Notes: Vision

Where we are going:

How is a distorted and upside-down 2-D retinal image transformed into the 3-D world we perceive?

Light

No species can see in the dark, but some are capable of seeing when there is little light

Light can be thought of as

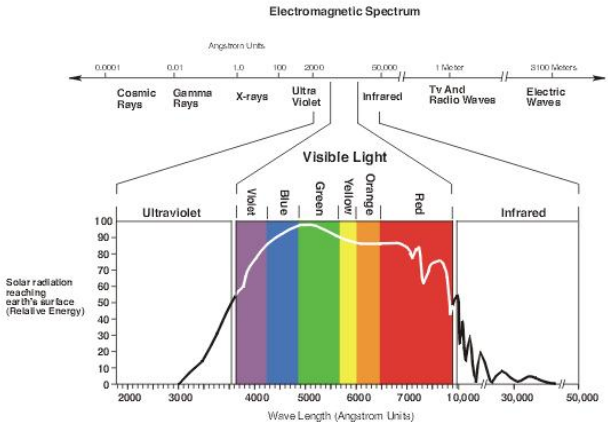
- Particles of energy (photons)
- Waves of electromagnetic radiation (has a wavelength)

Humans see light between 380-760 nanometers in wavelength

Properties of light:

_____ – perception of color

_____ – perception of brightness

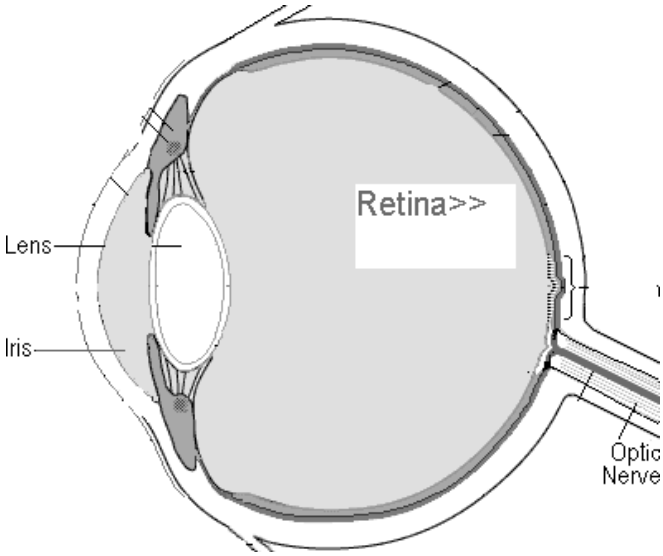


Source: http://www.perret-optic.ch/optometrie/Vision_des_couleurs/vis-couleur_gb.htm

The Eye

Focusing an image

_____ - contractions of ciliary muscles to deform the lens and change the focus



Retina

Transduction

transduction - conversion of one form of energy into another

visual transduction - turning _____ into a _____ _____

how does this happen: pigment absorb photons and react

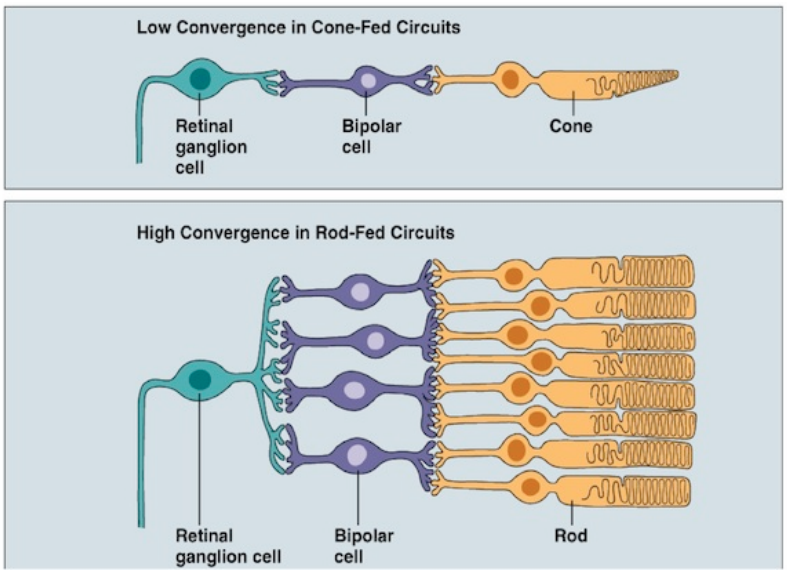
Rods & Cones

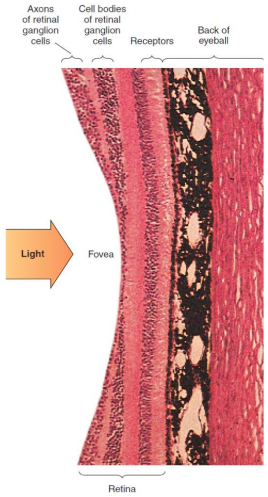
_____ - cells specialized for visual transduction

rods - specialized for seeing _____
- more sensitive to photons than cones
- signals from many rods are pooled into one retinal ganglion cell

cones - specialized for seeing_____ (more later)
- in most humans, there are 3 different cones sensitive to 3 different wavelengths of light

▸ **Convergence of Cones and Rods**





Rhodopsin - a _____ that changes shape when it absorbs _____

(*you won't be tested on cyclic GMP, just rhodopsin in general*:)

cyclic GMP keeps sodium channels open

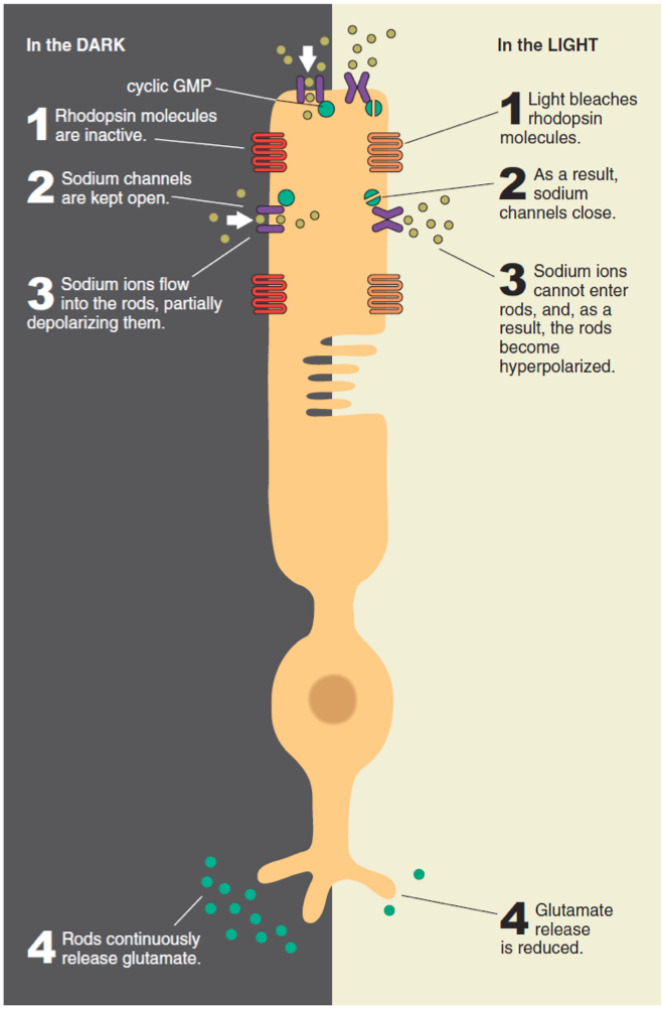
when rhodopsin absorbs light, it breaks up cyclic GMP

when light hits rhodopsin, this:

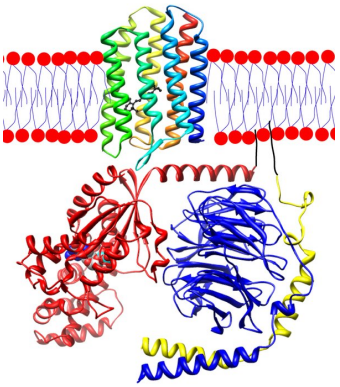
increases/decreases the amount of Na+ entering the cell

depolarizes/hyperpolarizes the cell

increases/decreases glutamate release



Rhodopsin:



Source: wikipedia.org/wiki/Rhodopsin

_____ - the ability to see when light is dim, requires _____ photoreceptors

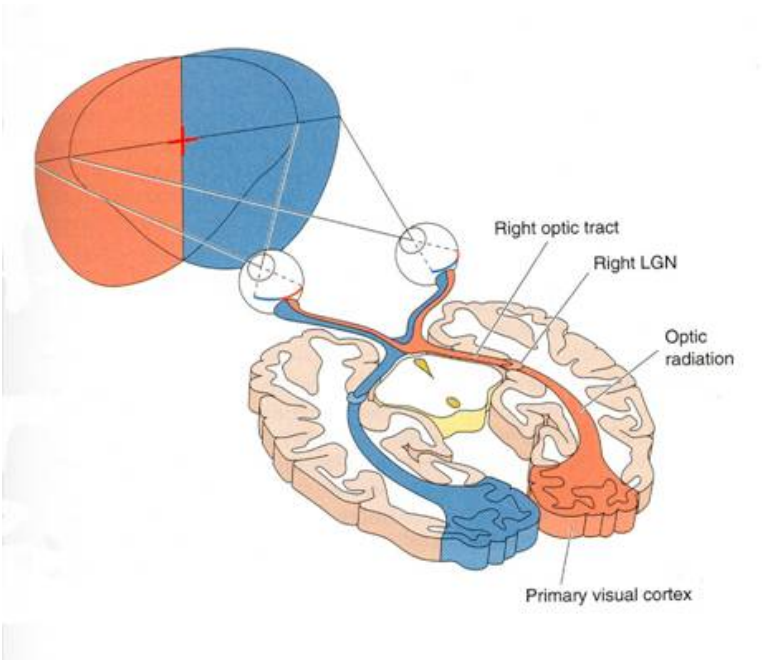
_____ - the ability to see details (resolution), requires _____ photoreceptors

_____ - the center of the retina
where the lens focuses the image
a high/low concentration of cones
a high/low concentration of rods

_____ - the area of the retina where the axons from the retinal ganglion cells leave the eye

Trick for seeing in the dark - don't look directly at what you want to see.
Why does this work?

Visual pathway



Source: http://www.dgward.com/physo101/sm06_pages/labs/Peripheral%20Vision%20and%20Visual%20Pathways.htm

Lateral geniculate nucleus (LGN)

- part of the thalamus, which is a relay station between most sense systems and the cortex
- exact role is unclear
- maybe involved in: making visual information more efficient, focusing attention, saccades

Visual cortex (more later)

- performs the processing on visual information to allow us to perceive visual scenes/stimuli

Information from LEFT visual field goes to RIGHT visual cortex (and vice versa)

NOT left EYE to right visual cortex

Retinotopic mapping

- If two retinal ganglion cells that are close together in the retina, their axons end close together in the visual cortex
- The retina is "mapped on" to the cortex

Low-level Visual Processing

"low-level" refers to early in the visual pathway & dealing with simple visual stimuli like brightness, edges & color.

"high-level" refers be areas that receive the pre-processed information from low-level parts of the visual system and that process more advanced stimuli like motion, faces, object-recognition & visual space

Receptive Fields

Definition: The area of visual space that stimulates or inhibits a neuron (or neural tissue)

The stimulus might be simple or complex. Examples:
- Some neurons might be stimulated by any light in a precise spot in the top right corner of the visual field
- Some neurons might be stimulated by a vertical edge anywhere on the left
- Some neurons might be stimulated by faces anywhere in the visual field

Receptive fields become larger
  farther away from the fovea - don't need to know exact location, just want to notice something
  at higher levels of the visual system - just want to react to a face (for example), doesn't matter where it is

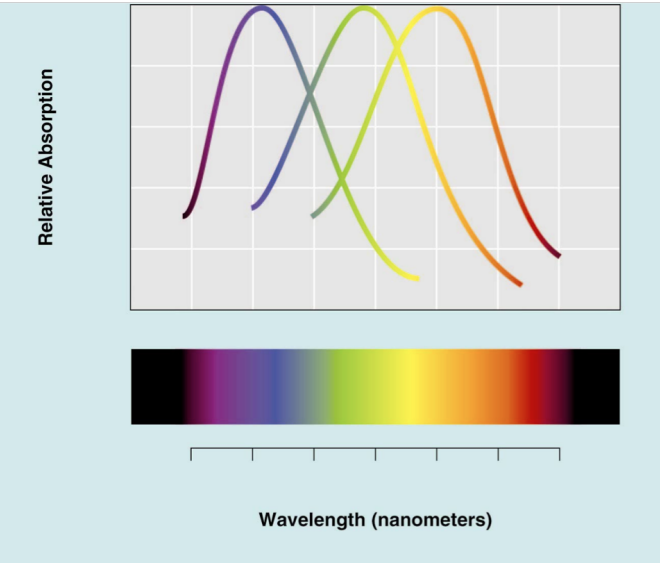
Hubel & Weisel

Videos: Intro & long version

Color

In most humans, there are three kinds of cones
- each with a different photo-sensitive pigment called iodopsins
- each of the three iodopsins is sensitive to different wavelengths of light

Number of cones varies
- some animals & people (with color blindness) have only 2 kinds of cones
- some animals (birds in particular) have 4 kinds of cones



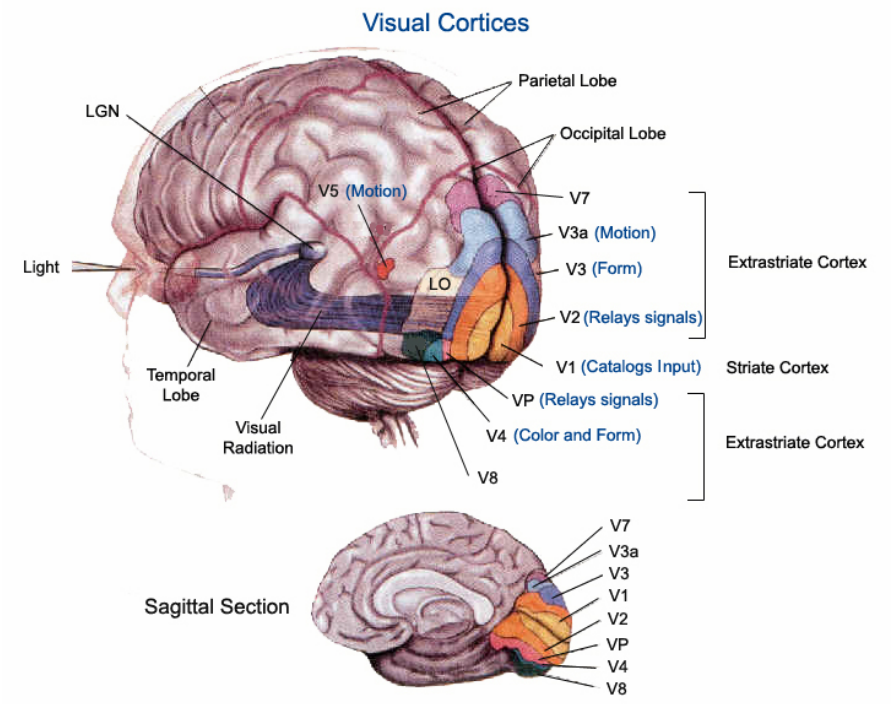
High-level Visual Processing

Sensation vs Perception

Incoming signal

- left/right visual fields to different hemispheres
- each hemisphere contains intermingling cells that respond to left and right eye
- retinotopically organized
- no perceptual processing (still basically "pixels")

Visual cortex

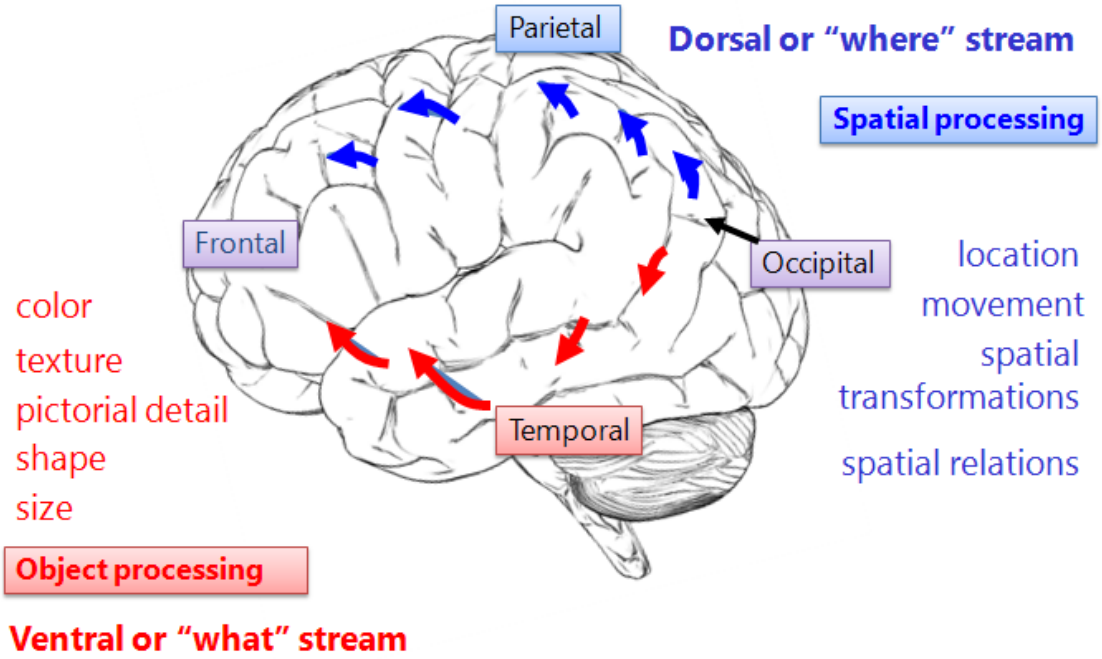


Source: http://www.techcyn.com/feature.php?id=f2&issue=1

_____ cortex - stripped appearance

primary visual cortex (striate) -> parastriate -> prestriate/extrastriate -> temporal lobe
increasingly complex processing

Dorsal vs Ventral stream



Ventral/what stream

- Used for recognition/identification
- Captures fine details but is slow
- Conscious awareness and interactions with long term memories.
- Notices fine details (fovea)
- Neurons respond to objects anywhere in the visual field

Dorsal/what stream

- Used for visually guided behavior
- Sensitive to motion, fast processing
- Not conscious processing
- Neurons respond based on where visual attention is allocated

Face recognition

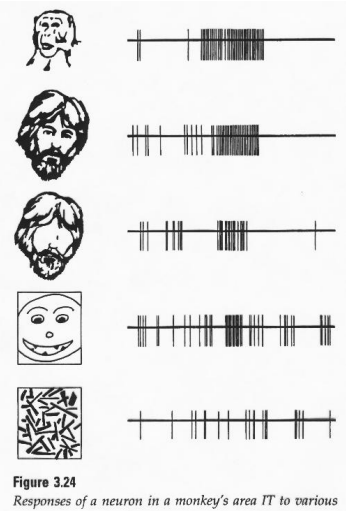


Figure 3.24
Responses of a neuron in a monkey's area IT to various

Fusiform Face Area

- in ventral stream / temporal lobe
- somewhat right lateralized
- particularly active to faces, though somewhat to objects in general
- example of extreme specialization in the visual system

Principles of Visual Processing

- Parallel processing
- Hierarchical
- Functionally segregated

These principles apply to many neural systems besides vision