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

Eye : The Sensor
Eye : Structure

- Iris (colored area)
- Pupil
- Cornea
- Lens
- Fovea (point of central focus)
- Optic nerve
- Retina
- Optic nerve fibers
- Receptor cells (rods and cones)
- Pigment epithelium

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

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

- 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 kind of cones.
- Three types of cone responsible for color vision.
- Rods do 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
Neural Circuits and their Effects on Perception

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

Response of A (small)

Response of B (large)
Mach Bands

Actual Intensity

Perceived Intensity

Explanation: Lateral Inhibition

High intensity

A 100
B 100
C 100
D 20
E 20
F 20

Low intensity

-10 -10 -10 -2 -2 -2

80 80 88 8 16 16
Explanation: Lateral Inhibition

Simultaneous Contrast
Explanation: Lateral Inhibition