Human Visual System summary

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Artificial Intelligence & Information Analysis Lab

Human Visual System

- **Human Visual System**
- Retina
- Visual Pathway
- Visual Cortex
- Visual defects

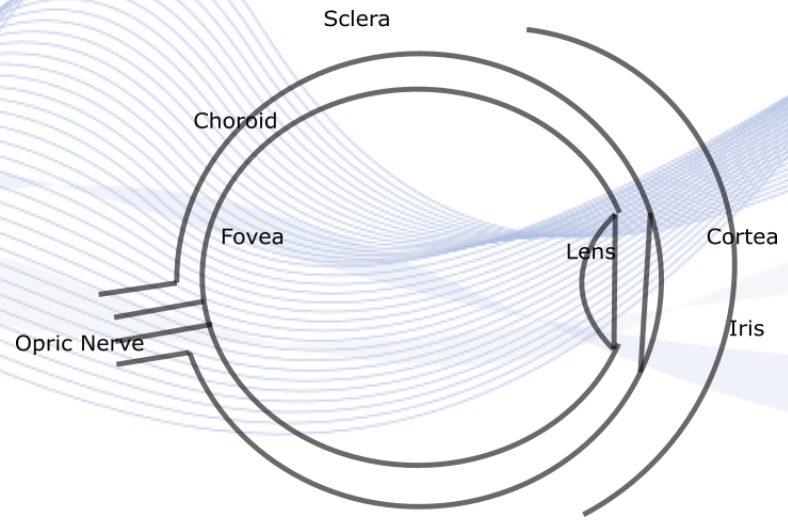
Human Visual System

- ***Human Visual System*** (***HVS***) is a nervous sub-system (neural network), which allows humans to transform the light input arriving at the eye into a ***visual experience*** [SAR2017].

- It consists of the ***eyes*** (notably lens, retina) and the following parts of parts of the central nervous system:
- ***optic nerve***, ***optic tract*** and ***visual cortex***.

Human Visual System

- ***Human eye***: spherical shape with a diameter of 20 mm.
- Light enters through the ***pupil*** of the ***iris*** (diameter 2-8 mm).
- It passes through the cornea, the ***lens***, the ***vitreous (humour)*** and is focused on the ***retina***.

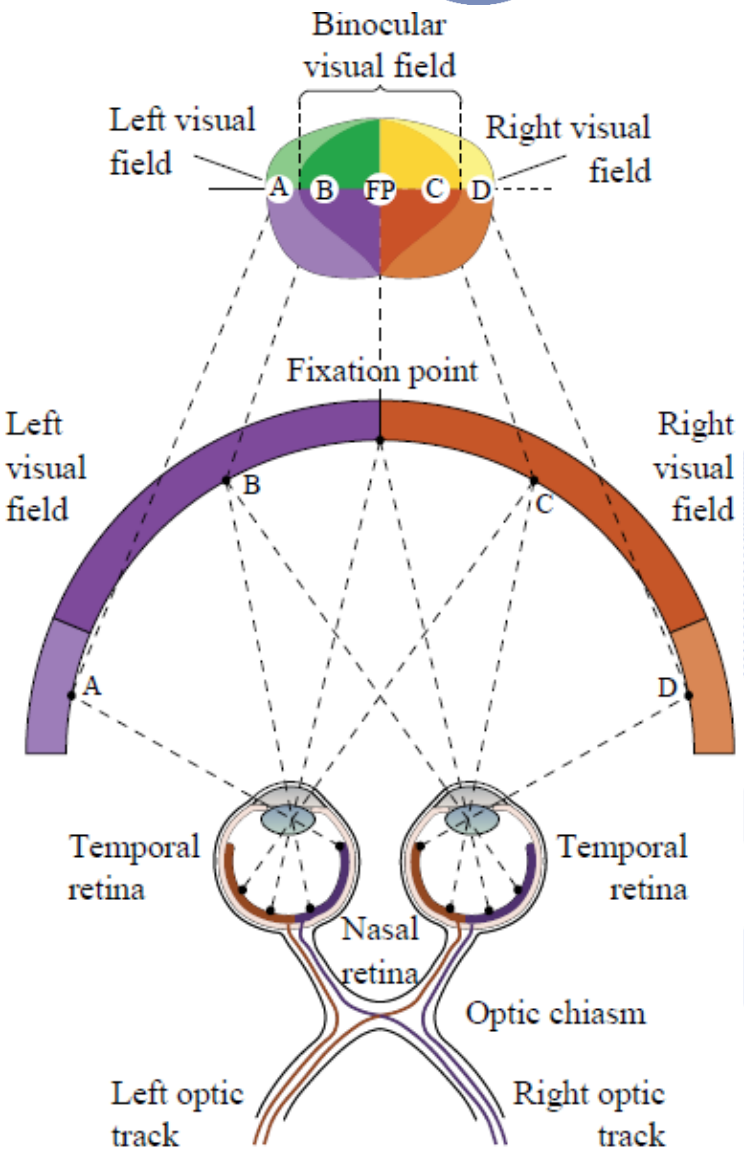


Human eye.

Human Visual System

- The horizontal separation of the eyes leads to a difference, ***stereo parallax***, in image location and appearance of an object between the two eyes, called ***stereo disparity***.

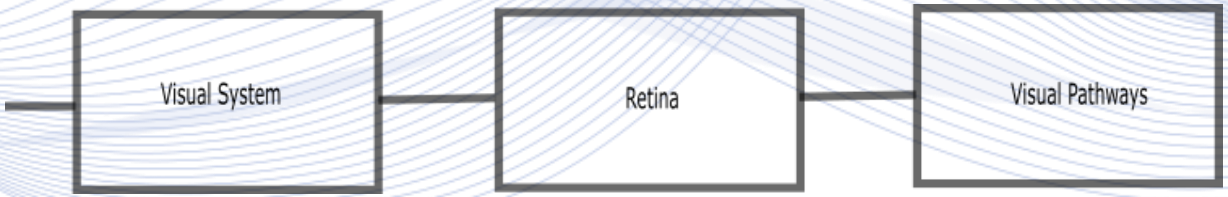
- Stereo parallax is utilized by the brain in order to extract depth information.



Human Visual System

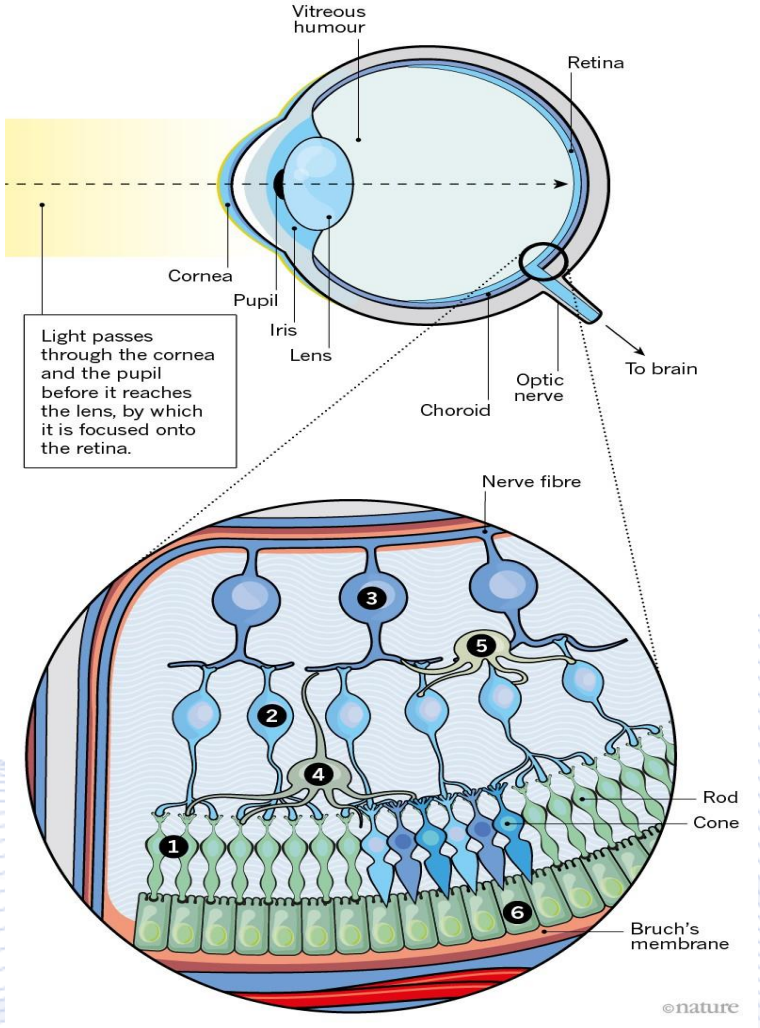
Human eye is a visual system consisting of:

- Cornea
- Iris/pupil,
- Lens
- Vitreous humor consisting primarily of water (60-70%).
- Retina.



Eye visual system model.

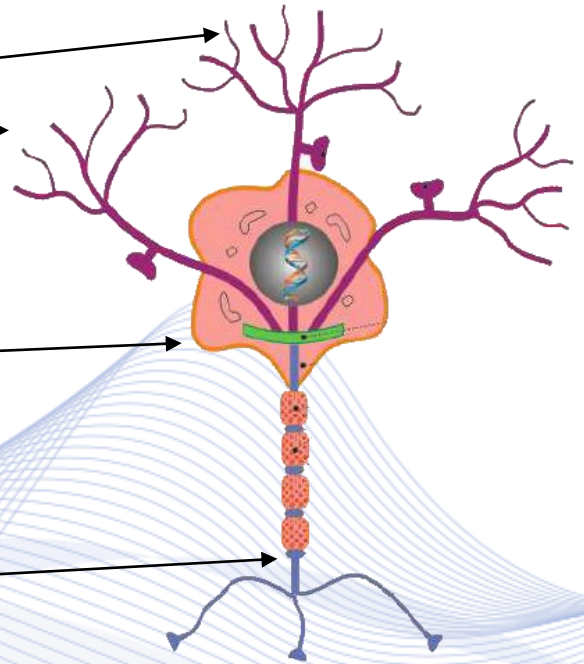
Retina



Retina structure [DAV2018].

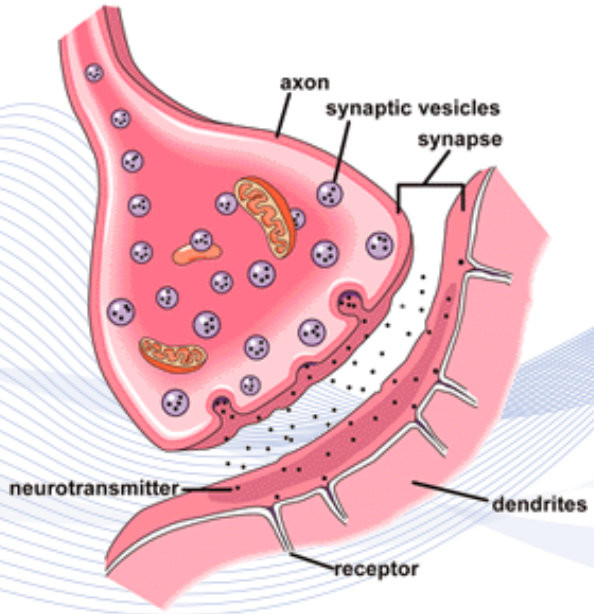
Biological Neuron

- Basic computational unit of the brain.
- Main parts:
  - ***Dendrites***
    - They act as inputs.
  - ***Soma***
    - Main body of neuron.
  - ***Axon***
    - It acts as neuron output.

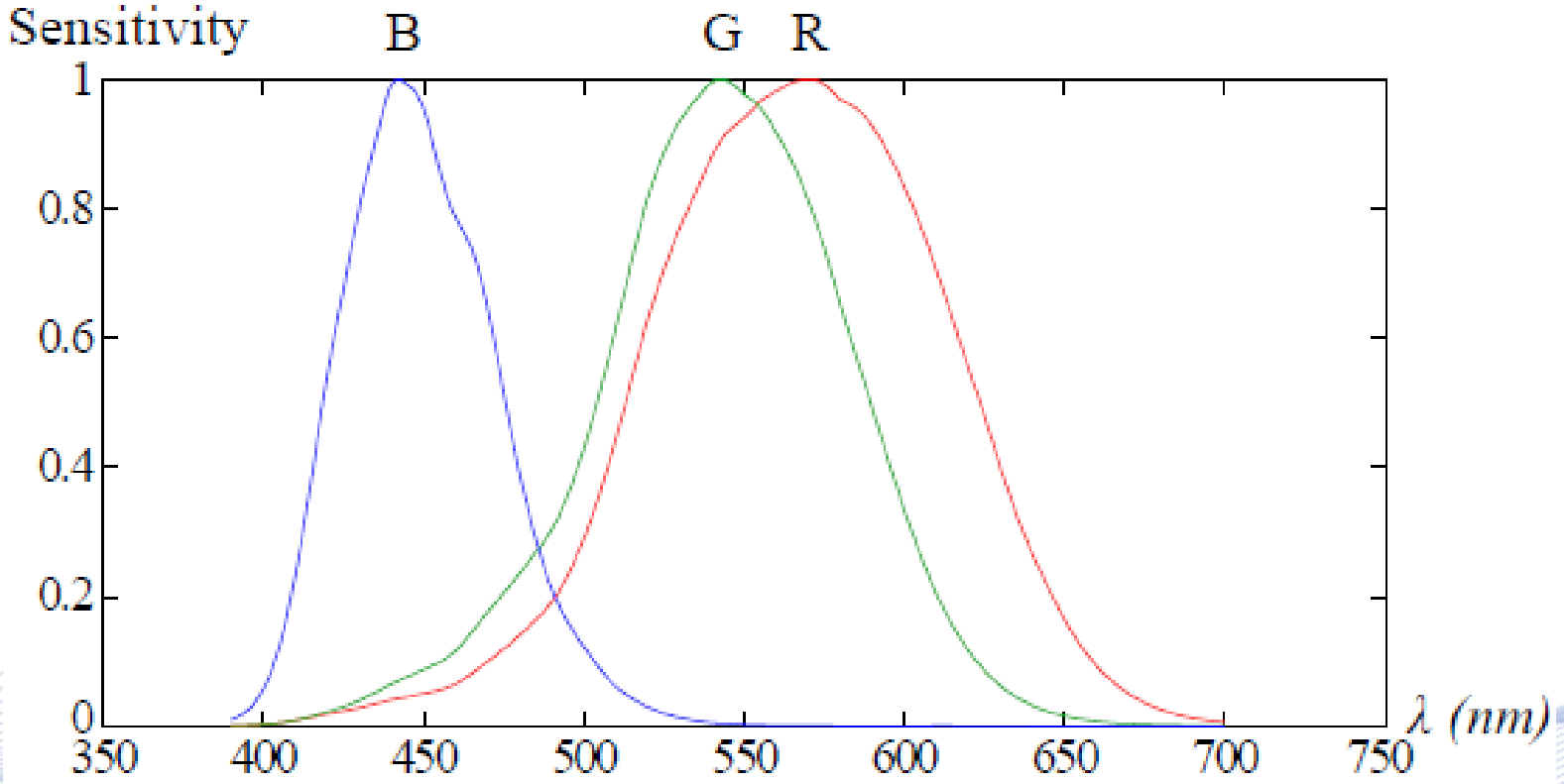


Biological Neuron Connectivity

- An electric action potential is propagated through the axon.
- Signal is transmitted through the synapse gap by neurotransmitter molecules.
- Each synapse has its own ***synaptic weight***.
- Synaptic weights can be:
  - positive (***excitatory synapses***).
  - Negative (***inhibitory synapses***).
- Transmitted signal is a series of electrical impulses.
- The stronger the transmitted signal, the

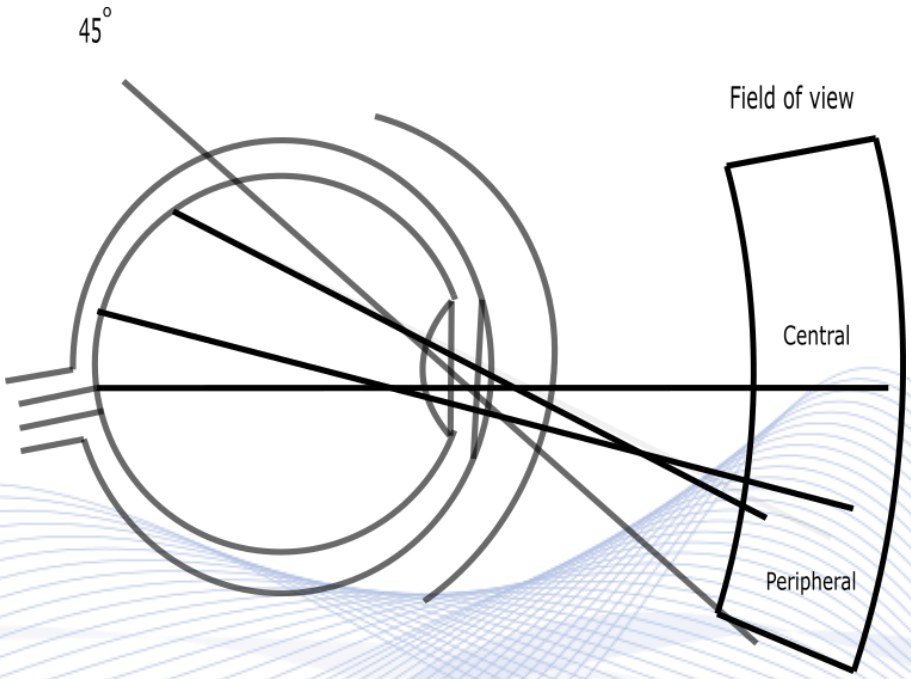


Color theory



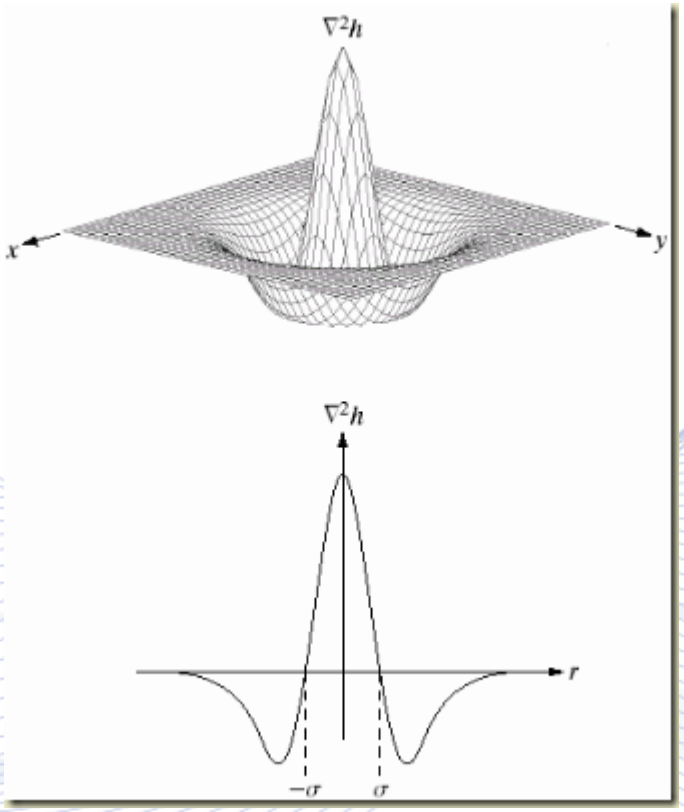
R, G, B cone sensitivity.

Retina



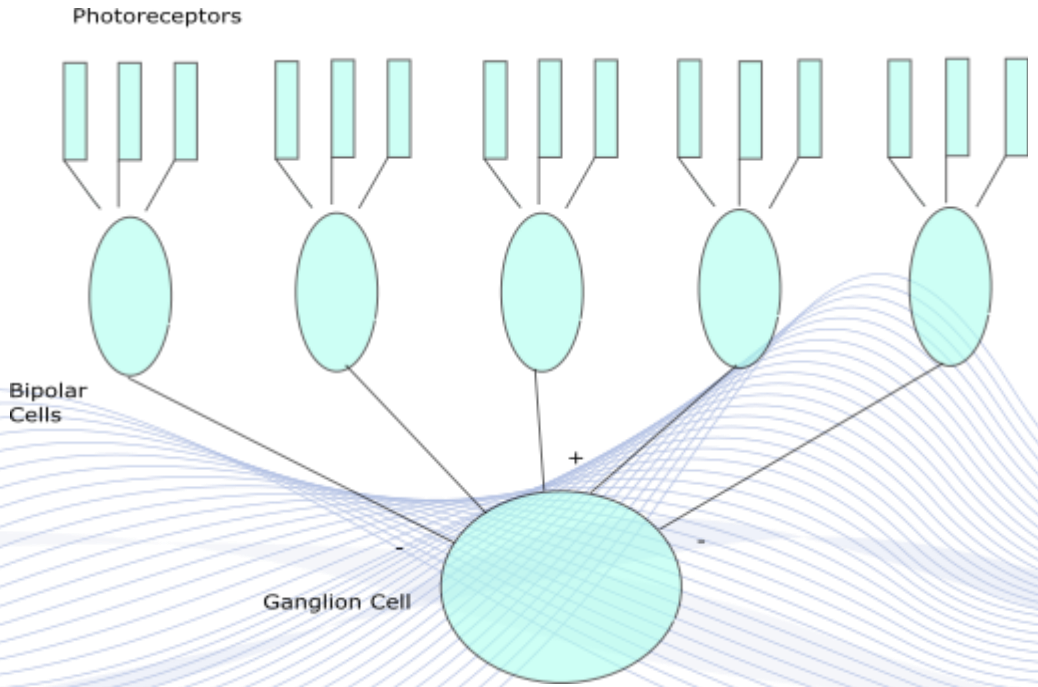
Rod and cone density change from retina center to its periphery.

Retina



Laplacian-of-Gaussian (LoG) function [LOG].

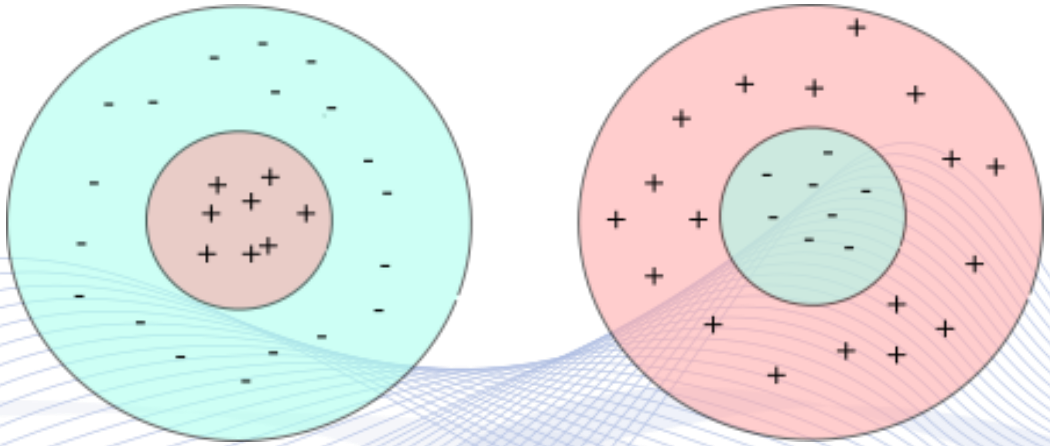
Retina



Ganglion receptive fields.

Retina

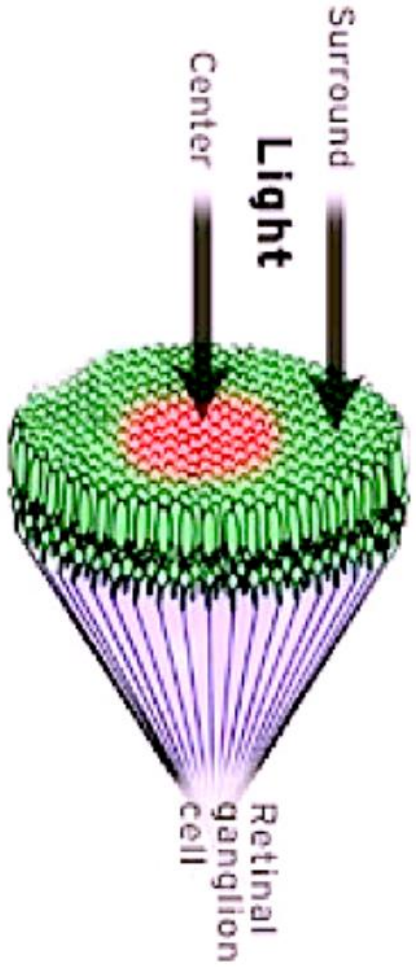
Receptive Fields

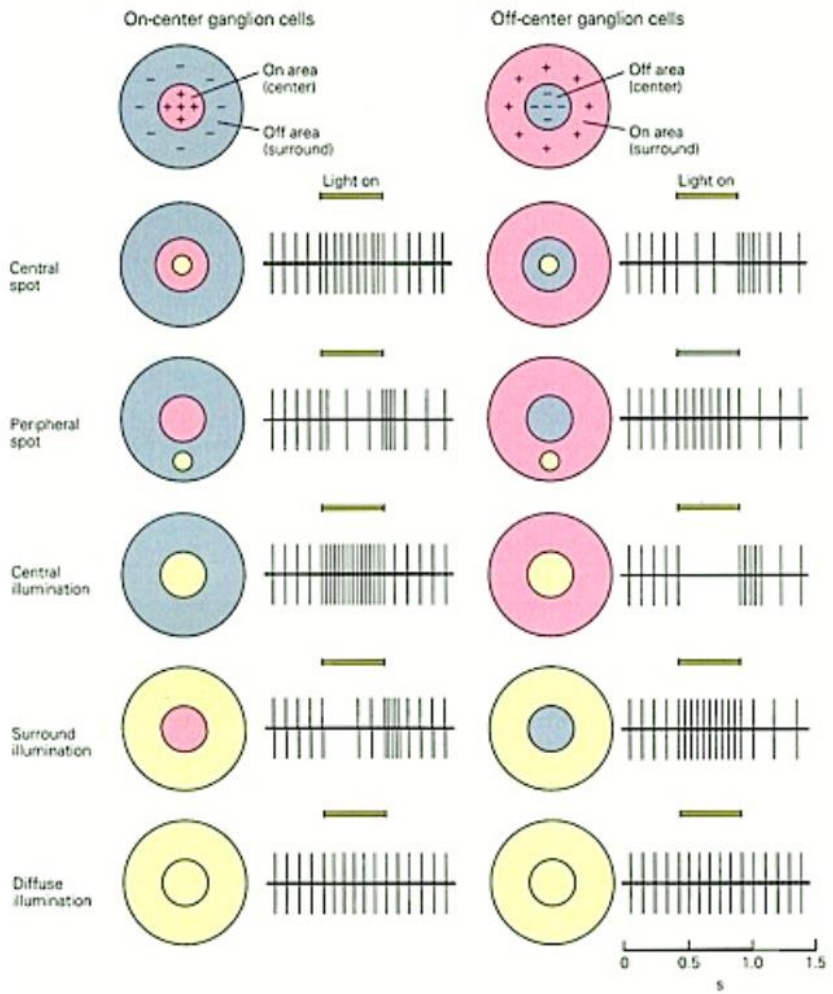


On-center, Off-surround Off-center, On-surround

Center-surround organization of ganglion receptive fields.

Retina





Center-surround organization of ganglion receptive fields.

Human Visual System

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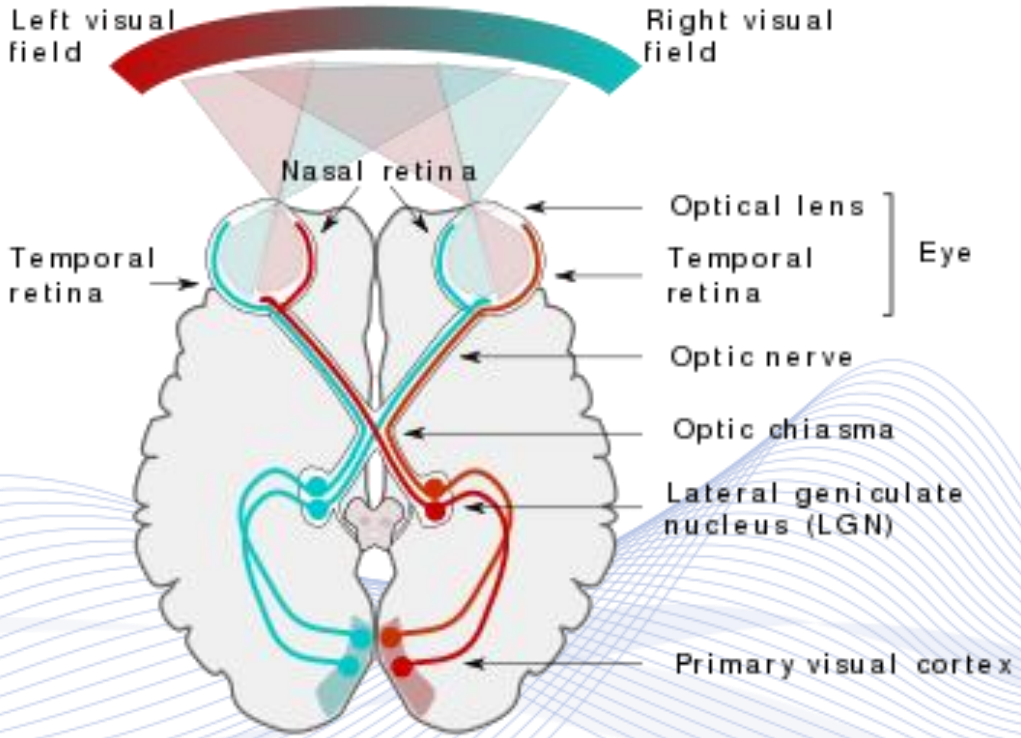
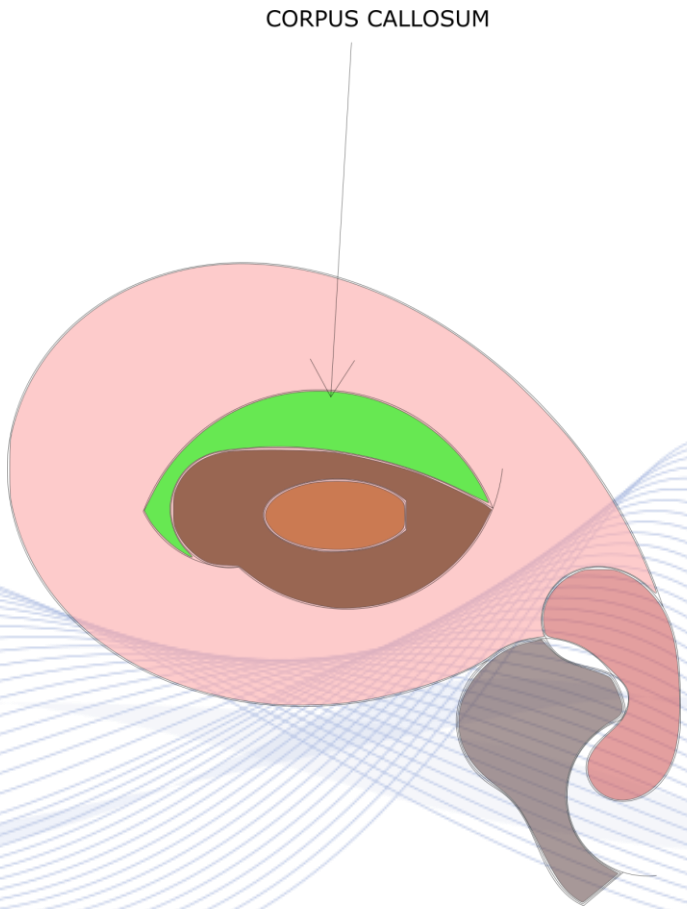
- Retina
- **Visual Pathway**
- Visual Cortex
- Visual defects

Visual Pathway



Human Visual System structure [WIKVS].

Corpus Callosum



Corpus callosum.

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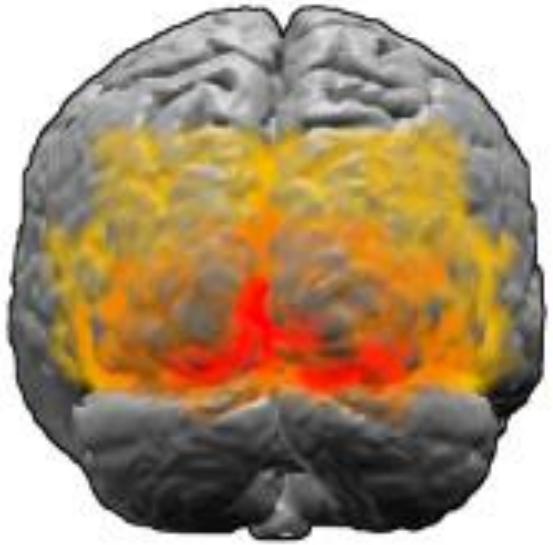
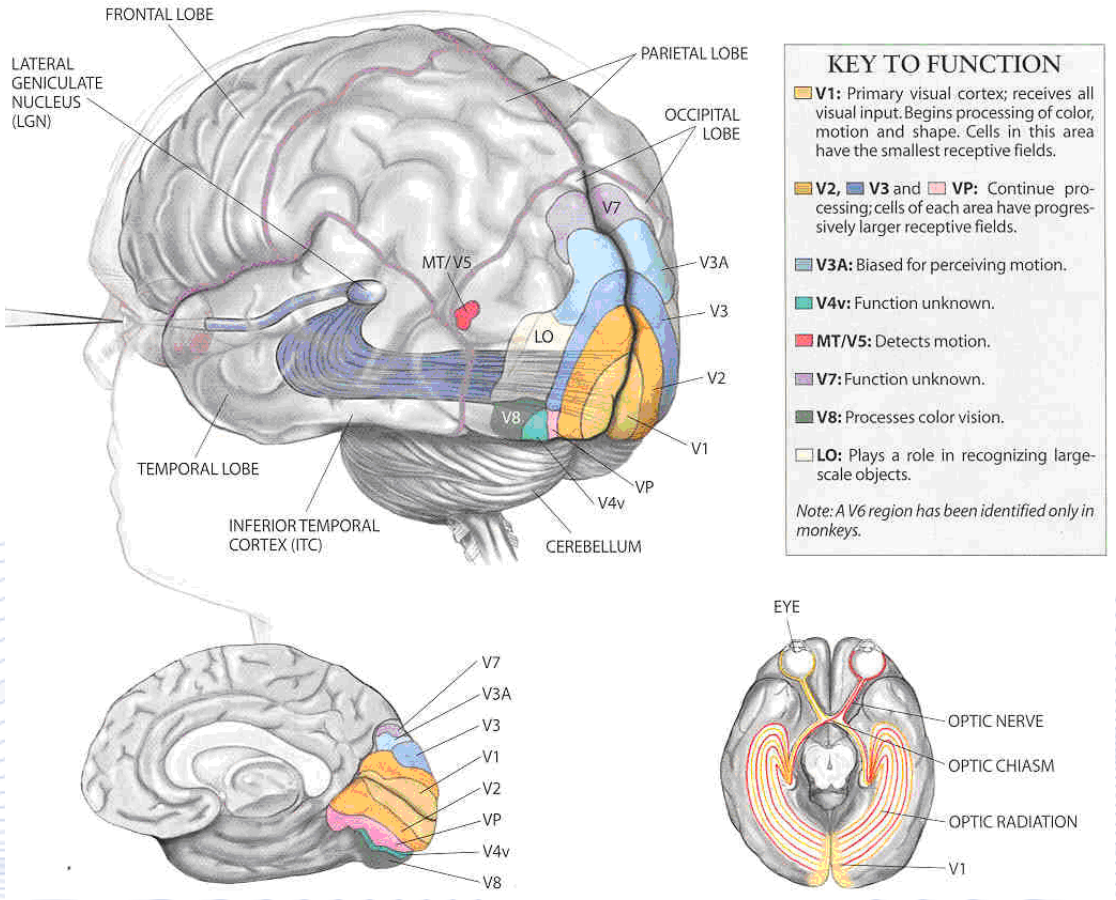
Visual Cortex



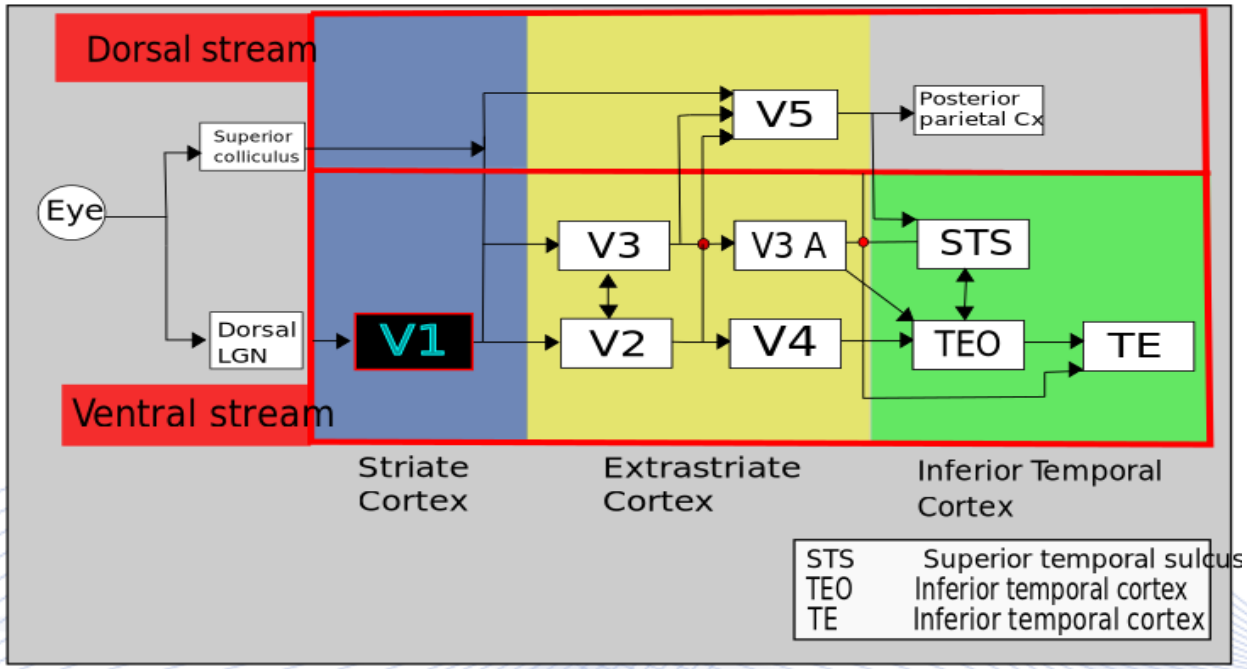
Visual cortex topology [WIKVC].

Visual Cortex



Visual cortex structure [NEUCC].

Visual Cortex



Organization of virtual cortex.

Human Visual System

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Visual defects

Any damage of any HVS subsystem can create vision disorders or visual defects:

- Eye disorders: ***refractive errors*** (myopia, hyperopia, astigmatism and presbyopia)
  - ***Cataract*** is a clouding of the eye lens.
  - ***Age-related Macular Degeneration*** (***AMD***) affects the macula, (central part the retina), damaging sharp and central vision.
  - ***Diabetic retinopathy*** is progressive damage to retina blood vessels.
  - ***Retinal detachment***.

Visual defects

- ***Glaucoma*** can damage the optic nerve, typically associated to eye fluid pressure increase.
- ***Amblyopia*** ("***lazy eye***") is due to abnormal development of visual acuity, typically found in some children.
- ***Strabismus*** is an imbalance in eye vergence or gaze orientation.

Defects related to visual path or Visual cortex:

- They result from brain dysfunction due to lesions, trauma or other defects.

Visual defects

Color related visual defects.

- The most common are retinal ones in nature and are genetically passed on between generations.
- Some retinal color deficiencies are:
  - a shift in cone wavelength sensitivity of cones or
  - degenerate or missing cones.
- Most often only one type of cone is affected (***dichromasy***).
- Total color blindness (***monochromasy***) is extremely rare.

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Q & A

Thank you very much for your attention!

More material in
http://icarus.csd.auth.gr/cvml-web-lecture-series/

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