



Exams and Grades

- Grading
 - 25% on assignments
 - 35% on midterm
 - 40% on finals
- Assignment 1
 - Due on 27 Jan (next Tuesday)

Slide 1

ICS 280: Visual Perception



Last class Summary

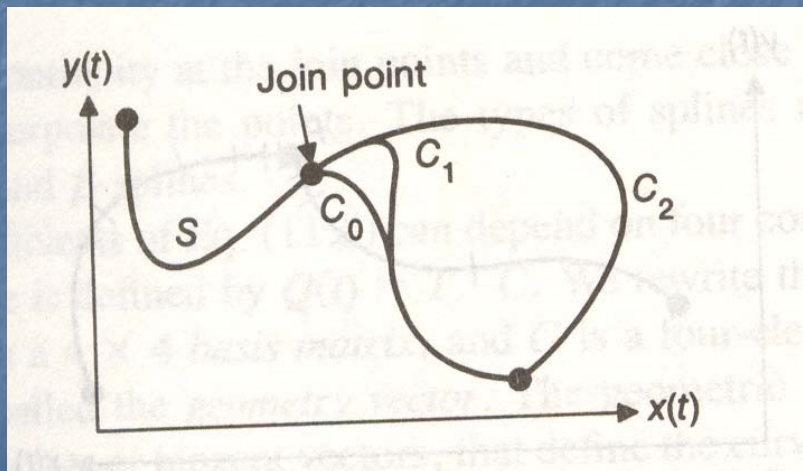
- Eye
 - Structure, Accomodation
 - Receptors
 - Distribution
 - Sensitivity
 - Function
 - Dark adaptation
 - Convergence
 - Receptive Fields

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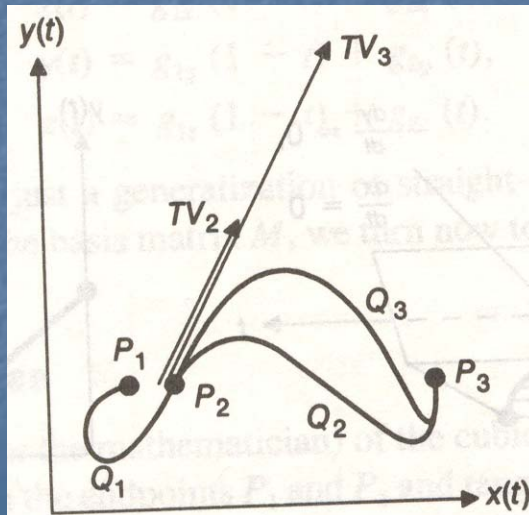
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Applications of Mach Band

Theory of Continuity



Geometric Continuity



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Mach Bands

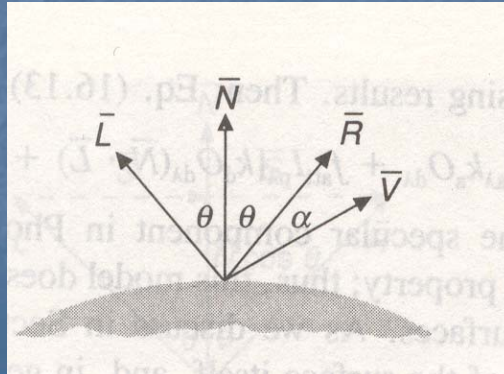
- Artifacts when any patch or curve does not show C^1 continuity
- They are always avoided
 - Shading
 - Blending
 - Image editing, contrast compressing, tone reduction
 - Geometric Modeling

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Shading

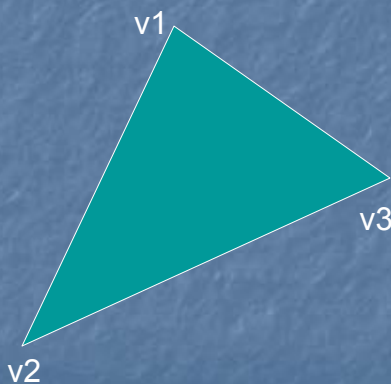
- $I_d = k_d (L \cdot N)$
- $I_s = k_s (2N (L \cdot N) - L) \cdot V$



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Shading

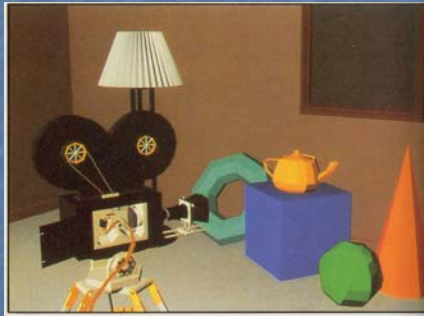


- Flat Shading
 - $[I(v1)+I(v2)+I(v3)]/3$
 - Is not C^1 continuous
- Interpolated Shading
 - Linear Interpolation of $I(v1)$, $I(v2)$ and $I(v3)$
 - Is C^1 continuous

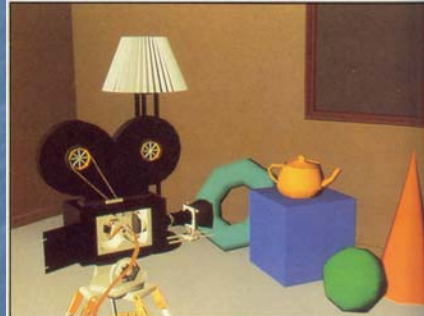
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Shading



Flat Shading



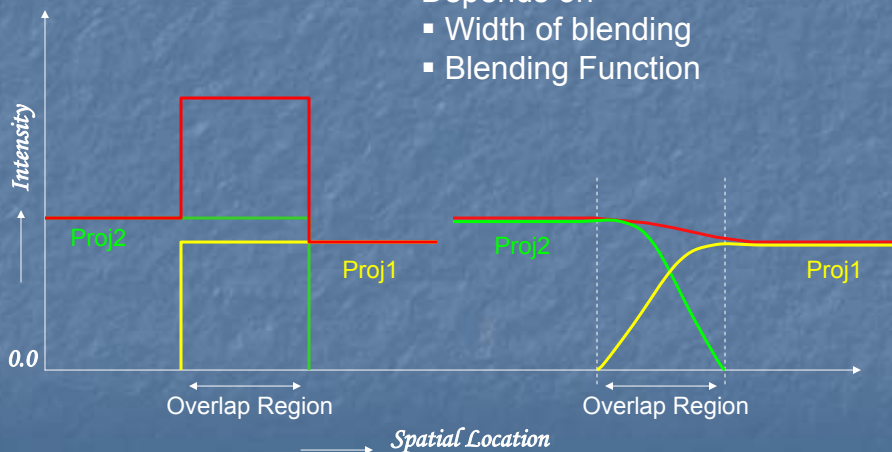
Interpolated Shading

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Intensity Blending

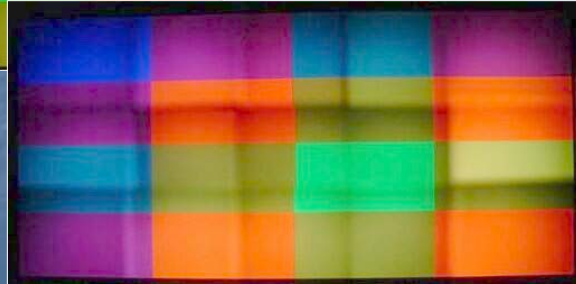
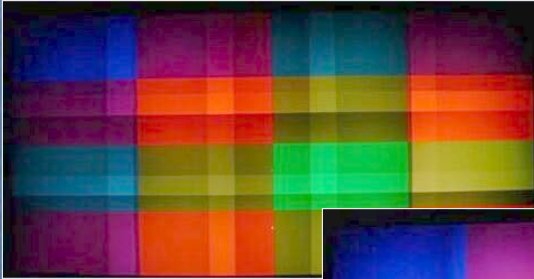
- Depends on
- Width of blending
 - Blending Function



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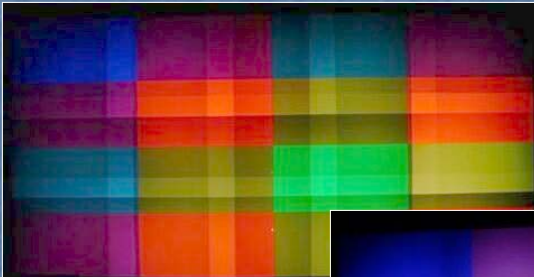
Intensity Blending



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Intensity Blending



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Applications

- Image Mosaics
- Multi-Projector Displays
- Image Editing



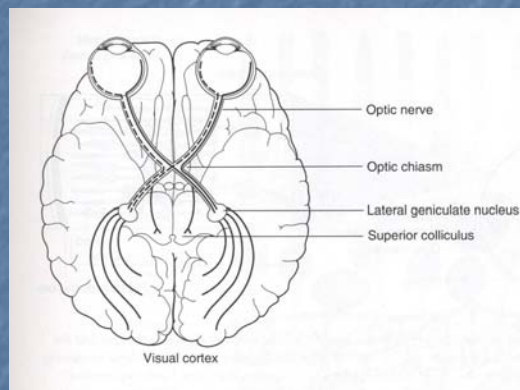
Geometric Modeling Primitives

- Three properties
 - Continuous
 - Continuous with transformations
 - Continuous with subdivisions

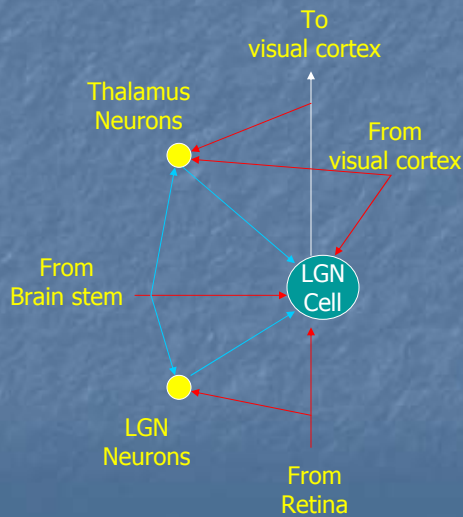
Lateral Geniculate Nucleus (LGN)

What happens beyond the retina?

- What happens in
 - Lateral Geniculate Nucleus (LGN)
 - Visual cortex
- Information Flow
- Organization of Neurons



Information flow in LGN



From Cortex



To Cortex

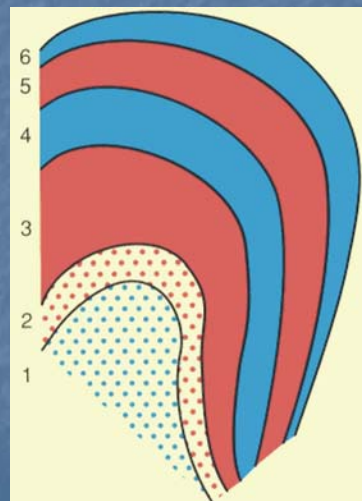
From Retina

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Information Organization in LGN

- LGN has six layer
- 1 million neurons in total
- Each layer receives signal from one eye
- Layer 2,3,5 receives from ipsilateral eye
- Layer 1,4,6 receives from contralateral eye

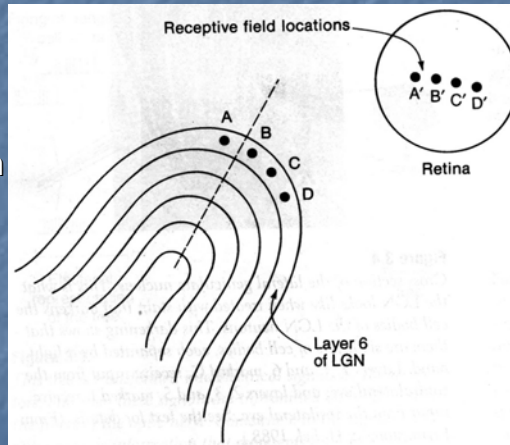


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Retinotopic Map

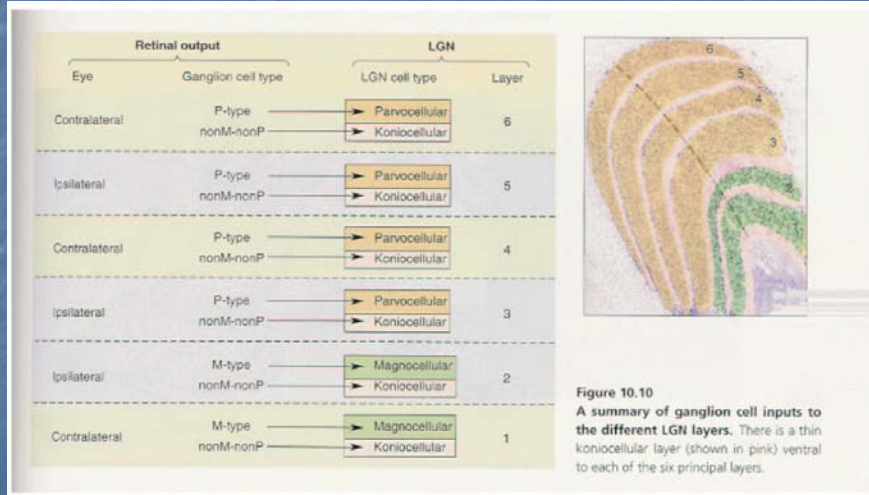
- Each location in LGN *maps* to a location on retina
- Receptive fields of neurons adjacent to each other in LGN have adjacent receptive fields in retina
- All the neurons on the same column across layers are sensitive to same area on the retina



Organization by Ganglion Cells

- P-cells (parvocellular)
 - Small medium sized cell body
 - Reaches layers 3,4,5,6
 - Responsible for color, fine textures, patterns and details vision
- M-cells (magnocellular)
 - Larger cell bodies
 - Reaches layers 1,2
 - Responsible for motion detection
- K-cells (koniocellular)
 - Largest cell bodies
 - Reaches all the six layers

Summary of LGN Organization



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Visual Striate Cortex



Information Processing

- 250 million neurons
- Process the incoming information from LGN
 - Make it clearer
- Neurons are specialized to respond to (*feature detectors*)
 - Orientation
 - Spatial Frequency
 - Length
 - Corners
 - Motion

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Three types of Cells

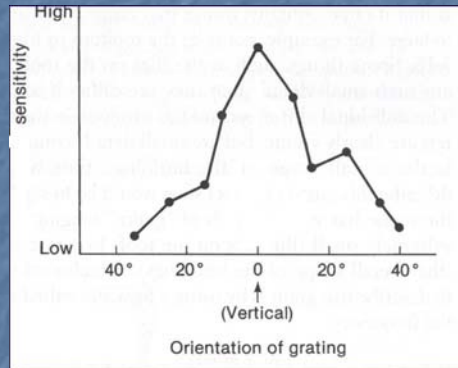
- Simple Cells
- Complex Cells
- End Stopped Cells

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Simple Cells

- Orientation sensitive
- Cylindrical shape excitatory center and inhibitory surround
 - Edge detectors
- Four different kinds

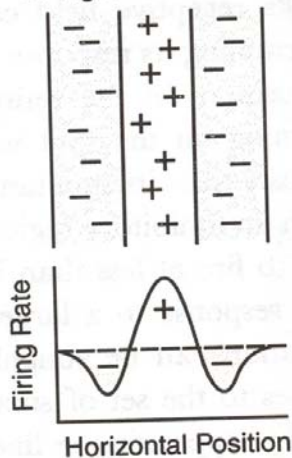


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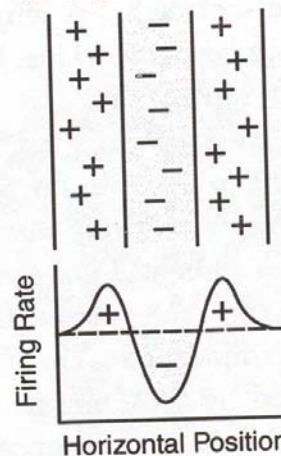
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Four kinds of Edge Detectors

A. Light Line Detector



B. Dark Line Detector

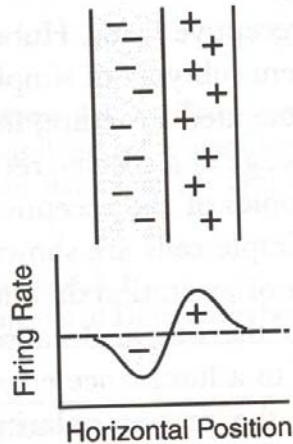


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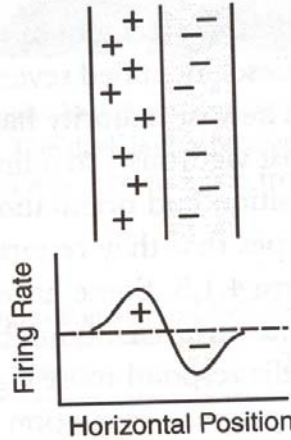
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Four kinds of Edge Detectors

C. Dark-to-light Edge Detector



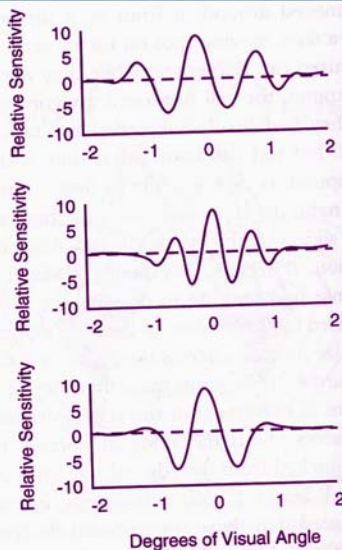
D. Light-to-dark Edge Detector



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May have complex receptive field



- Secondary lobes
- Adjacent to primary lobes

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Selective Adaptation

- When we view a certain state of a property
 - Initial phase : Neurons sensitive to it have increased firing
 - Later phase : This firing reduces and we become insensitive to this property
- *Adapt selectively* towards one particular state

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Example Experiment : Orientation

- Measure sensitivity to all different orientation
- Adapt to one orientation
- Measure sensitivity to all different orientation again
- Find the change in the sensitivity

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Designing the Experiment

- Stimulus
 - Grating Pattern
- Sensitivity Measure
 - Contrast threshold
- Contrast
 - Define as the amplitude/mean of grating
 - Threshold : amount of contrast required to detect grating
 - Sensitivity : $1/\text{threshold}$

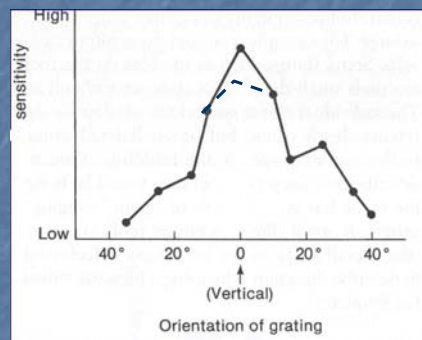
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Selective Adaptation

If stimulated by the same stimulus for a long time, sensitivity to the stimulus decreases



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Complex Cells

- Orientation Sensitive
- Non-linear
 - Never respond to stationary spot
 - Difficult to find their receptive field
- Motion Sensitivity
 - Responds to moving lines
 - Often, depends on the direction of motion

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Complex Cells

- Position Insensitivity
 - Does not matter if the position of stimulus changes slightly
- Spatial Extension
 - Larger receptive fields than the simple cells

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End Stopped Cells

- Far more specific
- Respond to moving lines and corners
 - Of specific length
 - Of specific orientation
 - Of specific size
- Probably hypercomplex version of the simple and complex cells

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What this shows...

- Our eye is very sensitive to edges, corners
- Any high frequency content

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Organization

- Retinotopic Map
- Cortical Magnification
 - Fovea is 0.01% of retina
 - Retinotopic map of fovea is 8-10% of cortex



Cortical Magnification

- Density of receptors and ganglion in retina is very mismatched
 - In fovea about 50,000 ganglion cells per sq. mm.
 - In periphery about 1000 ganglion cell per sq. mm.
- Density of neurons from fovea and periphery is close to uniform



Cortical Magnification

- Foveal input allocated extra cortical neurons
- Three to six times more than those at periphery
- One of the factors for higher acuity in the fovea

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Location Columns

- Retinotopic Map
- Same region on retina along the depth
- Adjacent regions in the retina correspond to adjacent columns

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Orientation Columns

- Same columns have similar orientation preference
- Orientation preference changed across columns continually
- For every 1mm region, the entire range of orientations were covered

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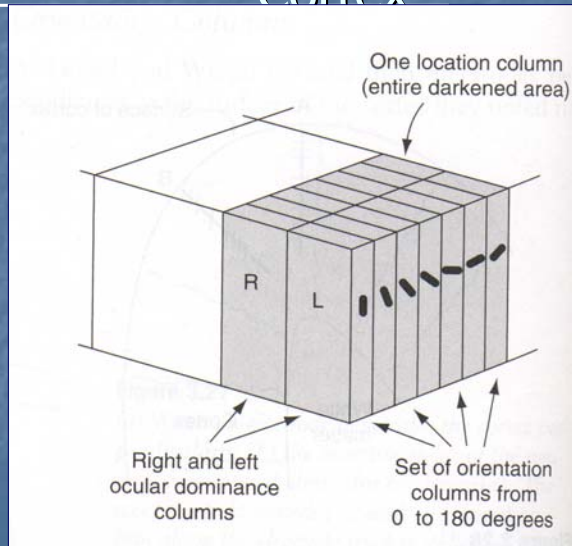
Ocular dominance columns

- Each columnar region is more sensitive to one eye
- The dominant eye alternates between the columnar regions

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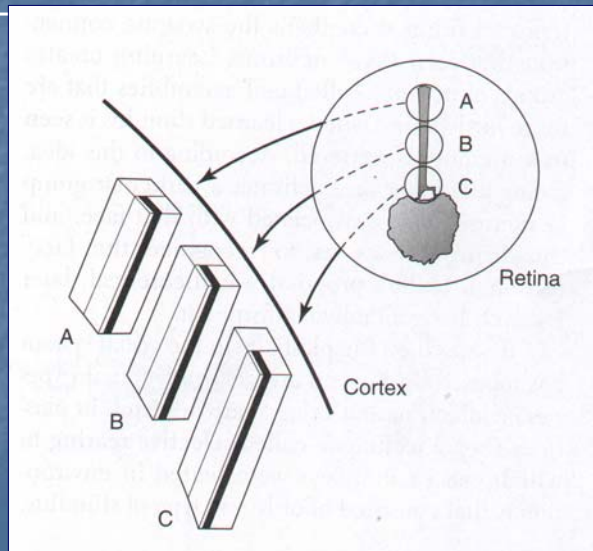
Hypercolumn View of the Cortex



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Information Processing by Cortex



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Visual Perception



Development of Receptive Fields

- Is it there from birth?
- How much is the development dependent on learning?
- Experiments with visually deprived kittens