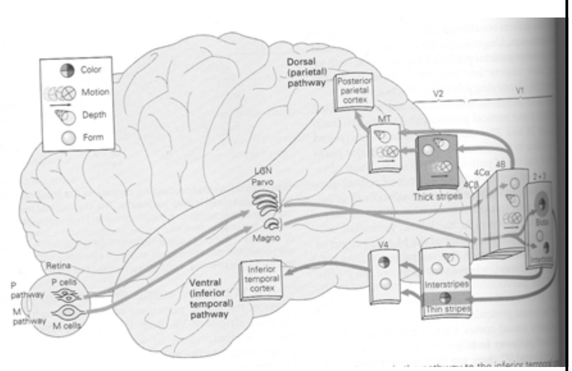
Lateral Geniculate Nucleus (LGN)

- Gateway between retina and V1
- Cell responses similar to ganglion cell responses





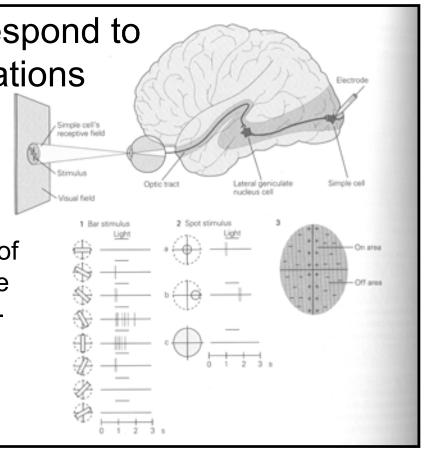
Projections from Retina to Primary Visual Cortex



V1

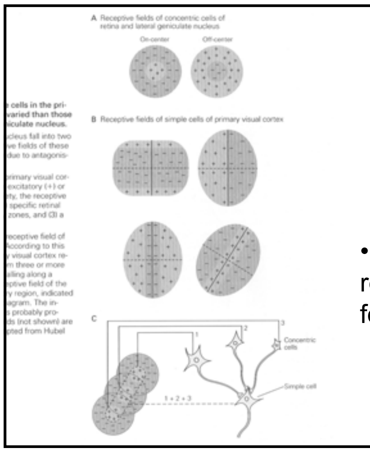
- = primary visual cortex
- = area 17 (Brodmann's classification)
- = striate cortex (staining patterns)
- What does it code for?
- Imagine the 50's and 60's
- Do V1 cells also respond to circular stimulation like in the retina, or may be even to objects?

V1cells respond to orientations



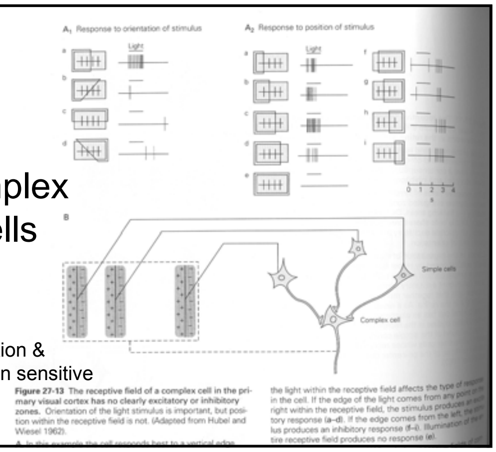
- orientation of specific angle
- 'orientation-selective'

Receptive Field Shapes of Simple Cells



- many different receptive field formations

Complex Cells



- orientation & motion sensitive

Who discovered those orientation-selective cells?

- Described by Hubel and Wiesel in the 50's and 60's. Won Nobel Prize for discovery and characterization.
- Accidental detection:

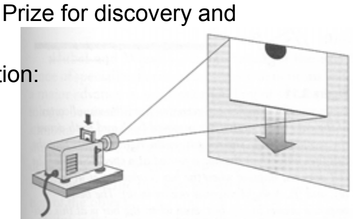
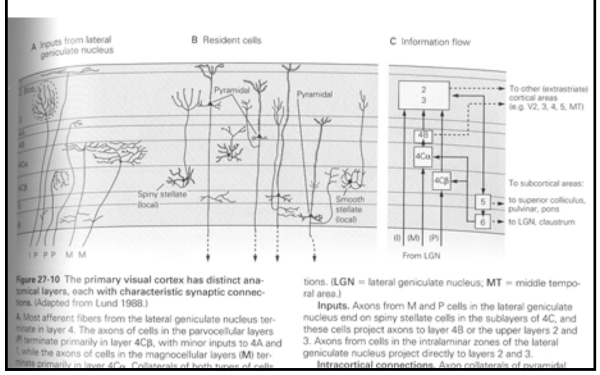
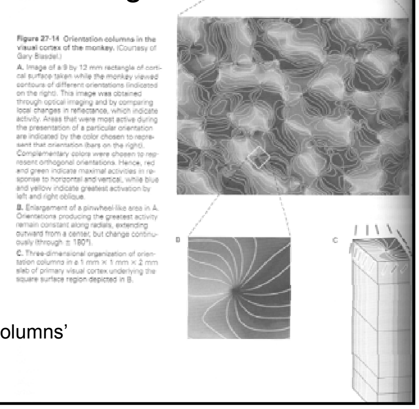


Figure 3.8
When Hubel and Wiesel dropped a slide into their slide projector, the image of the edge of the slide moving down unexpectedly triggered activity in a cortical neuron.

Layers of V1/Cortex

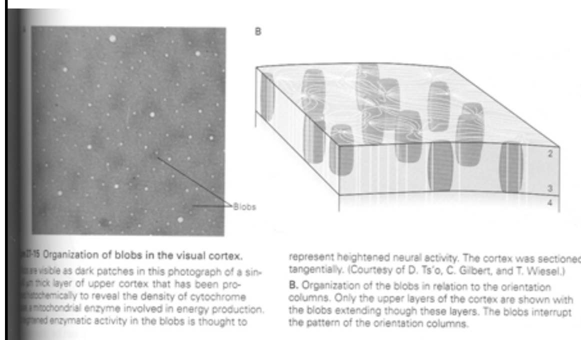


How are V1 cells organized?...



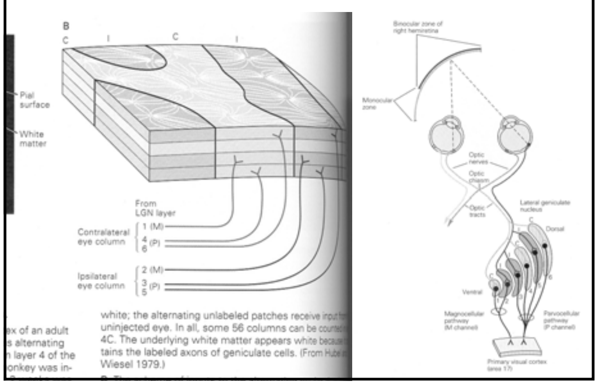
• … in ‘orientation columns’

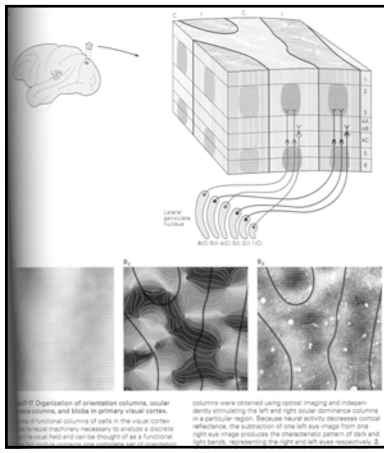
There also exist blobs…



• cells in blob regions tend to respond to color stimuli

Ocular Dominance Columns





All together
(orientations, ocular dominance, blobs)

• Hypercolumns