



The Brain, Biology and Cognition (BBC)

Vision and Perception

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What Do We See?

When info enters eye, its projected to back of eye called retina.

Projected image is not accurate internal copy of external world.

Distorted, upside-down 2D image transformed to 3D world we perceive

Vision Research:

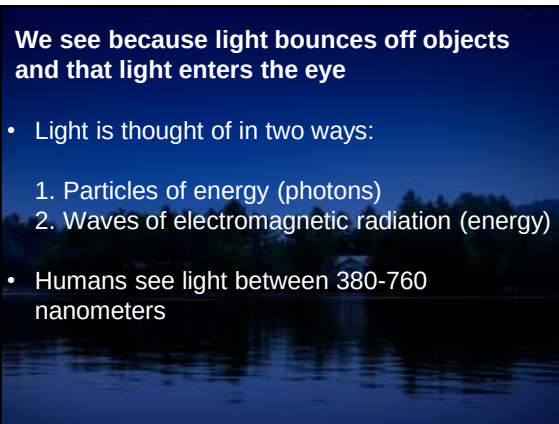
1. probes components of visual system
2. Aims to assess what we see



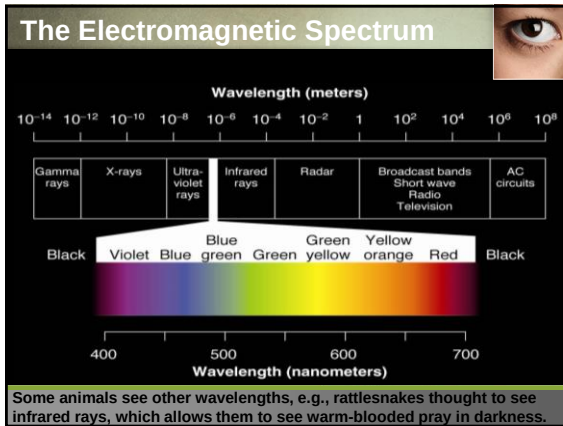
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We see because light bounces off objects and that light enters the eye

- Light is thought of in two ways:
 1. Particles of energy (photons)
 2. Waves of electromagnetic radiation (energy)
- Humans see light between 380-760 nanometers



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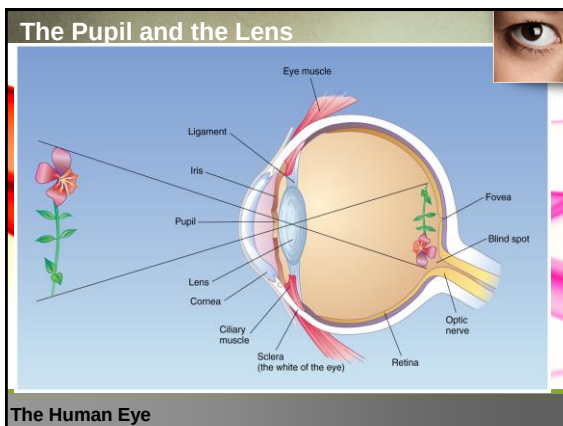


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The Pupil and the Lens

- Amount of light reaching retina controlled by **iris** (eye colour)
- Light enters through **pupil** (size changes in response to changes in illumination).
- Comes from compromise between:
 - Sensitivity of eye** – ability to see when light is dim, and
 - Acuity of eye** – ability to see details of objects.
- Behind pupil is **Lens** – focuses light on **retina**
- Ciliary muscles** alter shape of lens as needed
 - Increases ability of lens to bend (refract) light and brings close objects to sharp focus.
 - When we focus on distance, lens is flattened.
 - Process called **accommodation**.

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Eye Position and Binocular Disparity

- We have 2 eyes – so why don't we see 2 of everything?
 - Movement of eyes are coordinated so each point of world is projected to corresponding points on both retinas.
- To do this our eyes **Converge**: turn slightly inward when objects are close.
- But position of images on retinas are never same because eyes do not view world from same position.
- Results in: **Binocular disparity** – difference in position of same image on two retinas
- Visual system uses this to construct & provide the brain with 3-D image and distance information



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The Retina and Translation of Light into Neural Signals

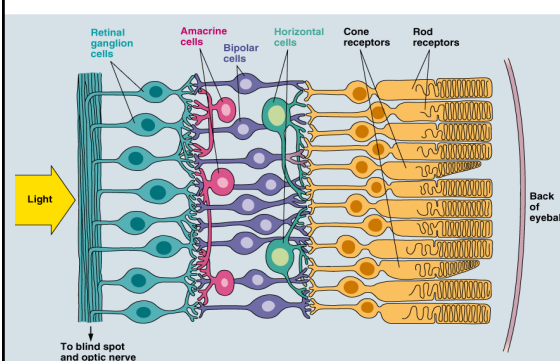
- Light landing on retina is transferred to neural signals to be processed by CNS.
- The retina is “inside-out”
 - Light passes through several cell layers before reaching receptors
- Retina is composed of 5 layers of different types of neurons: receptors, horizontal cells, bipolar cells, amacrine cells, and retinal ganglion cells.
- Vertical path: receptors > bipolar cells > retinal ganglion cells
- Lateral path: Horizontal cells & Amacrine cells



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The Retina and Translation of Light into Neural Signals

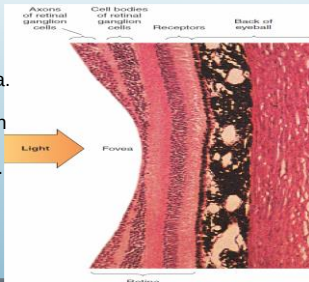
Cellular Structure of the Mammalian Retina



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The Retina and Translation of Light into Neural Signals

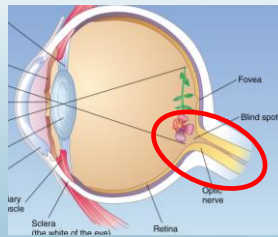
- Arrangement creates 2 visual problems:
- Incoming light distorted by retinal tissue it must pass before reaching receptors.
- Dealt with by fovea: indentation ~0.33cm in diameter at centre of retina.
- Thinning of retinal ganglion cell layer at fovea reduces distortion of incoming light.



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The Retina and Translation of Light into Neural Signals

- For bundle of retinal ganglion cell axons to leave eye, there is a gap in receptor layer - **blind spot**.
 - Section of no receptors: anything falling on area not picked up.
- To deal with this, system uses info by receptors around blind spot to fill in gaps in image.
- Called **completion**
- Suggests visual system does more than just create a copy of the external world.



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Cone and Rod Vision

Duplexity theory of vision – cones and rods mediate different kinds of vision

Cones:

Photopic (daytime) vision

- High-acuity color info in good lighting
- Only cones found at fovea

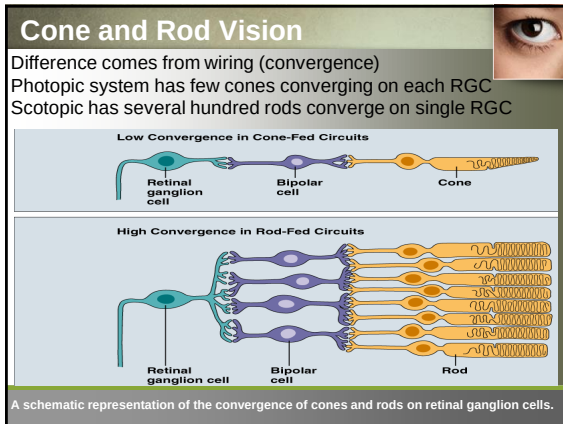
Rods:

Scotopic (nighttime vision)

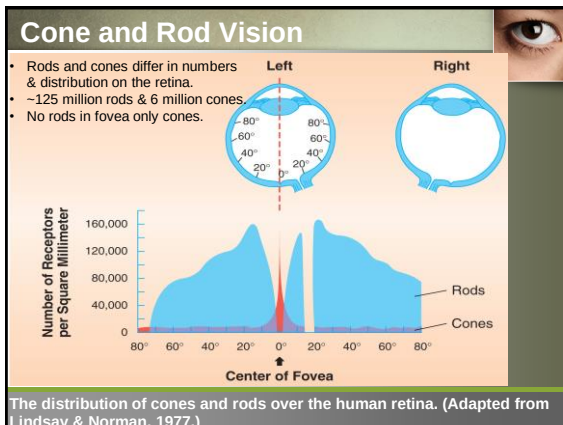
- High-sensitivity, allowing low-acuity vision in dim light, but lacks detail and color information
- More convergence than cone system, increase sensitivity, decrease acuity



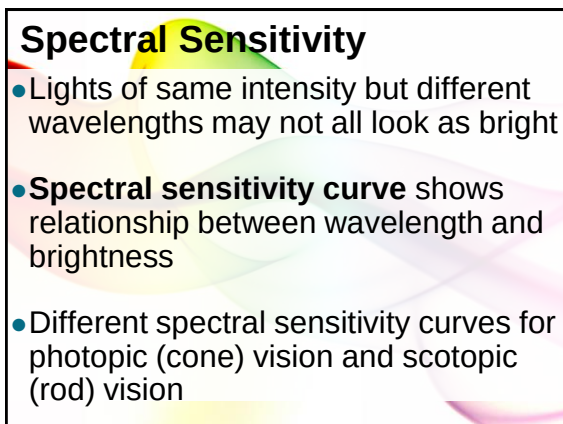
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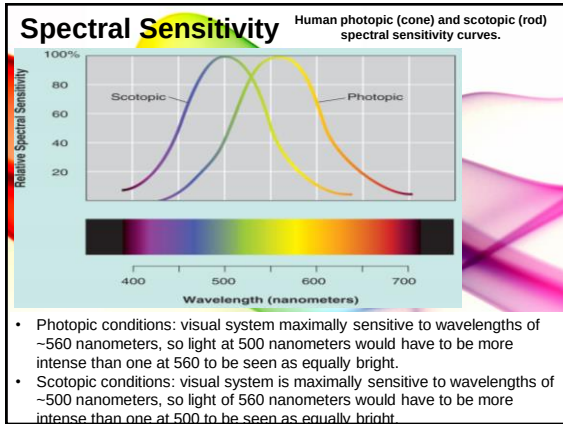
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Eye Movement

- Our eyes continually scan visual field.
- So, visual perception at any one time is summation of recent visual information.
- This is why the world remains there even when we blink.
- Even when we fix eyes on one object, eyes constantly move
 - These involuntary fixational eye movements are of 3 types: tremor, drift, and saccades.

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Visual Transduction: Conversion of Light to Neural Signals

• How does light turn to neural signals?

- **Transduction:** conversion of 1 form of energy to another
- **Visual transduction:** conversion of light to neural signals by rods & cones.
- Contain chemicals (photopigments) that absorb light and transduce it to neural activity.
- Red pigment (pigment = substance that absorbs light) called rhodopsin extracted from rods in 1876.
- When exposed to continuous intense light it was bleached (lost colour & ability to absorb light)
- When put back in darkness, red colour & light-absorbing capability returned.

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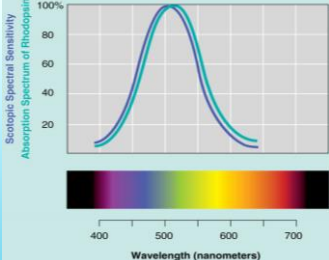
Visual Transduction: The Conversion of Light to Neural Signals



- Relationship between absorption spectrum of rhodopsin (in green) & human scotopic spectral sensitivity curve (in blue).
- Fact that they are so close shows that in dim light our sensitivity to various wavelengths is a direct consequence of rhodopsin's ability to absorb them.

■ The sensitivity of human vision to different wavelengths under scotopic conditions

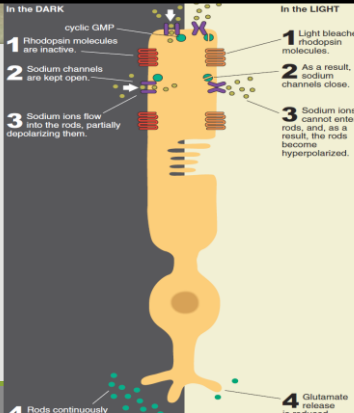
■ The ability of rhodopsin to absorb different wavelengths of light under scotopic conditions



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Visual Transduction

The inhibitory response of rods to light



In the DARK

- Rhodopsin molecules are inactive.
- Sodium channels are kept open.
- Sodium ions flow into the rods, partially depolarizing them.
- Rods continuously release glutamate.

In the LIGHT

- Light bleaches rhodopsin molecules.
- As a result, sodium channels close.
- Sodium ions cannot enter rods, and, as a result, the rods become hyperpolarized.
- Glutamate release is reduced.

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