THE VISUAL SYSTEM

ICS 280: Visual Perception

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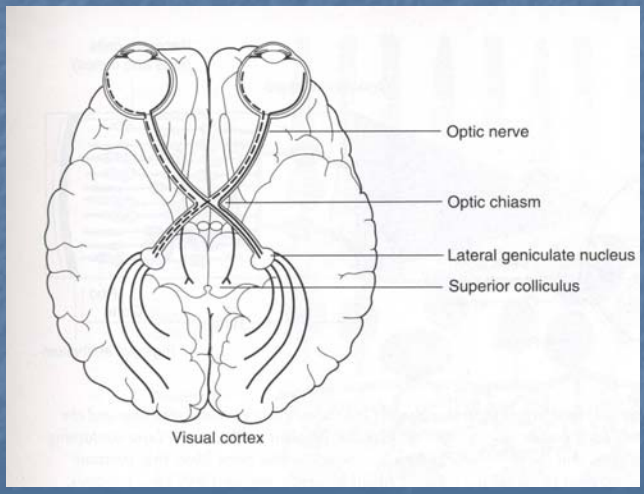
What do we perceive?

- Example: Switch off the light in room
- What we perceive
  - Not only the property of the scene
  - But also that of the visual system
- Our perception is filtered by the human visual system

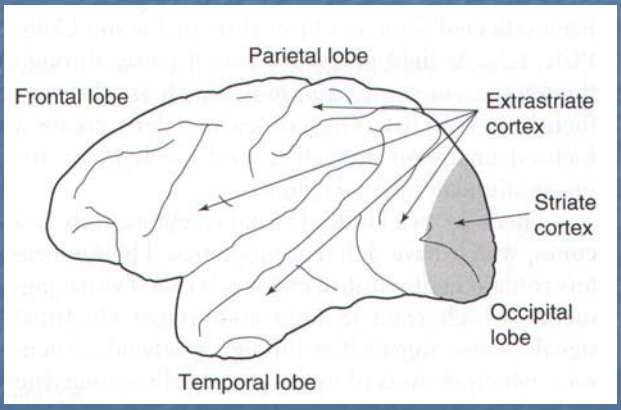
Visual System

- Eye - sensor
- Lateral geniculate nucleus
- Striate cortex
  - Striped Appearance
- Extra striate cortex

Visual System

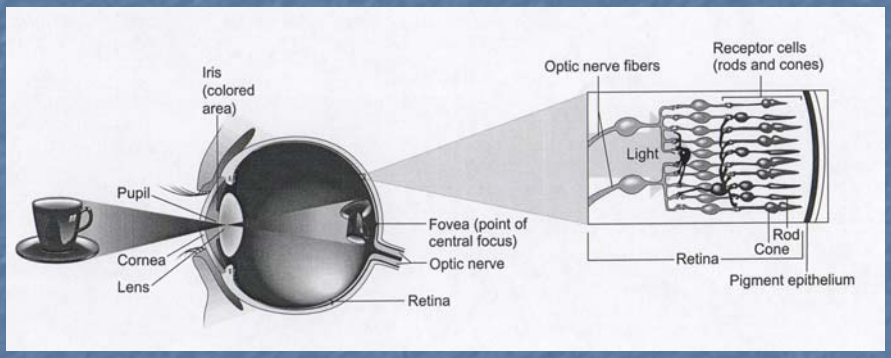


Visual System



Eye : The Sensor

Eye : Structure



Eye : Accommodation

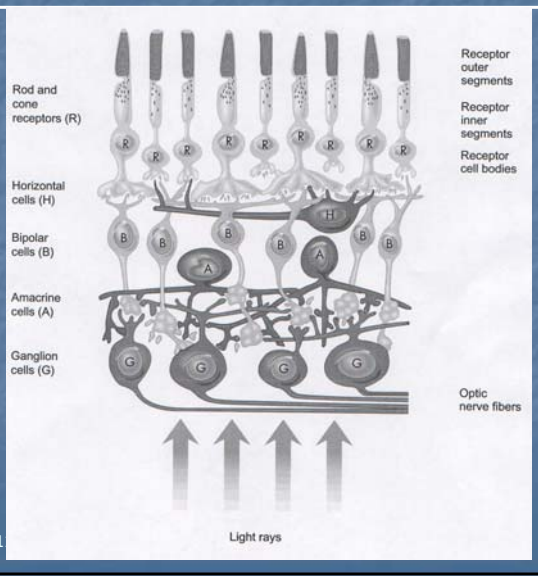
- Accommodation : Flexible focusing ability
  - Cornea – 80% of focusing ability
  - Lens – 20% *adaptable* focusing ability
- Focus at one depth at a time
- Limitation
  - Depth of field
  - Near and far point

Myopia/Presbyopia

- Far and near point is different for different individuals
  - If near point is far: presbyopia
  - If far point is near: myopia

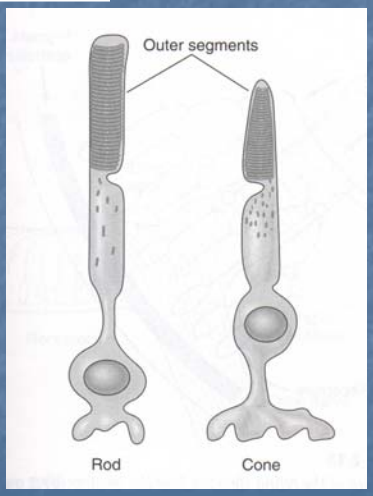
Receptors in Eye

Receptor Organization

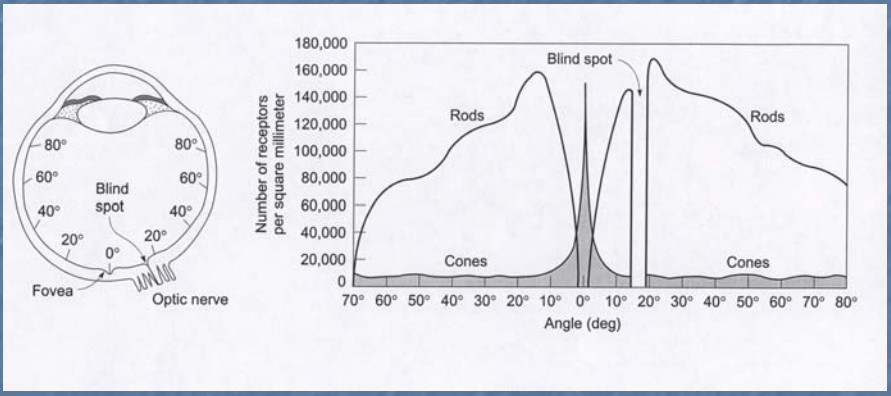


Receptors

- Rods
  - 120 million
  - Only in periphery
- Cones
  - 5 million
  - 1% in fovea
  - Rest in periphery
- In periphery 20:1 ratio for rods and cones



Receptor Distribution

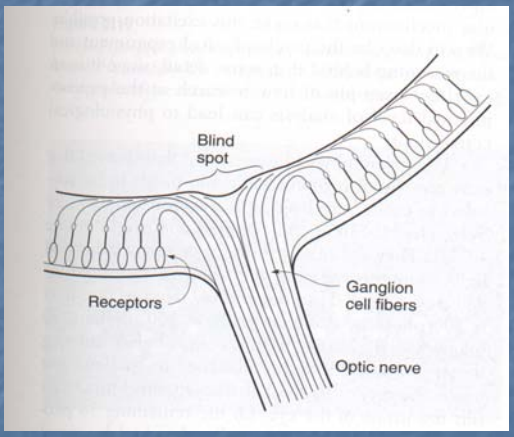


Receptor Distribution

- Turned away from light
- To get nutrition from opaque pigment epithelium
- The other cells are transparent not to block light reaching the retina
- Block the axons of the ganglion cells from leaving the eye

Blind Spot

- Ganglion nerve fibers fold and leave by crossing a part of retina
- This part does not have any receptors
- Filled out by the brain



Receptor Functions

- Cones – for vision in photopic conditions
- Rods – for vision in scotopic conditions

Receptor Functions

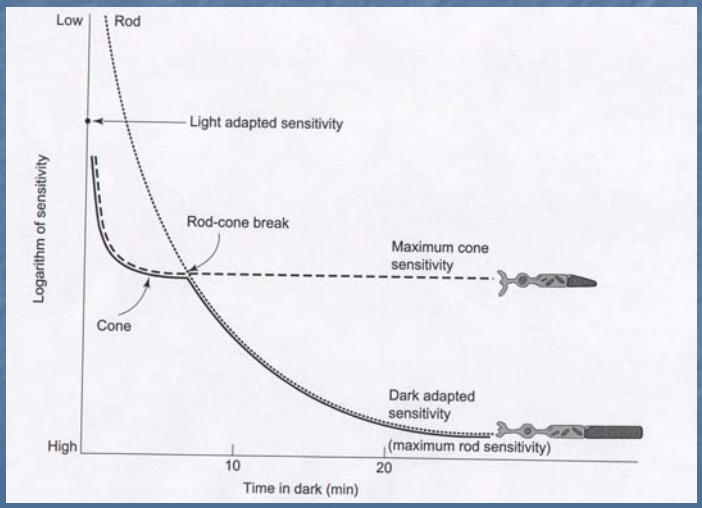
- Conversion of light to electrical energy
  - Light sensitive chemical pigment in the receptors
  - Absorbs photons and changes the shape to create a graded potential across the membrane of the outer segment
  - Logarithmic response supports Stevens Law
  - Potential is transmitted down the outer membrane to other cells

Receptor Functions

- Pigment Bleaching
- Pigment Regeneration
  - 30 minutes for rods and 6 minutes for cone

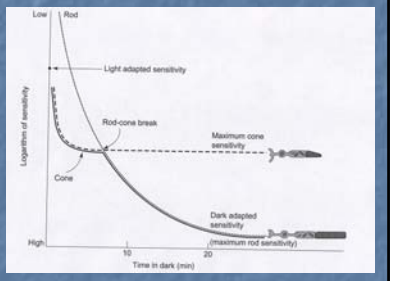
Effects of Visual Pigments on Perception

Dark Adaptation Curve

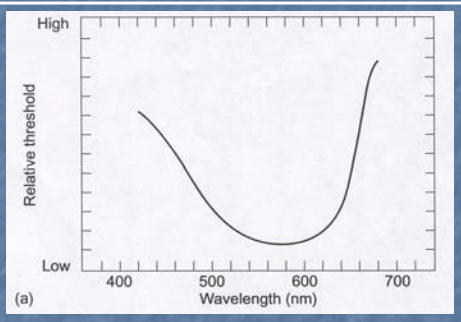


Dark Adaptation

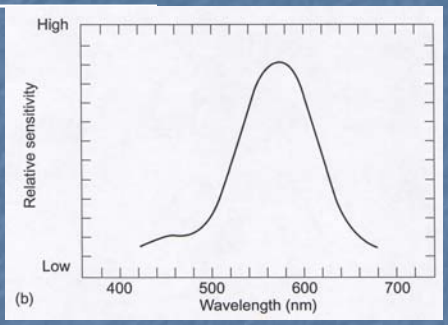
- Initial rapid increase
  - 6 minutes
- Slower further increase
  - 25-30 minutes
- Rods have higher sensitivity than cones
  - Rods responsible for dark vision
- Pigment Regeneration
  - 6 minutes for cones
  - 30 minutes for rods



Spectral Sensitivity



Threshold Curve

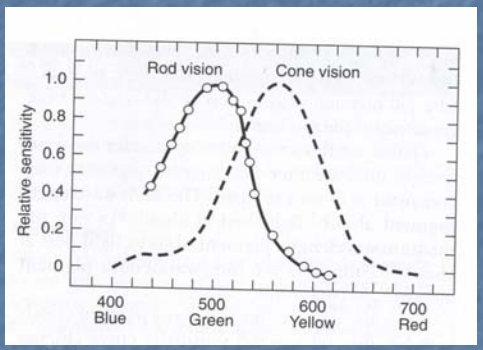


Sensitivity Curve

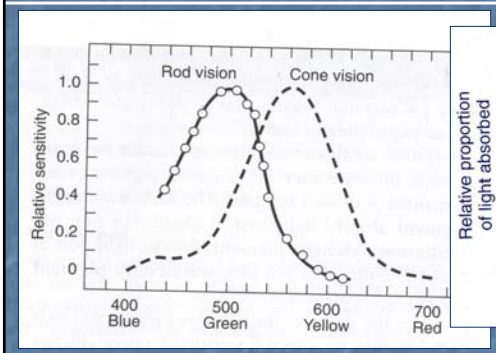
Relative threshold of light required to detect monochromatic light of each wavelength

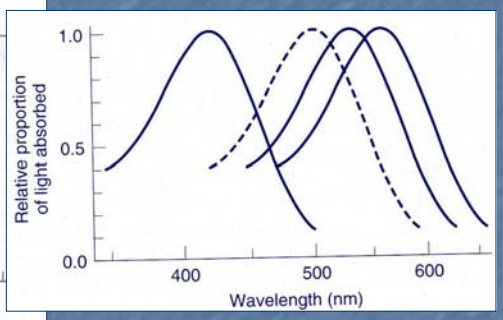
Rod and Cone Sensitivity

- Rods have sensitivity to shorter wavelengths
- Peak near *500nm* being maximum sensitive to the blue green region
- Shift of wavelengths in dark
  - Purkinje shift
  - Things appear bluish in dark
  - Green foliage seems to stand out in the dusk



Cone Sensitivity

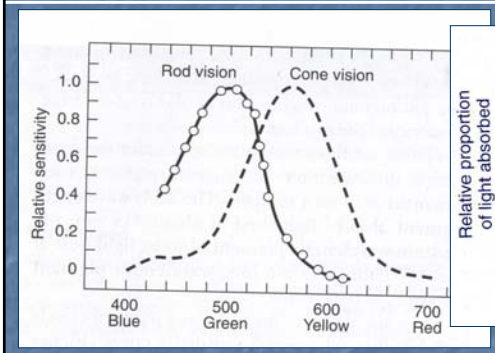


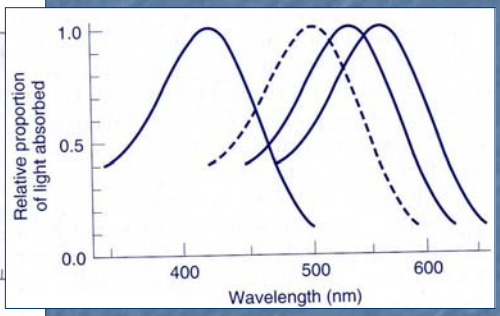


Cone curve is the combined sensitivity of three cones

- ❑Short wavelength
- ❑Medium wavelength
- ❑Long wavelength

Cone Sensitivity





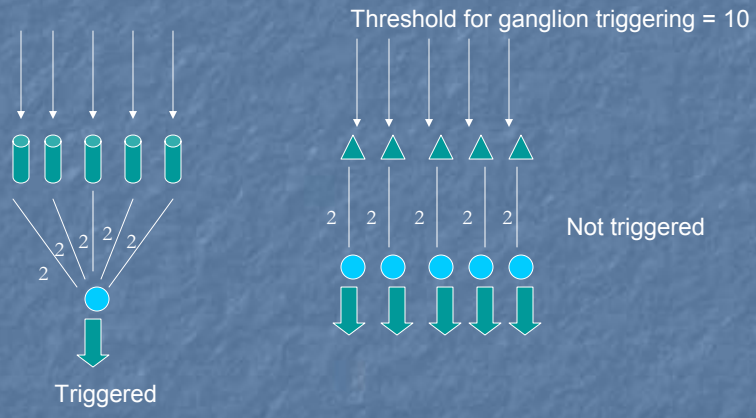
- Why does the sum look different near the shorter wavelengths?
  -Depends on the relative proportions of each kinds of cones.
- Three types of cone responsible for color vision.
- Rods does not help in color vision. No color perception in dark.

Effects of Neural Processing on Perception

Convergence

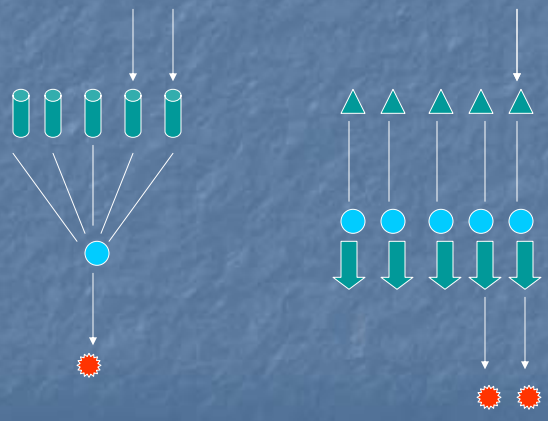
- Measured number of neuron synapse on another neuron
  - Eye : Number of receptor neuron synapses on a ganglion cell
- Each ganglion cell receives many synapses
  - Rods to cones convergence ratio is 20:1
  - 1 million ganglion cells, 120 million rods and 6 million cones
  - Rods have higher convergence than cones

Rods are more sensitive in dark

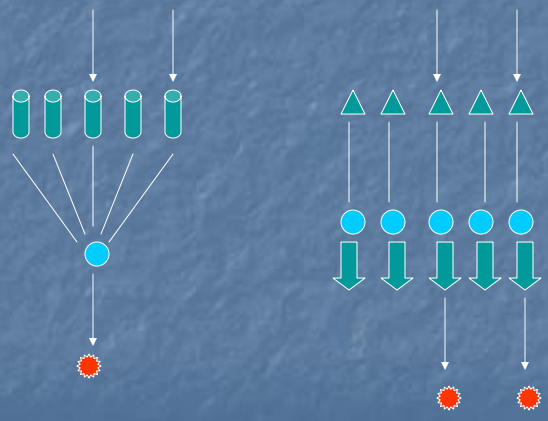


Rods have greater spatial summation than cones

Cones give visual acuity



Cones give visual acuity

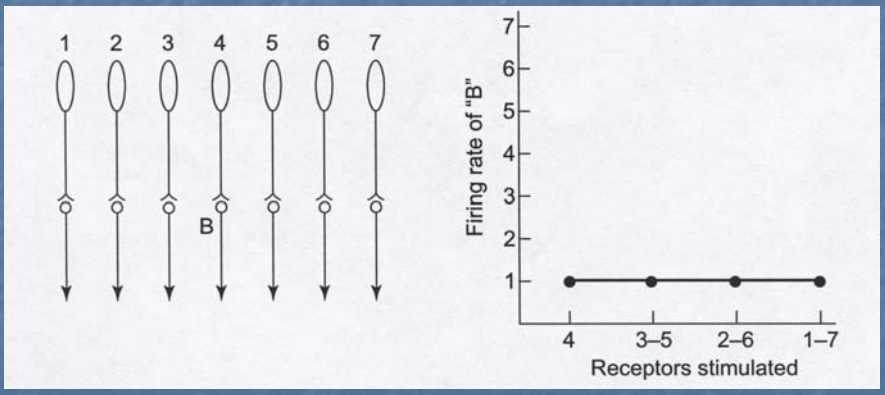


Neural Circuits and their Effects on Perception

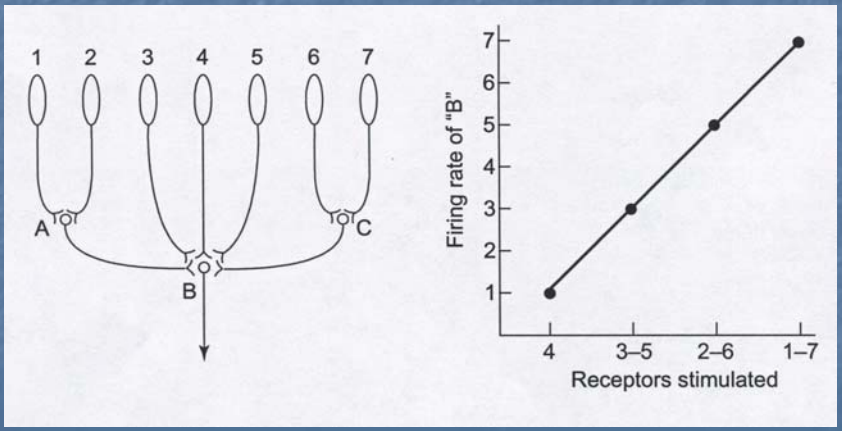
Neural Circuits

- Many neurons connected through convergence
  - Small – a few neurons
  - Large – a few hundred thousand neurons

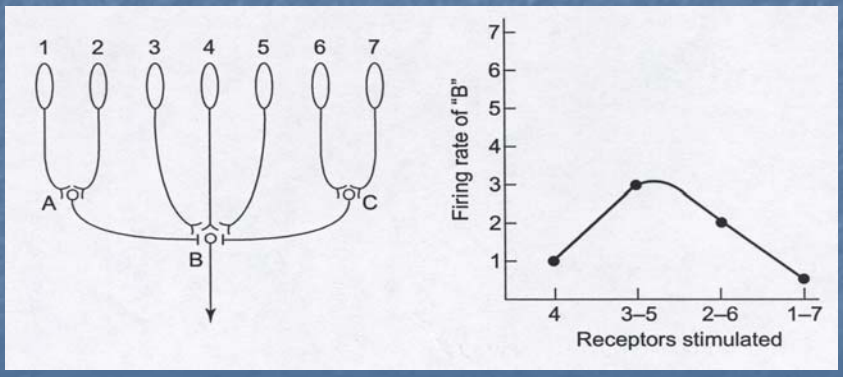
Neural Processing by Excitation and Inhibition



Neural Processing by Excitation and Inhibition

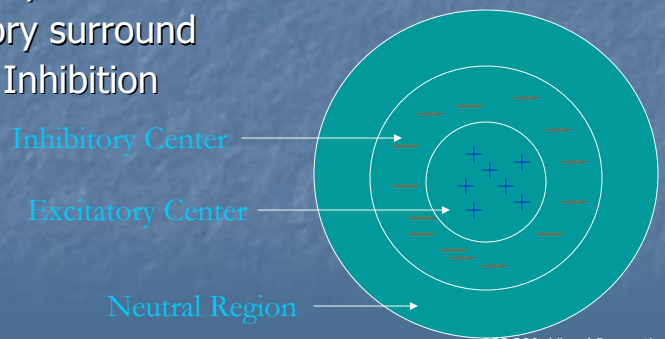


Neural Processing by Excitation and Inhibition

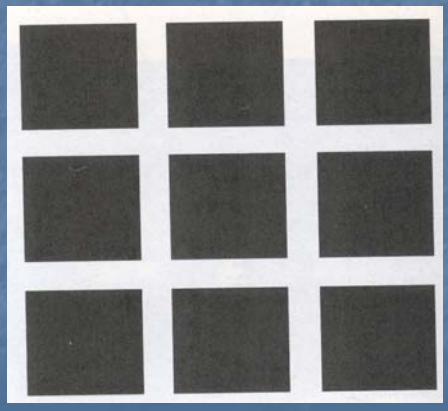


Receptive Fields

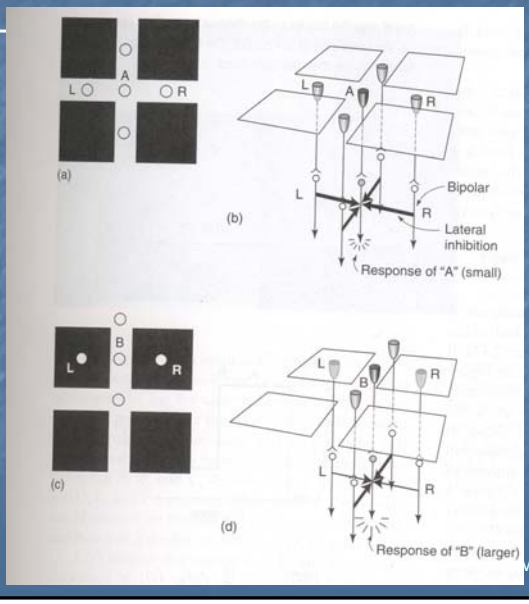
- The area of the retina that when stimulated influences the firing rate of the ganglion cells
- Excitatory center
- Inhibitory surround
- Lateral Inhibition



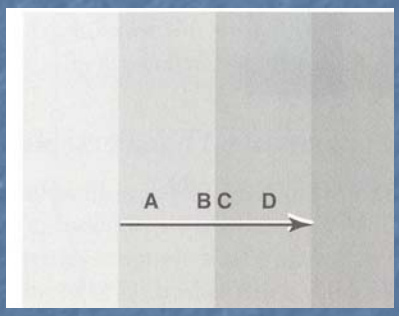
Hermann Grid

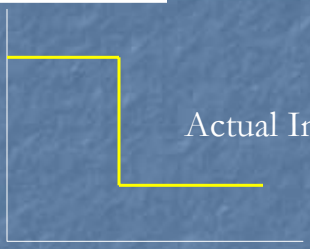


Explanation : Lateral Inhibition



Mach Bands





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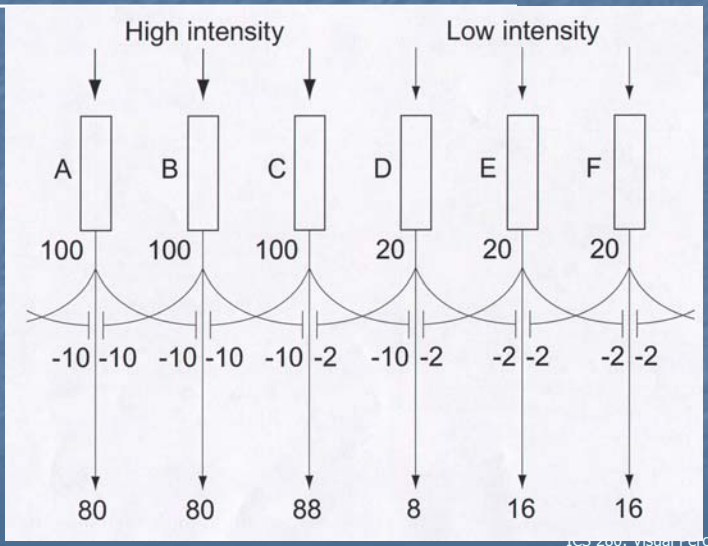

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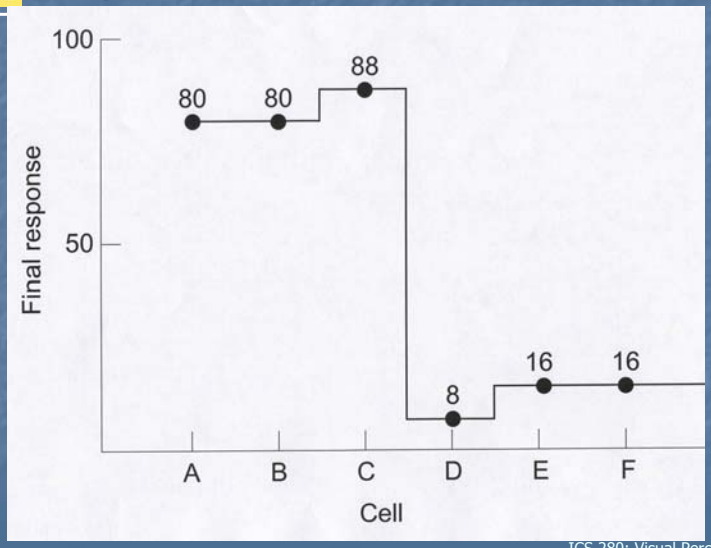
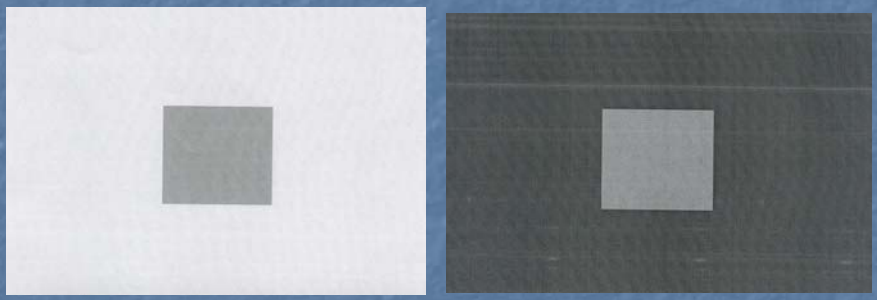


Simultaneous Contrast



Explanation : Lateral Inhibition