THE VISUAL SYSTEM: **<u>COLOR VISION</u>**

Photopigments

Contained within "outer segments" of receptor cells (rods & cones)
Synthesized from **Vitamin A ---** retinal **---** pigment molecule
Alter receptor cell's membrane potential when struck by photon of light
Acts like a **G-protein** (metabotropic receptor)
Minimum # of pigments necessary for differentiating any wavelengths
Minimum # of pigments necessary for differentiating all wavelengths
e.g. rats – have only rods (rhodopson)
humans – have 3 cone opsins
8% of cones – contain short wavelength opsin
46% of cones – contain medium wavelength opsin
46% of cones – contain long wavelength opsin

Supports Young's (1802) and von Helmholtz's (1852) **trichromatic theory** of color vision that proposed that there must be 3 different color receptors in the human eye…Why did they propose this?

Each photopigment responds to a **<u>range</u> of light wavelengths**
(see Fig. 6.26, Pinel, 5th ed.; Fig. 6.9, Kalat, 7th ed.)
visible light (for humans): 350 to 750 nanometers
"**spectral sensitivity curve**"

Rhodopson – peak sensitivity @ 505 nm (400 – 600 nm range)
"short" Opsin – peak sensitivity @ 420 nm (350 – 570 nm range)
"med." Opsin – peak sensitivity @ 530 nm (450 – 650 nm range)
"long" Opsin – peak sensitivity @ 560 nm (500 – 700 nm range)

Overall peak sensitivity in human eye: 555 nm

< 400 nm is "**ultraviolet**"; > 700 nm is "**infrared**"

See "blue" vs. "green-yellow" vs. "reds" vs. "white" light

<u>Pathway into Visual Cortex</u> (Occipital Lobes)

Cones --- bipolar cells --- ganglion cells --- Lateral Geniculate Nucleus (Thalamus) --- Occipital Lobes

Find **"opponent-process" neurons** along this pathway

+ response to "long" (red) wavelengh & - response to "med" (green)
- response to "long" wavelength & + response to "med"

or

+ response to "short" (blue) wavelength & - response to "med" (yellow)
- response to "short" wavelength & + response to "med"

in **cortex**, find **"dual-opponent color" neurons**

e.g. cell X is maximally excited by red light in the middle of its receptive field on the retina with green light in the surround area of its receptive field; this same cell X would be maximally inhibited by green light in the middle and red light in the surround area of its receptive field

(maximally excited = fires when lights turned on; maximally inhibited = fires when lights are turned off)

Predicted by color afterimages (see p. 155 of Pinel)

Supported Hering's (1878) **Opponent-Process Theory** of color vision

Location of wavelength-responsive ("color") neurons in visual cortex:

Are not distributed evenly throughout cortex

Are found in columns ("**blobs**") that go from Layer I down to Layer VI, Except are **not** found in lower part of Layer IV

Are found in the **parvocellular** pathway (ventral visual pathway, from occipital area to postterior inferior temporal lobe)

From cones in/near the fovea

Especially in areas V1 (striate cortex), V2 (prestriate cortex), and **V4** (**posterior temporal lobe**)

Note: **"color constancy" effect**

Color "Blindness"

Can occur because of **failure to make photopigments**

- e.g. humans who lack the "long" or "medium" wavelength opsins
  - "red-green" blind, about 8/100 people (**l female + 7 males**)
  - Is a "**sex-linked**" trait carried on the X (sex) chromosome
  - Have normal numbers of cones, cones have "wrong" opsin in them, blind to either greens or reds
  - **Have** normal visual acuity
  - Are **often unaware** of their insensitivity to a range of wavelengths until carefully tested (e.g. for police force, pilot's license or the military)

Can occur because of failure to **make cone and photopigment**

- e.g. humans who lack "short" wavelength opsin
  - "blue-yellow" blind, can see only reds and greens
  - Occurs in 1/l0,000 humans (rare), **not sex-linked**
  - Lacking the "short" opsin and its cone (so only have 92% of normal cone number)
    - Nonetheless, normal visual acuity

Can occur because of **damage to the visual cortex**

- e.g. humans with damage to posterior temporal/parietal area (V4)
  - can still name/see individual colors but have no color constancy
- e.g. case in Sachs book of artist (painter) who lost sense of color