



Indian Institute of Technology  
Kanpur

In Collaboration  
with

...



# National Program on Technology Enhanced Learning (NPTEL)

Presents

...

Course Title:

# Basic Cognitive Processes

By: Dr. Ark Verma,  
Assistant Professor of Psychology,  
Department of Humanities & Social Sciences,  
IIT Kanpur

# Lecture 15: Physiology of Visual Perception

# Visual Perception: The Beginning

- The precondition for vision is light, i.e. electromagnetic radiation that can be described in terms of wavelength.
- Humans can perceive only a small range of wavelengths that exist: the visible wavelengths are from 380 - 750 nm.

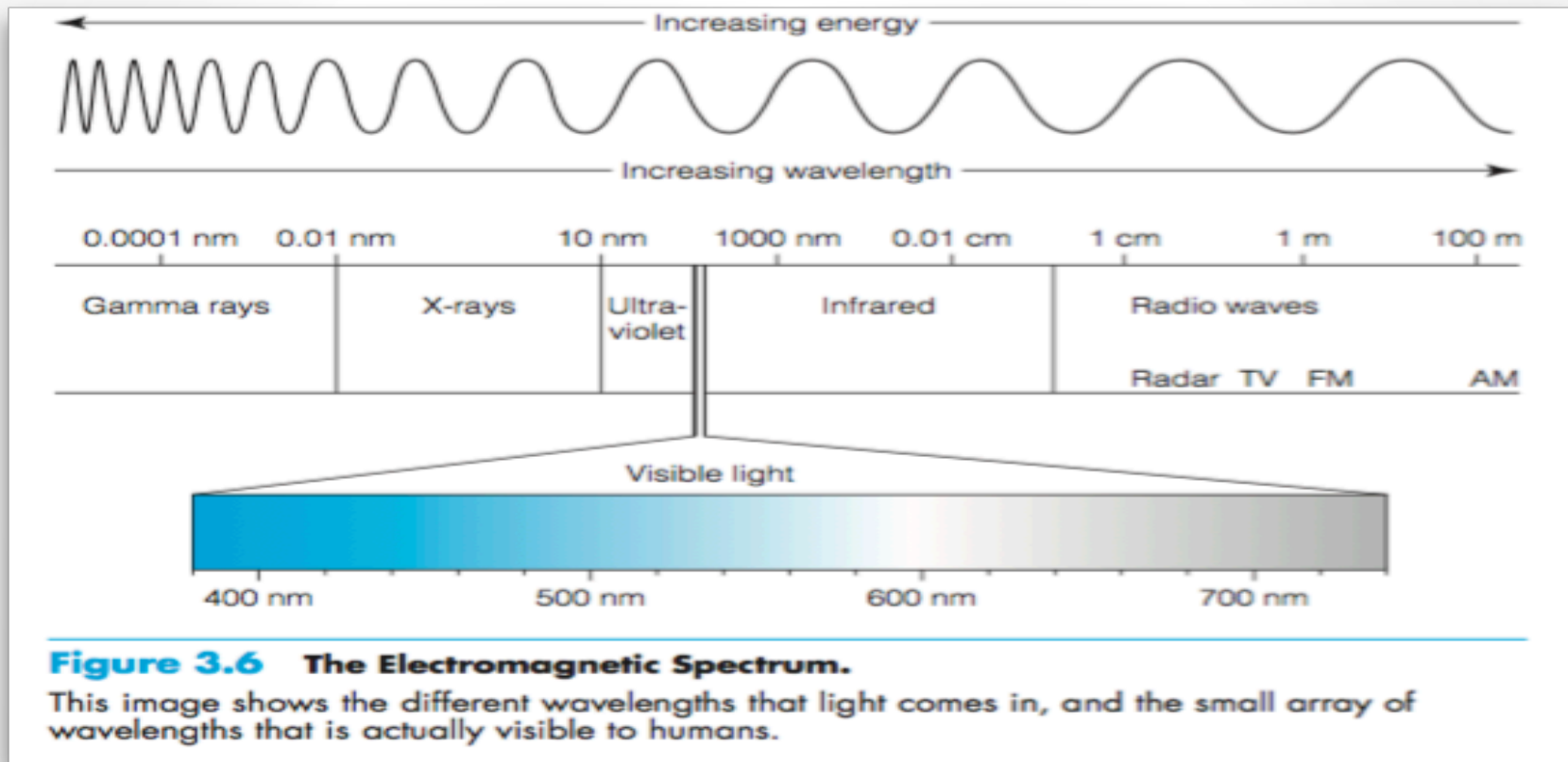
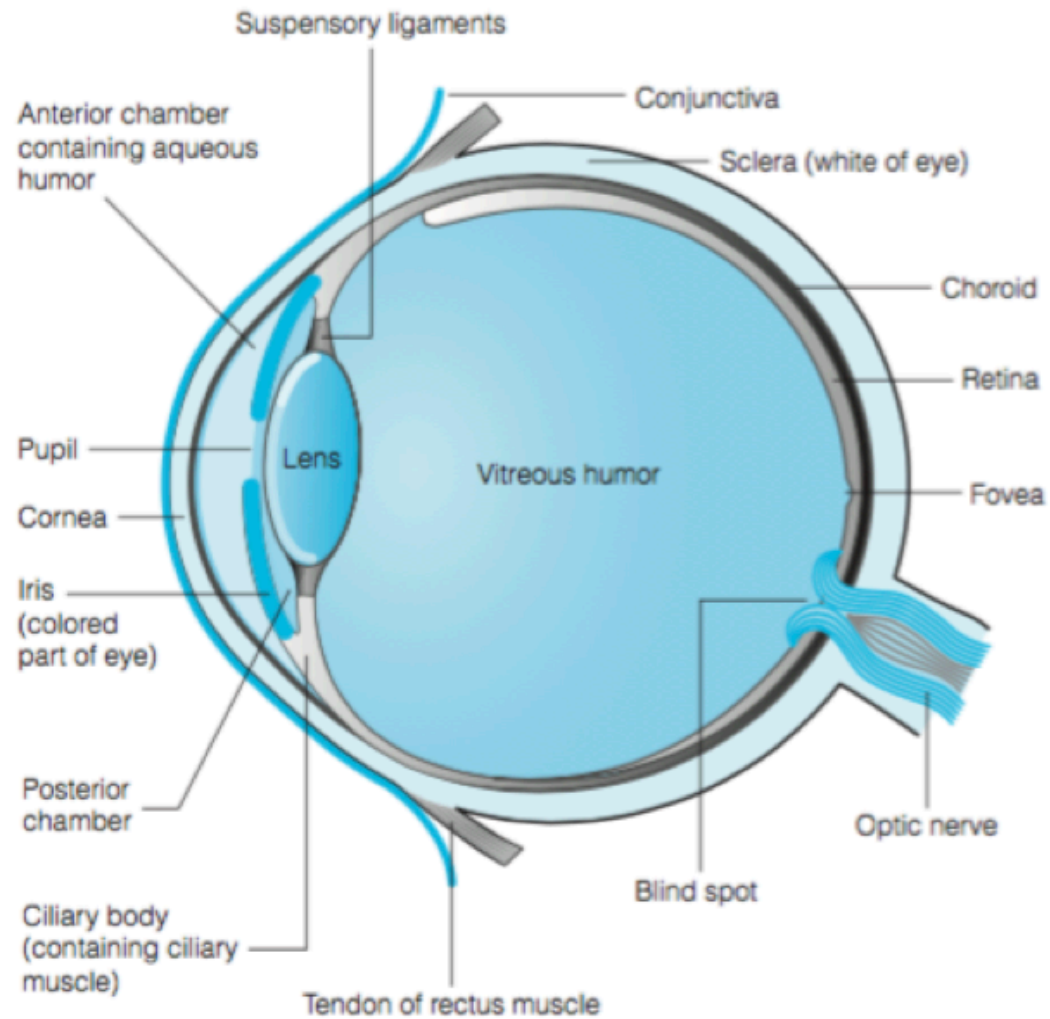


Image: Sternberg & Sternberg (2011). Cognitive Psychology. Wadsworth Publishing. 6<sup>th</sup> Ed. (Fig 3.6, p. 92).



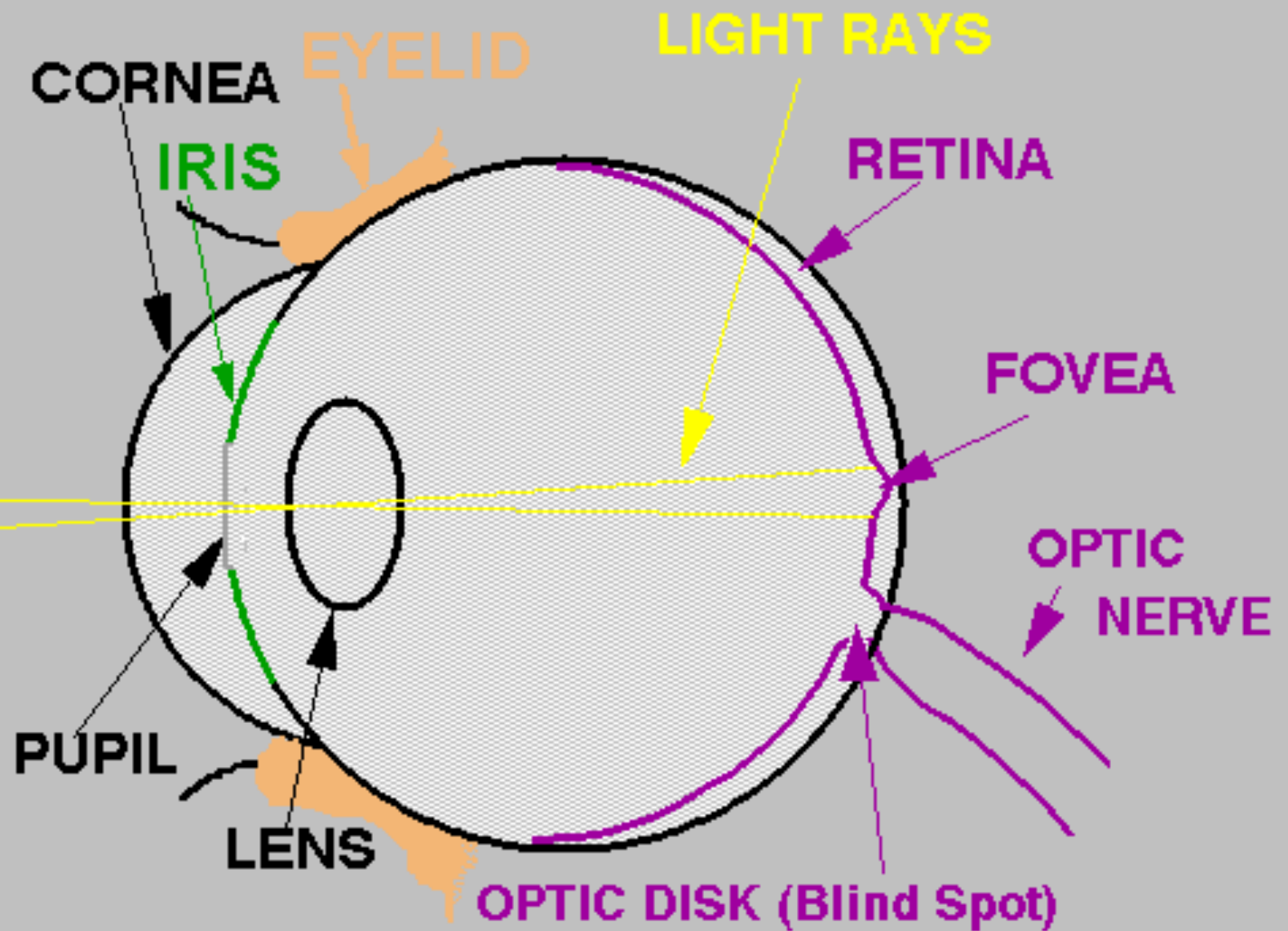
- Vision begins when light passes through the protective covering of the eye, i.e. the **cornea**, which is a clear dome that protects the eye.
- Light, then passes through **the pupil**, i.e. the opening in the center of the **iris**.
- It continues through the crystalline lens and the vitreous humor, which is a gel - like substance that comprises the majority of the eye.



**Figure 3.7 The Human Eye.**  
The composition of the human eye.

Image: Sternberg & Sternberg (2011). *Cognitive Psychology*. Wadsworth Publishing. 6<sup>th</sup> Ed. (Fig 3.7, p. 93).

- Eventually, the light focuses on the **retina**, where electromagnetic light energy is transduced i.e. converted - into neural electrochemical impulses (Blake, 2000).
- Vision is most acute in the **fovea**, which is a small, thin region of the retina, of the size of the head of a pin.
- The retina contains of three main layers of neuronal tissue:
  - ganglion cells
  - amacrine, horizontal & bipolar cells
  - photoreceptors: rods & cones



- the first layer of neuronal tissue - closest to the front, outward facing surface of the eye - is the layer of ganglion cells; whose axons constitute the **optic nerve**.
- the second layer consists of three kinds of interneuron cells:
  - **Amacrine cells & horizontal cells** make single lateral connections among the adjacent areas of the retinal in the middle layer of cells.
  - **Bipolar cells** make dual connections forward and outward to the ganglion cells, as well as backward & inward to the third layer of retinal cells.

- the third layer of the retina consists of the **photoreceptors**, which convert light energy into electrochemical energy that is transmitted by neurons to the brain.
  - there are two kinds of photoreceptors - **rods & cones**.
- Each eye contains roughly around 120 million rods & 8 million cones.
- Rods & cones differ not only in shape but also in their compositions, locations & responses to light.

1. Light entering eye triggers photochemical reaction in rods and cones at back of retina.

2. Chemical reaction in turn activates bipolar cells.

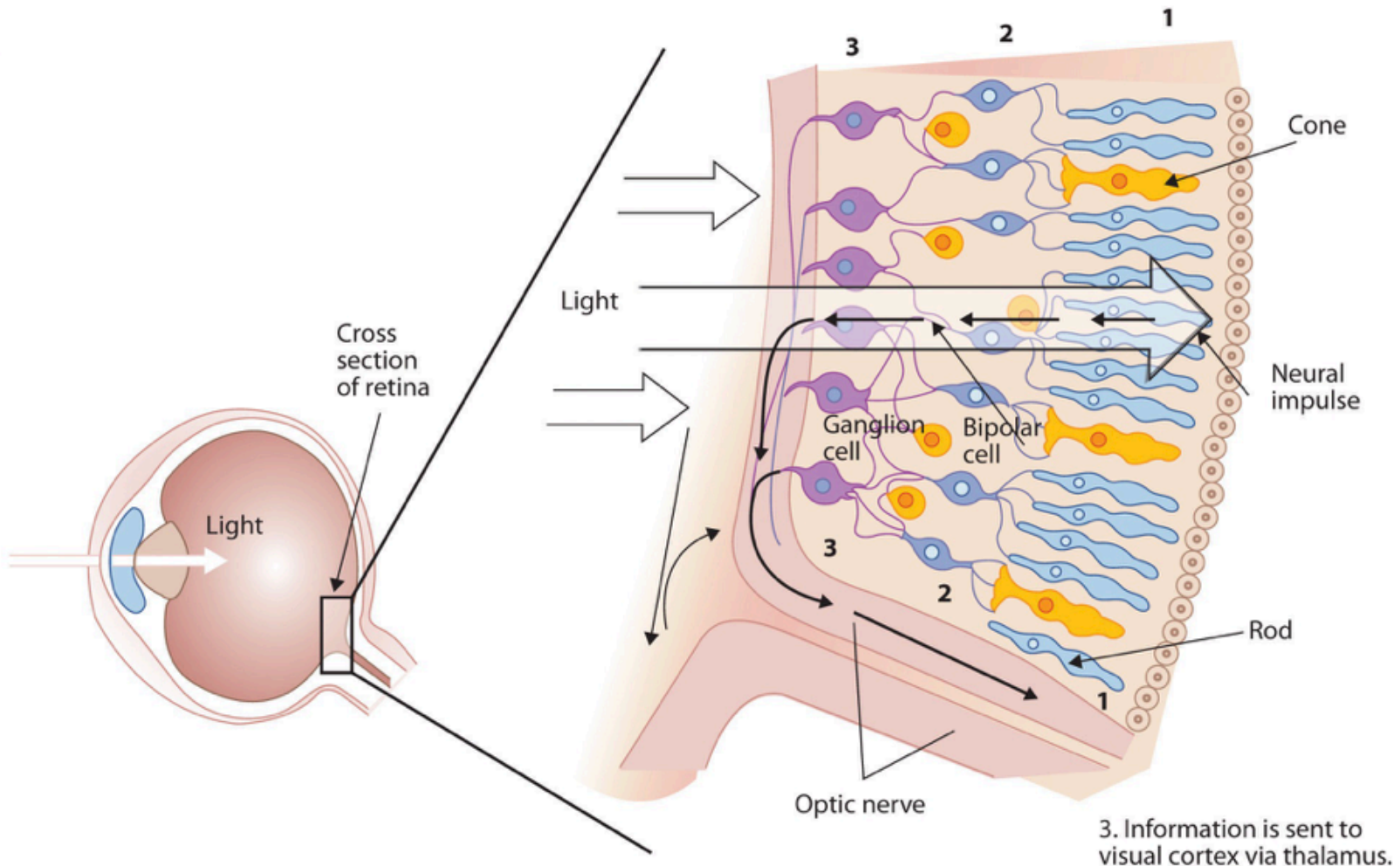


Image: Stangor (2010) *Introduction to Psychology*. Flat World Knowledge. (p. 180 Under creative commons license)

- Within the rods & cones are **photopigments**, i.e. chemical substances that react to light and transform physical electromagnetic energy into an electrochemical neural impulse that can be understood by the brain.
- The rods are long & thin photoreceptors; more highly concentrated in the periphery of the retina than in the foveal region. are responsible for night vision and are sensitive to light & dark stimuli.
- The cones are short & thick photoreceptors and allow for the perception of colour. are highly concentrated in the foveal region than in the periphery of the retina.



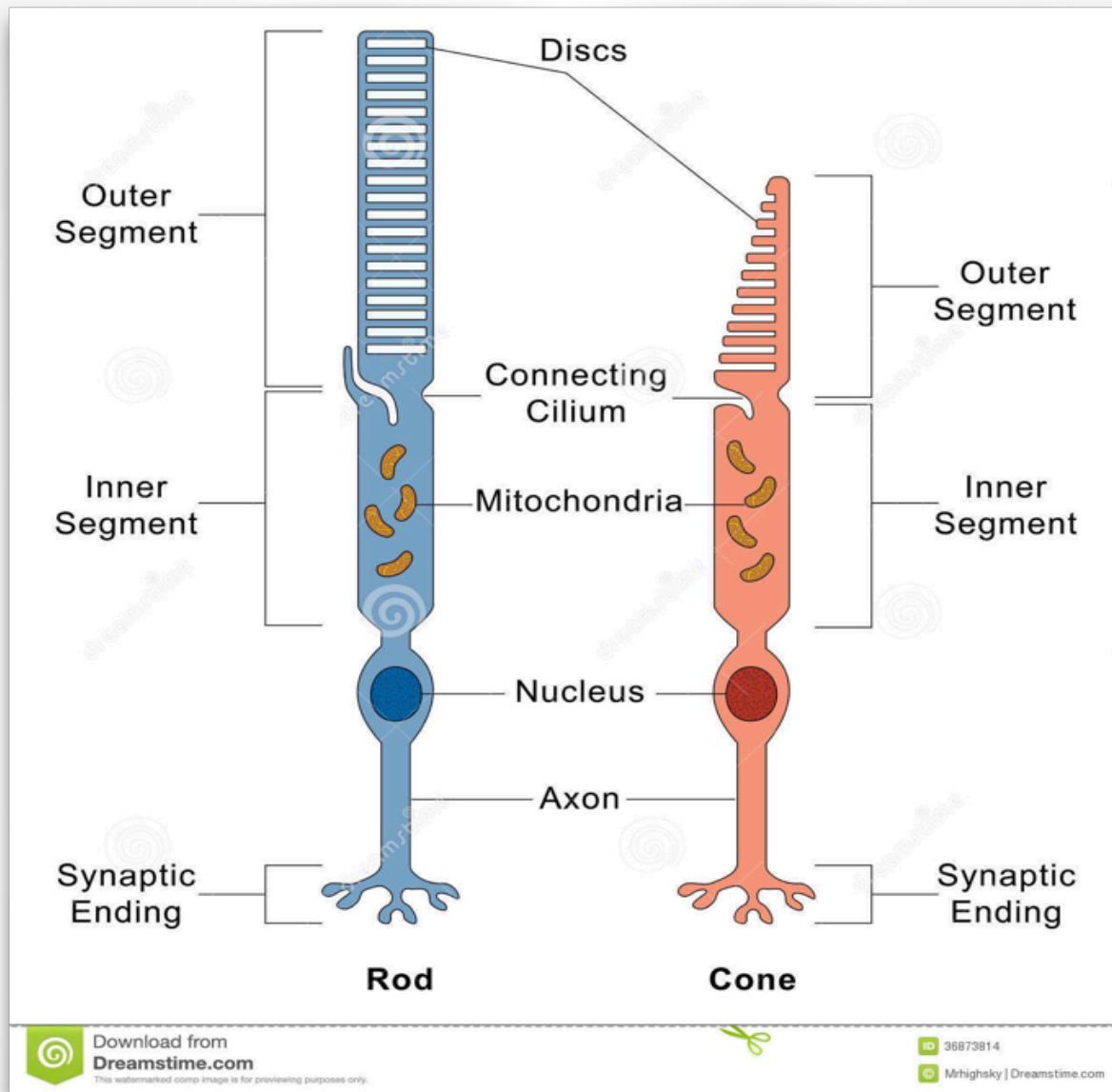
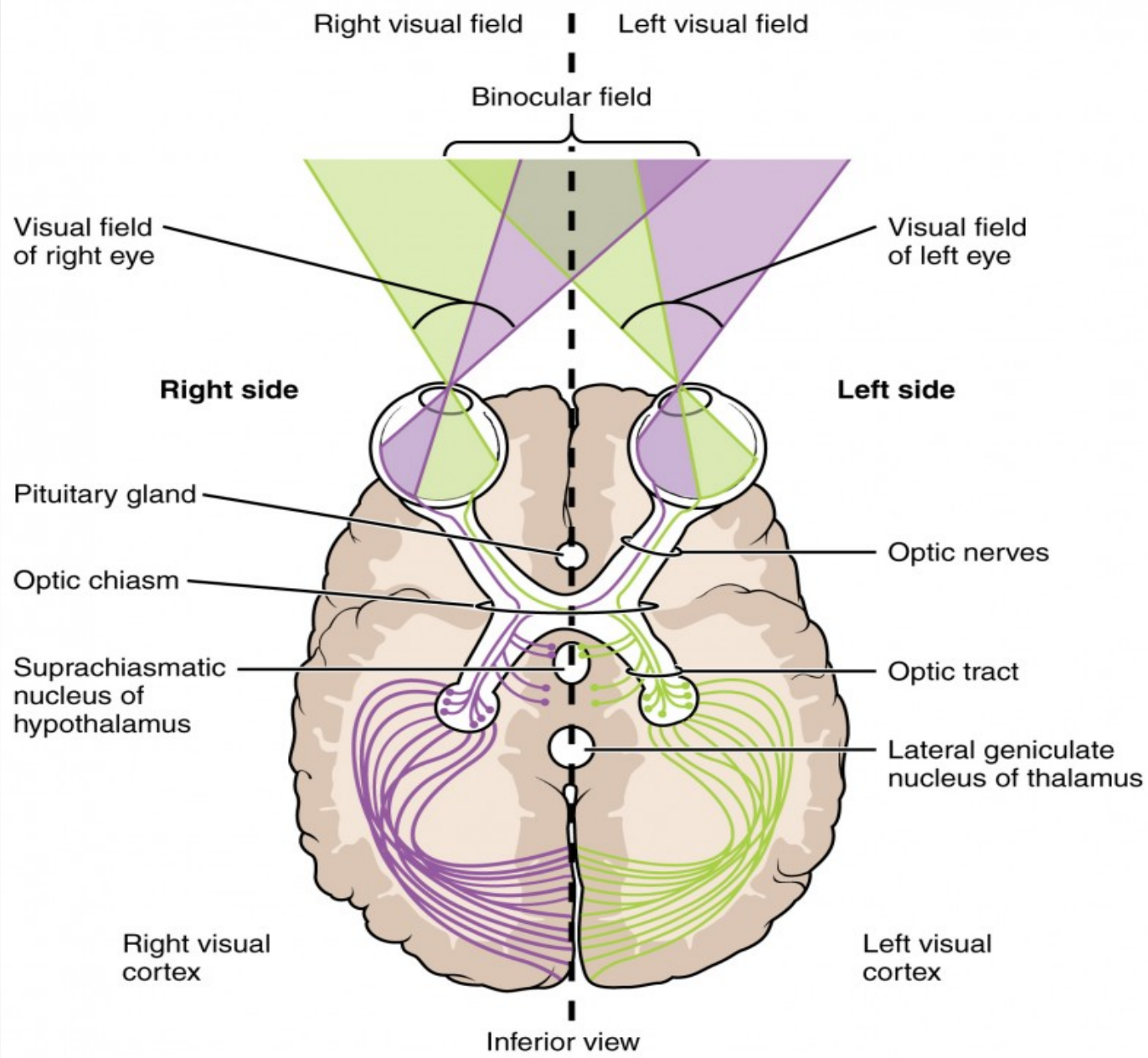


Image: [<https://ghr.nlm.nih.gov/art/large/rod-and-cone-cells.jpeg?ow>]

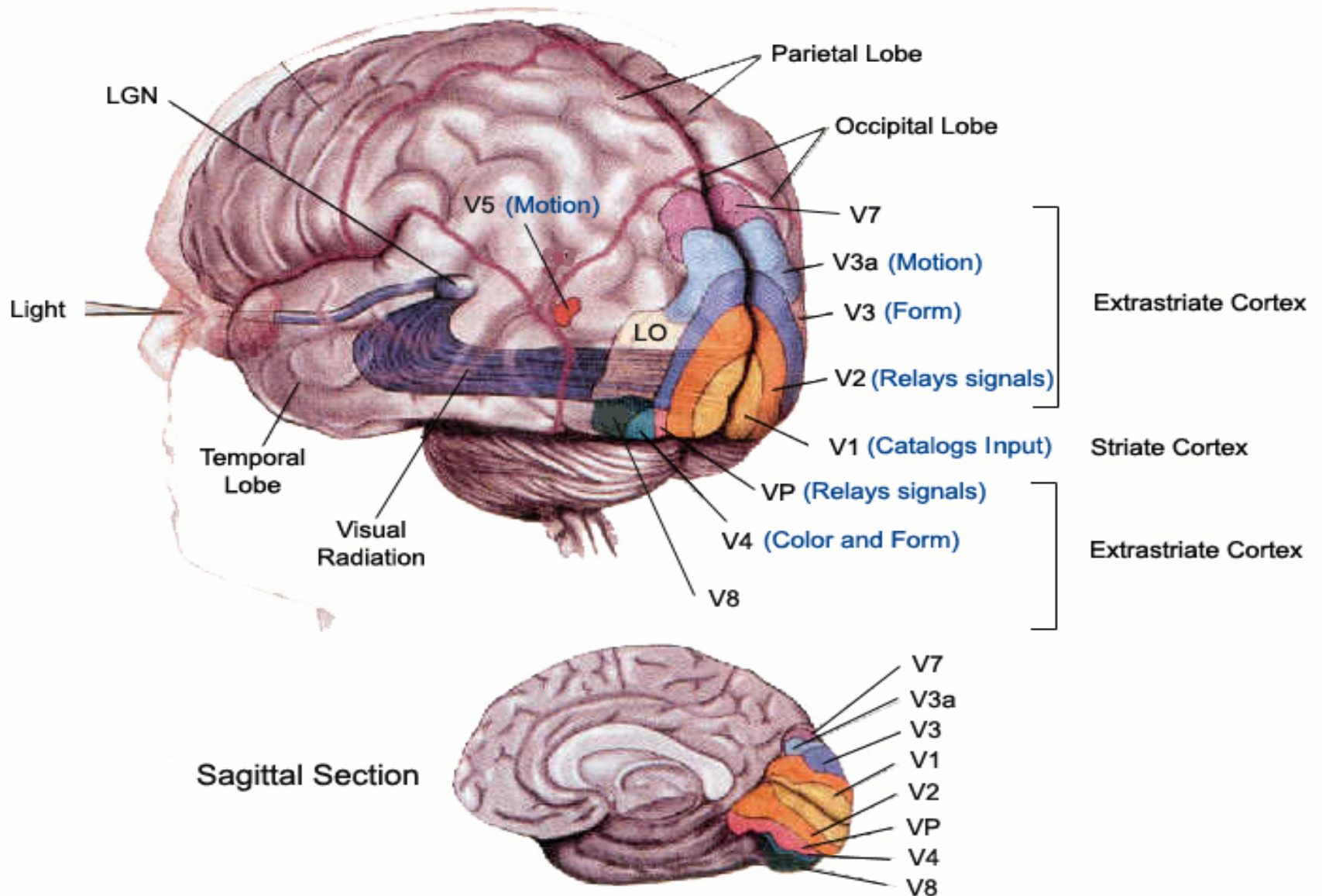
- The rods, cones & photo pigments could not do their work were they not somehow hooked up to the brain.
- The neurochemical messages processed by the rods & cones of the retina, travel via the bipolar cells to the ganglion cells.
- the axons of the ganglion cells in the eye collectively form the optic nerves for that eye.

- The optic nerve of the two eyes join at the base of the brain to form the **optic chiasm**.
- at this point, the ganglion cells from the inward or nasal, part of the retina - cross through the optic chiasm and extend to the opposite hemispheres of the brain.
- the ganglion cells from the outward, or temporal area of the retina goes to the hemisphere on the same side of the body.

- the lens of each eye inverts the image of the world as it projects the image onto the retina.
- After being routed through the optic chiasm, about 90% of the ganglion cells then go to the **lateral geniculate nucleus** of the **thalamus**.
- From the thalamus, the neurons carry information to the primary visual cortex (V1 or the striate cortex) in **the occipital lobe** of the brain.
- The **visual cortex** contains several processing areas; each handling different kinds of visual information, relating to intensity & quality, including colour, location, depth, pattern & form.



## Visual Cortices



# To Sum Up

- We understood the basic physiology of visual perception.
- We talked about the passage of light from the environment through the various parts of the eye.
- We talked about transduction & how information about the environment is relayed from eye via the optic nerve to areas in the visual cortex.

# References

- Sternberg & Sternberg (2011). Cognitive Psychology. *Wadsworth Publishing*. 6<sup>th</sup> Ed.