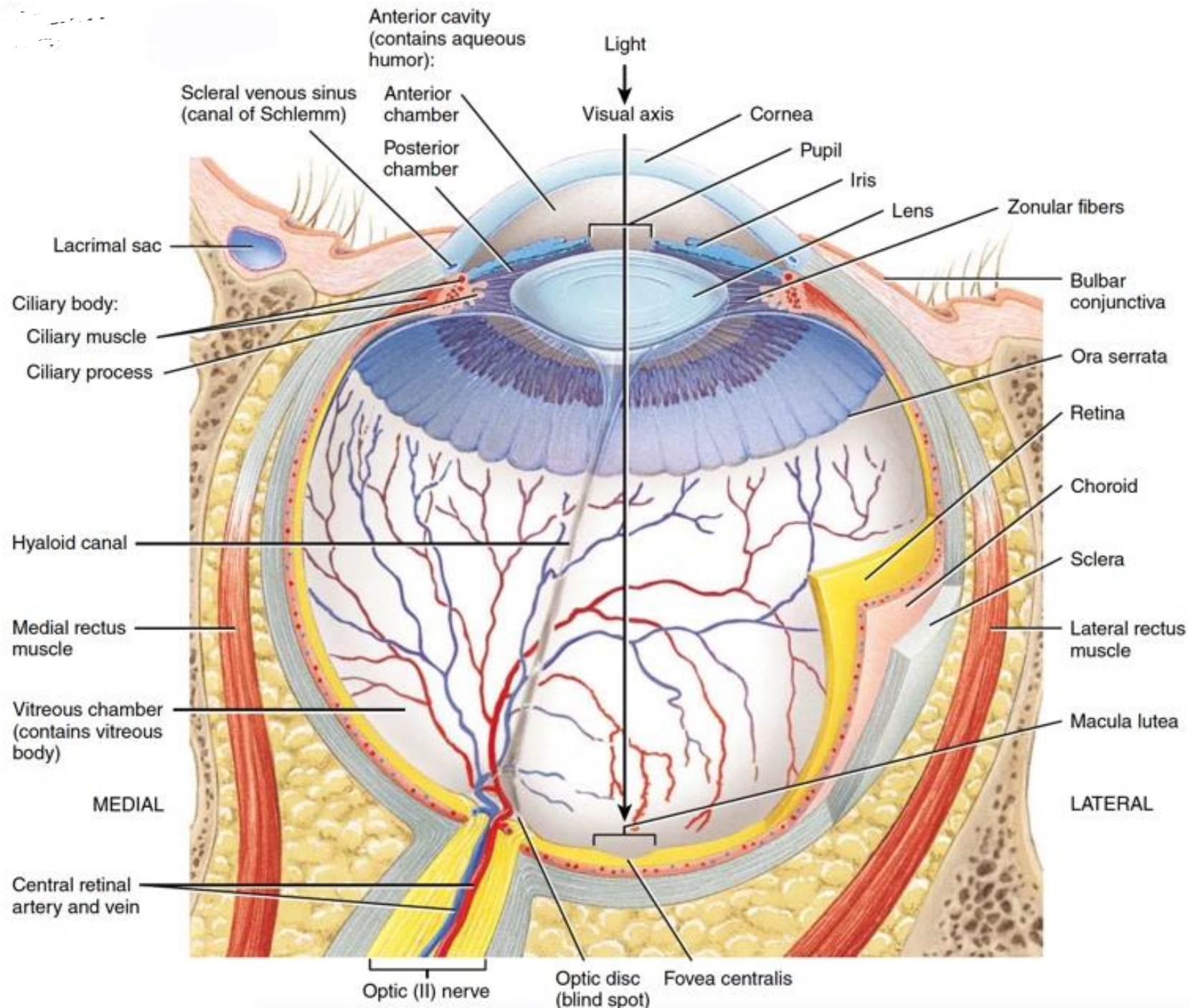
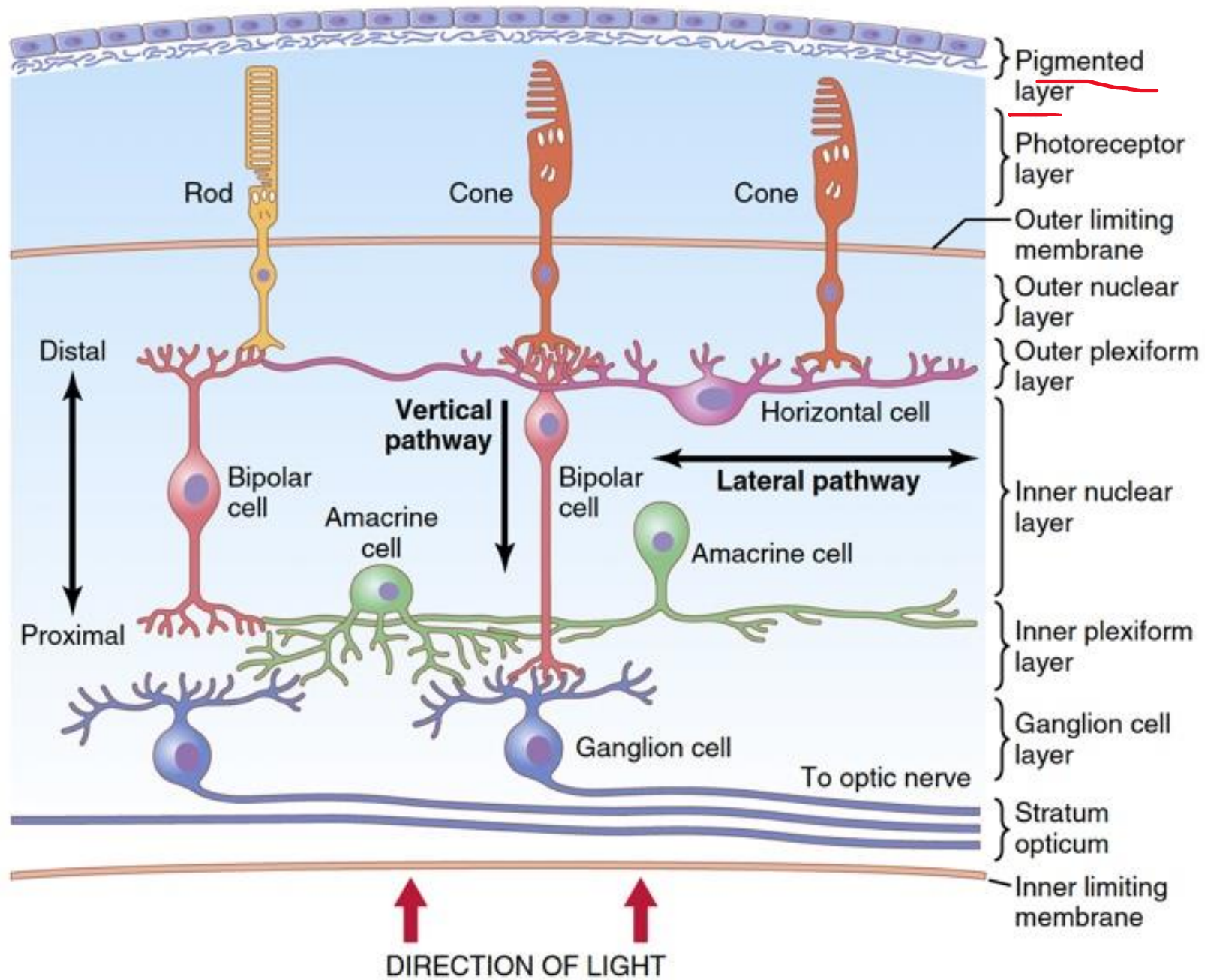


# Physiology for medical students

## Vision-II

Fatima Ryalat, MD, PhD





# Optic disc

- The point on the retina at which the optic nerve leaves and through which blood vessels pass is the optic disc.
- This region is often called the blind spot; no image can be detected in this area because it has no rods and cones.
- We are normally not aware of the blind spot because central processing somehow “fills in” the missing spot.

# Fovea

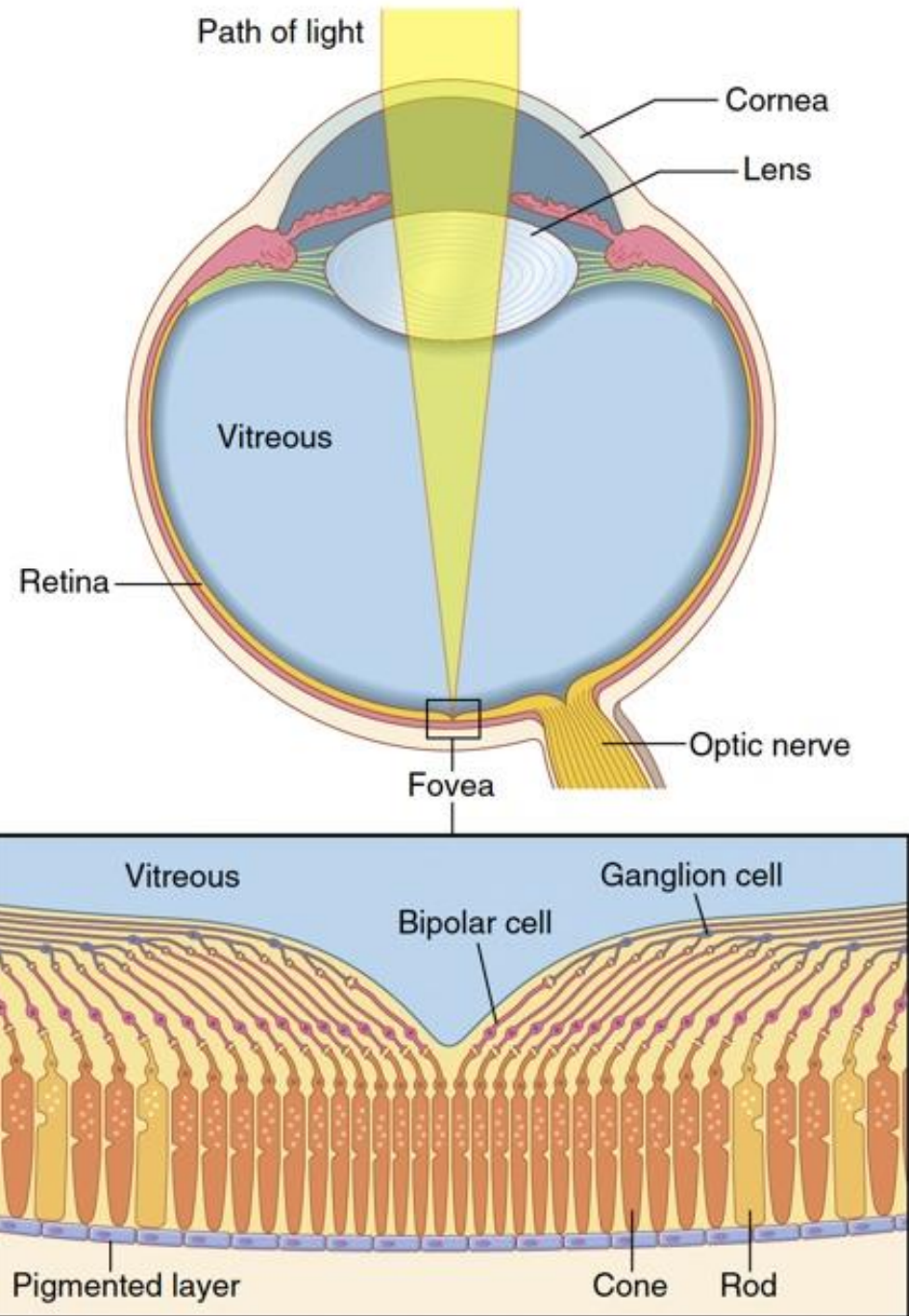
- Light must pass through the ganglion and bipolar layers before reaching the photoreceptors in all areas of the retina except the fovea, located in the center of the retina.
- Because of this feature, and because only cones (which have greater acuity or discriminative ability than the rods) are found here, the fovea is the point of most distinct vision.

# Fovea

- The fovea is a minute area in the center of the retina, especially capable of acute and detailed vision.
- The central fovea is composed almost entirely of cones. These cones have a special structure that aids their detection of detail in the visual image—that is, the foveal cones have especially long and slender bodies, in contradistinction to the much fatter cones located more peripherally in the retina.

# Fovea

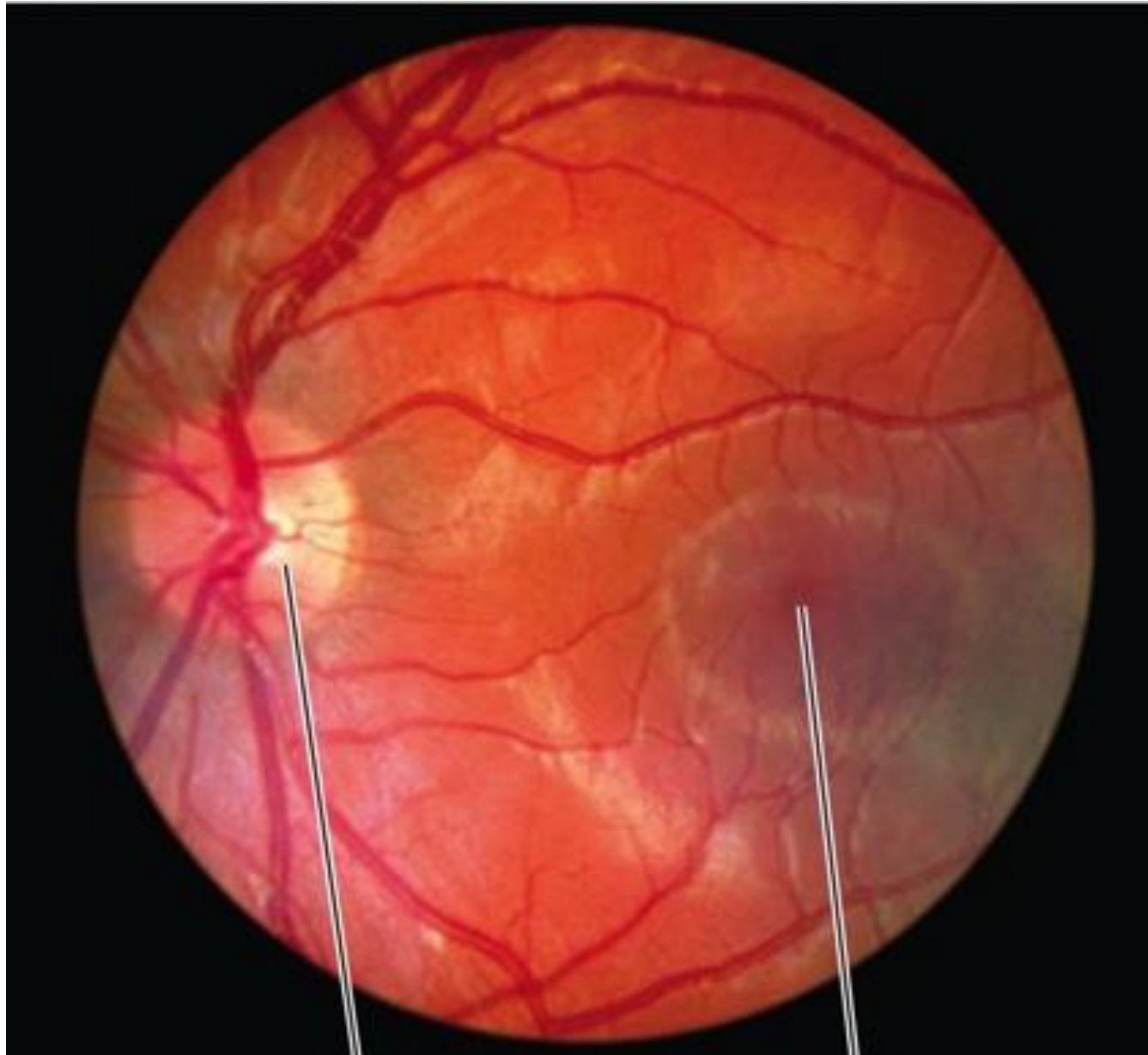
- Also, in the foveal region, the blood vessels, ganglion cells, inner nuclear layer of cells, and plexiform layers are all displaced to one side rather than resting directly on top of the cones, which allows light to pass unimpeded to the cones.



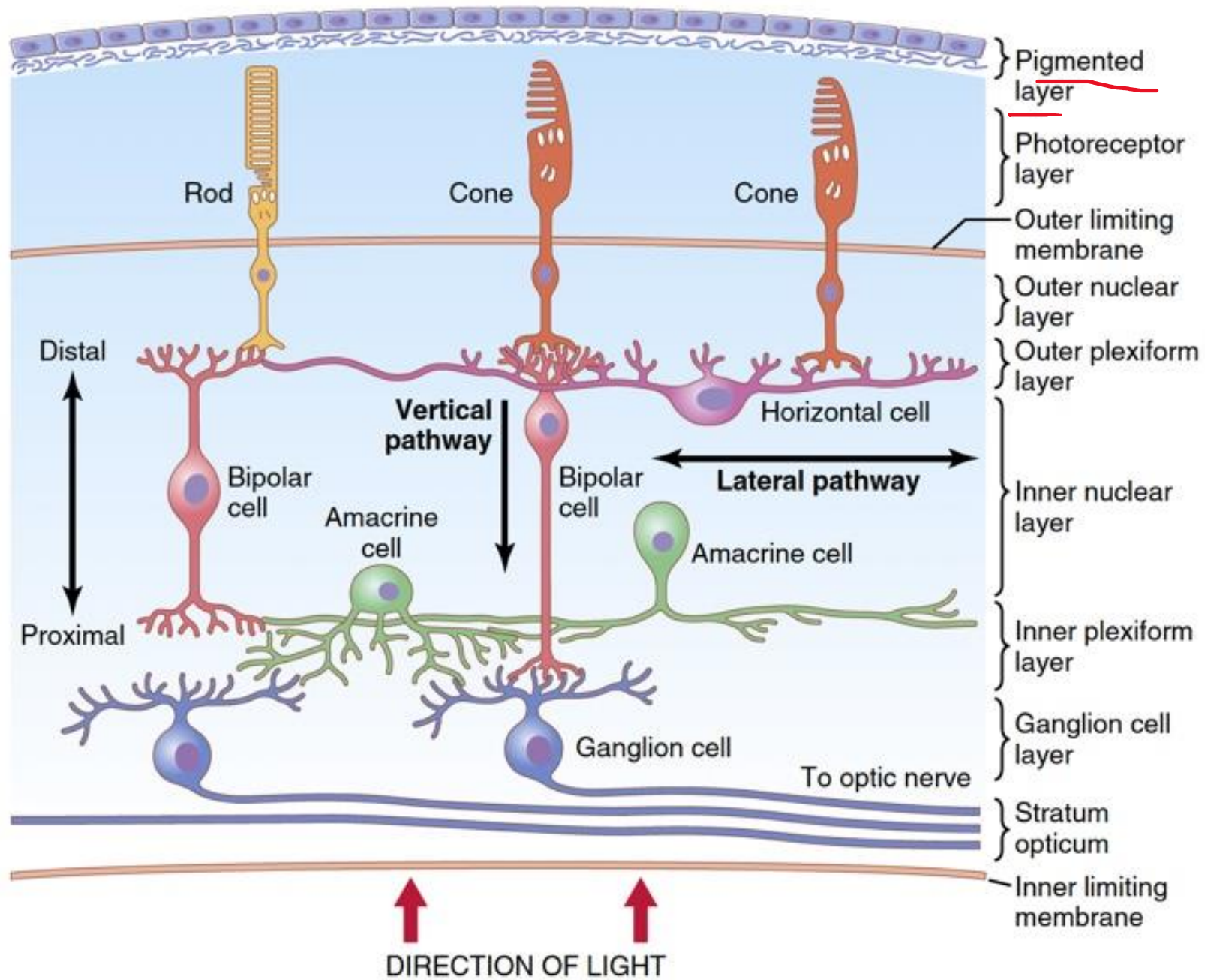


# Macula

- The area immediately surrounding the fovea is called the macula lutea, has a high concentration of cones and fairly high acuity.
- Macular acuity is less than that of the fovea because of the overlying ganglion and bipolar cells in the macula.
- Macular degeneration.





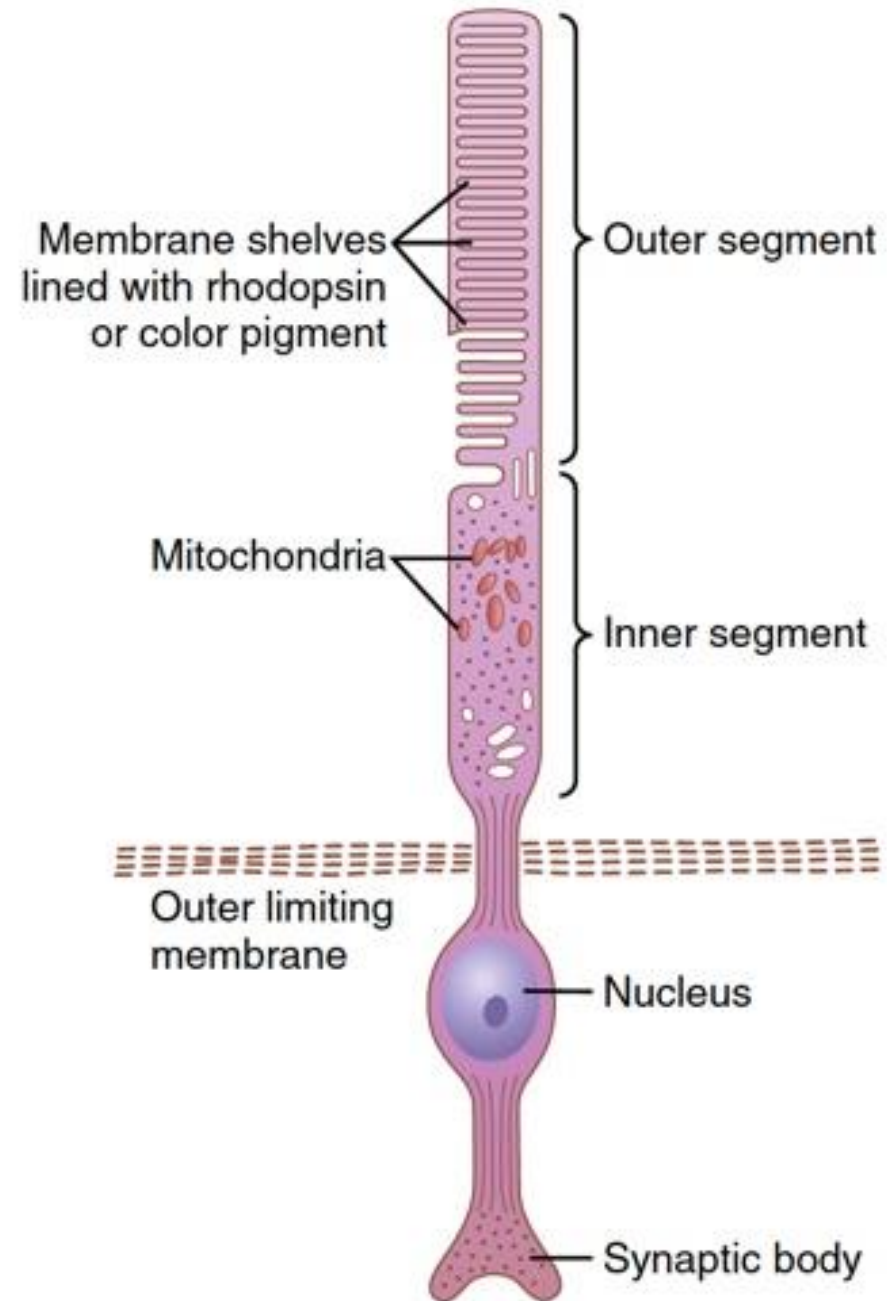


# Pigment

- The black pigment melanin in the pigment layer prevents light reflection throughout the eye ball, which is extremely important for clear vision.
- Albinism

# Vitamin A

- The pigment layer also stores large quantities of vitamin A. That is exchanged back and forth through the cell membranes of the outer segments of the rods and cones, which are embedded in the pigment.
- vitamin A is an important precursor of the photosensitive chemicals of the rods and cones.
- Night blindness



# Photoreceptors

- The major functional segments of either a rod or cone are:
- (1) the outer segment; (2) the inner segment; (3) the nucleus; and (4) the synaptic body.
- The light-sensitive photochemical is found in the outer segment. In the case of the rods, this photochemical is rhodopsin; in the cones, it is one of three “color” photochemicals, usually called simply color pigments, that function almost exactly the same as rhodopsin except for differences in spectral sensitivity.
- In the outer segments of the rods and cones, note the large numbers of discs. Each disc is actually an infolded shelf of cell membrane. There are as many as 1000 discs in each rod or cone.

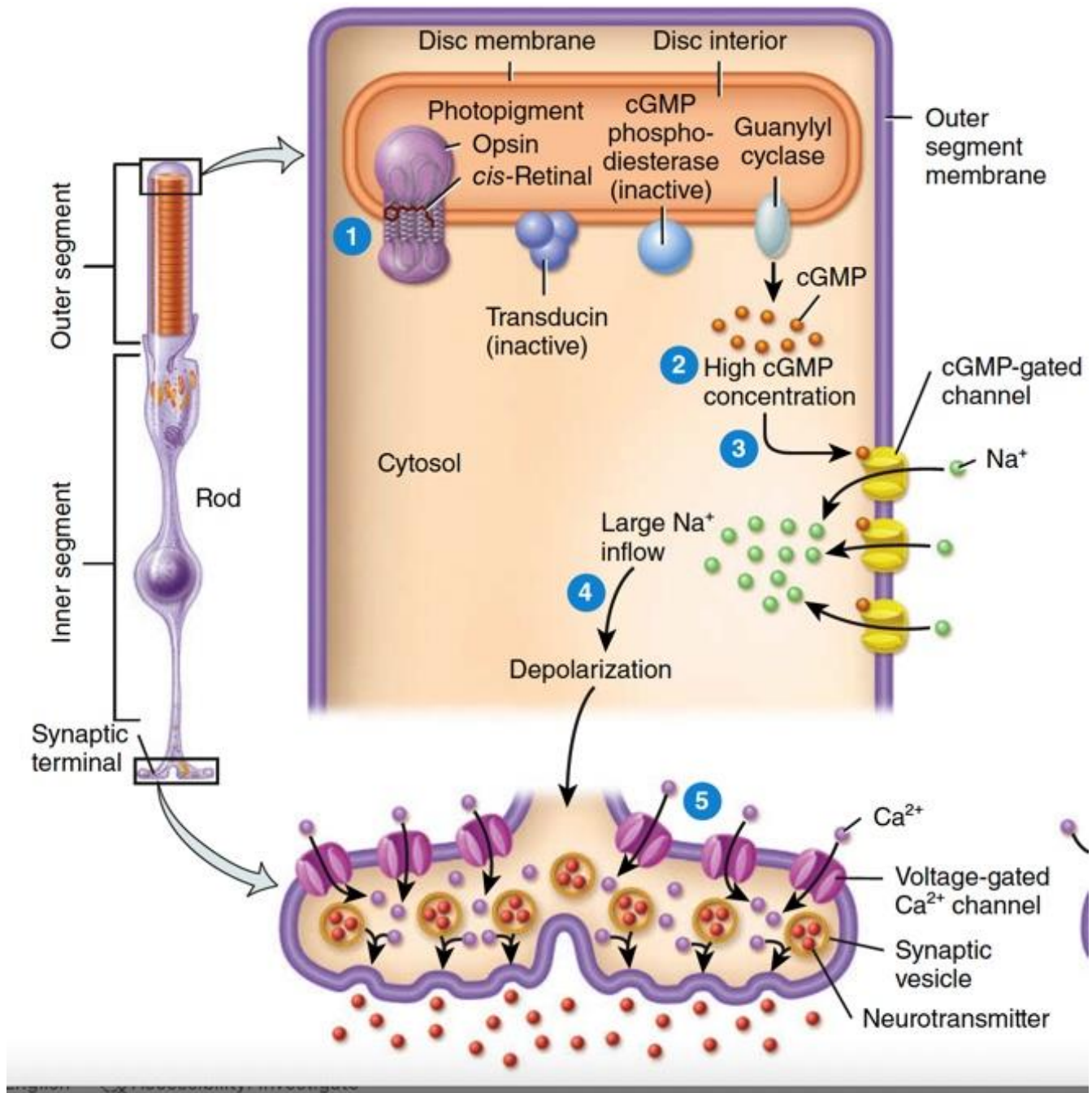


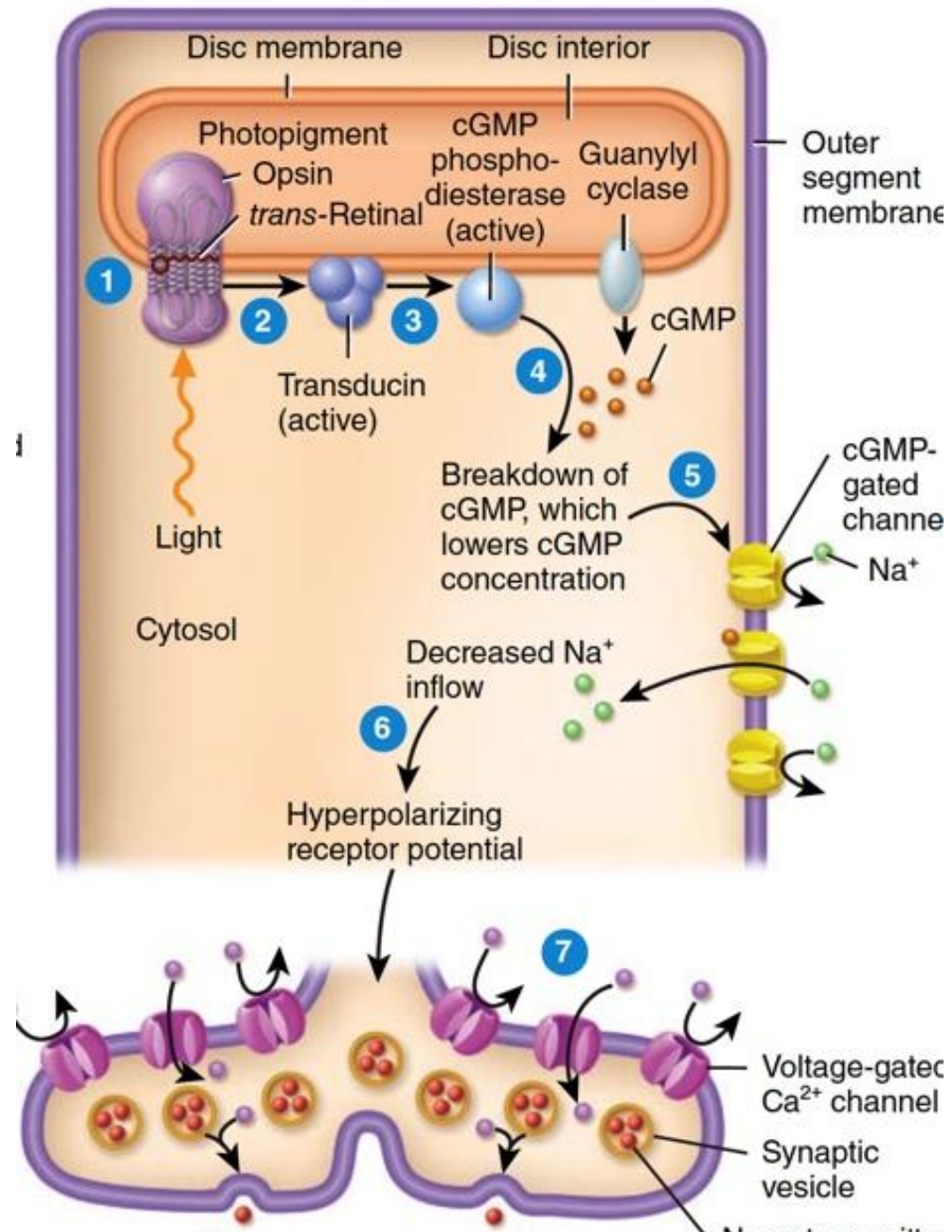
# Photoreceptors

- The inner segment of the rod or cone contains the usual cytoplasm, with cytoplasmic organelles. Especially important are the mitochondria, which play the important role of providing energy for function of the photoreceptors.
- The synaptic body is the portion of the rod or cone that connects with subsequent neuronal cells, the horizontal and bipolar cells, which represent the next stages in the vision chain.

# Photoreceptors

- Both rhodopsin and the color pigments are conjugated proteins. They are incorporated into the membranes of the discs in the form of transmembrane proteins.
- The concentrations of these photosensitive pigments in the discs are so great that the pigments themselves constitute about 40% of the entire mass of the outer segment.





# Photo-transduction

- The outer segment of the rod that projects into the pigment layer of the retina has light-sensitive pigment called rhodopsin.
- This substance is a combination of the protein scotopsin and the carotenoid pigment retinal.
- Furthermore, the retinal is a particular type called 11-cis retinal. This cis form of retinal is important because only this form can bind with scotopsin to synthesize rhodopsin.

- all-trans retinal no longer fits with the orientation of the reactive sites on the protein scotopsin, the all-trans retinal begins to pull away from the scotopsin.
- Several changes lead to the formation of metarhodopsin II, also called activated rhodopsin, that excites electrical changes in the rods.
- When light energy is absorbed by rhodopsin, the rhodopsin begins to decompose within a very small fraction of a second.

# Re-formation

- The first stage in re-formation of rhodopsin is to reconvert the all-trans retinal into 11-cis retinal.
- This process requires metabolic energy and is catalyzed by the enzyme retinal isomerase.
- Once the 11-cis retinal is formed, it automatically recombines with the scotopsin to re-form rhodopsin, which then remains stable until its decomposition is again triggered by absorption of light energy.

# Cones

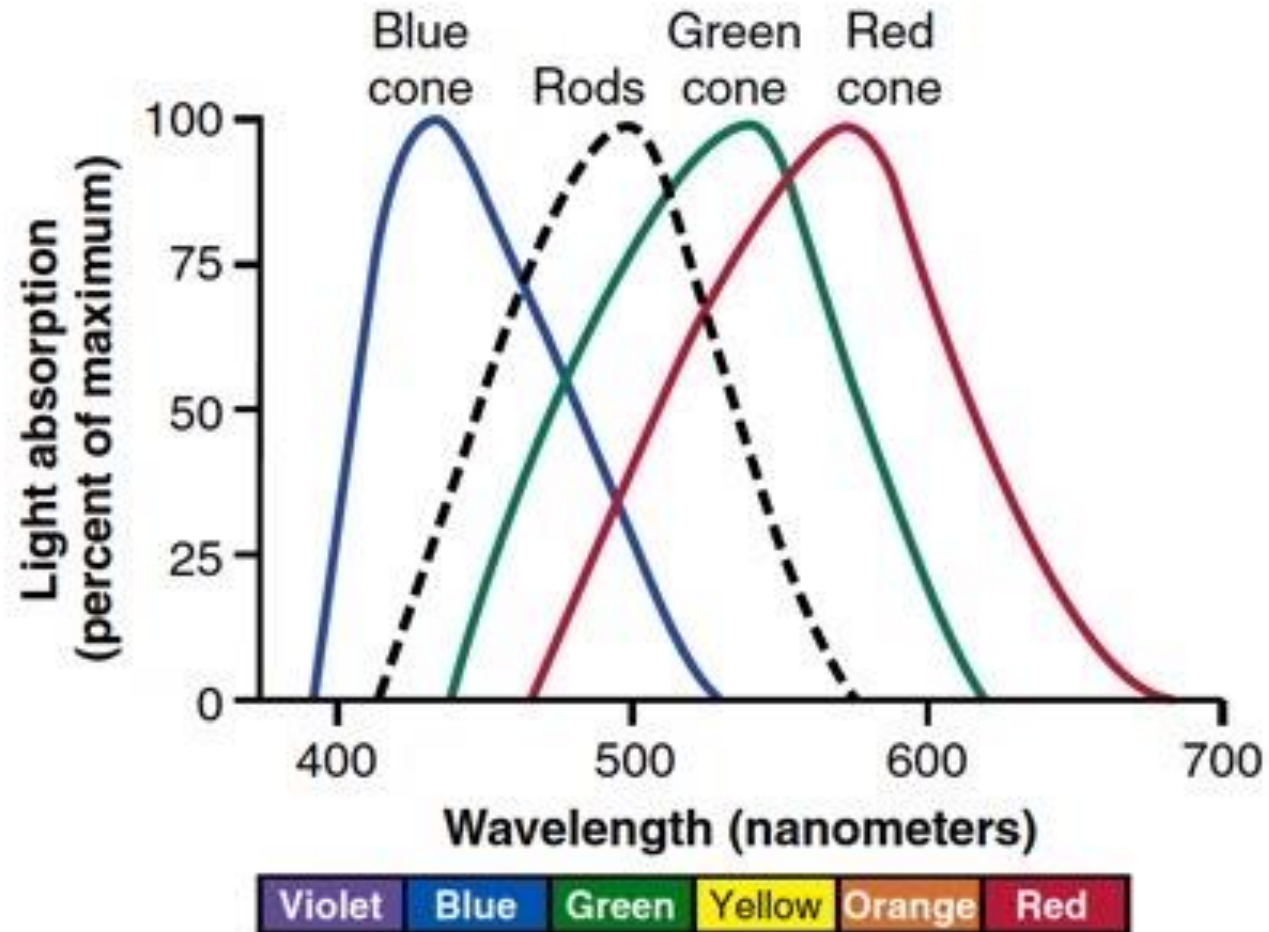
- photochemicals in the cones have almost exactly the same chemical composition as that of rhodopsin in the rods.
- The only difference is that the protein portions, or the opsins—called photopsins in the cones—are slightly different from the scotopsin of the rods.
- The retinal portion of all the visual pigments is exactly the same in the cones and rods.



# Color vision

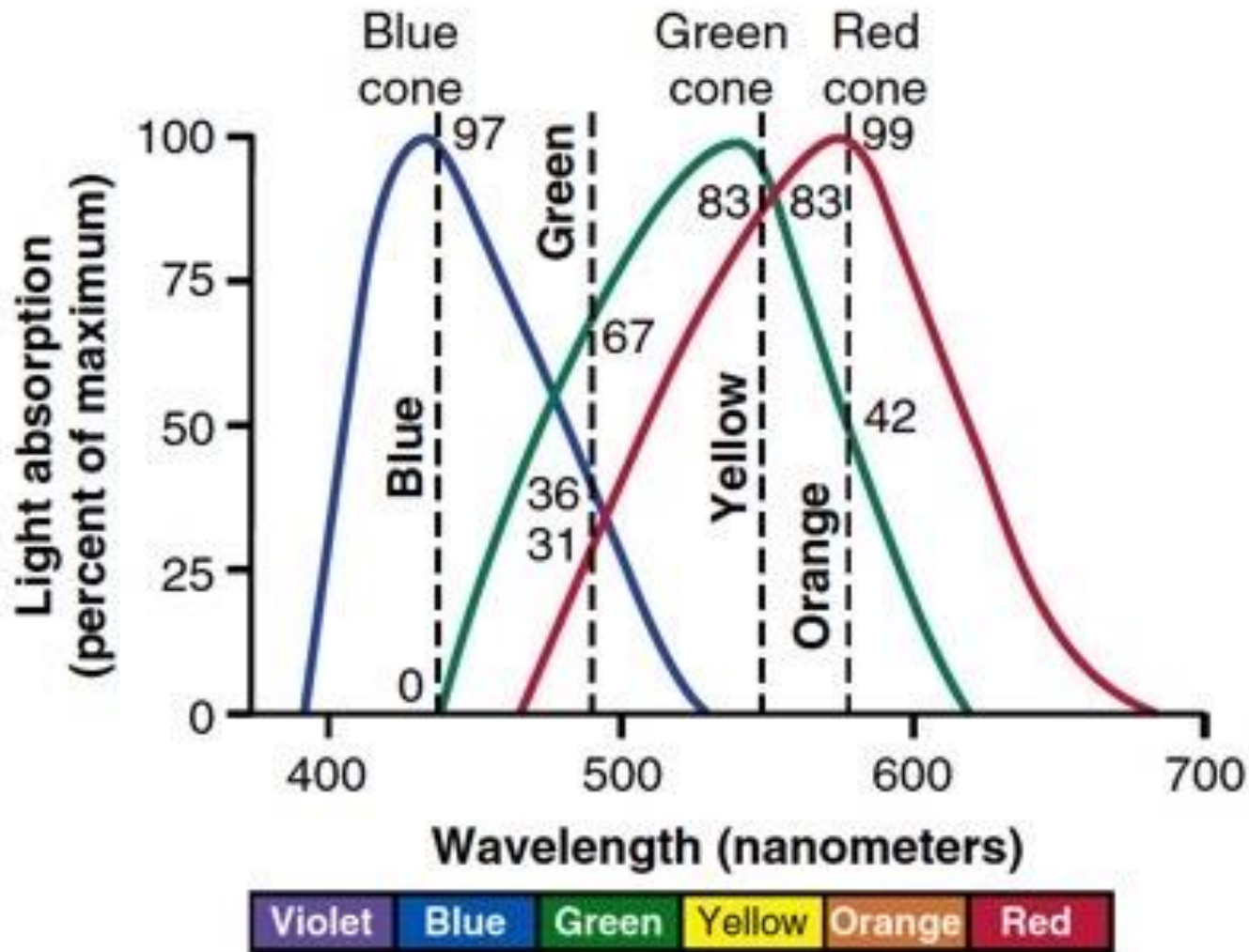
- Each photopigment maximally absorbs a particular wavelength but also absorbs a range of wavelengths shorter and longer than this peak absorption.
- The farther a wavelength is from the peak wavelength absorbed, the less strongly the photopigment responds.
- The absorption curves for the three cone types overlap so that two or three cones may respond to a given wavelength but to a different extent.

# Color vision



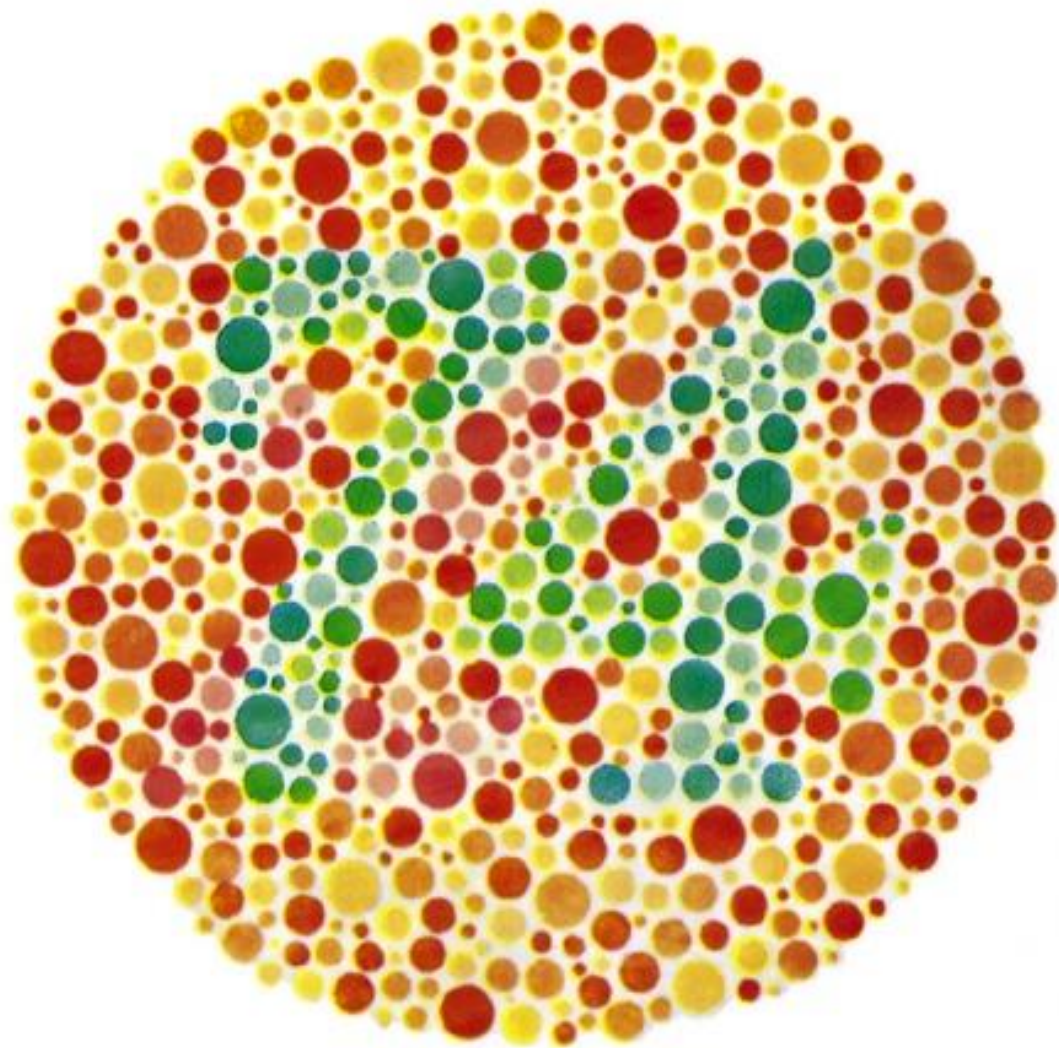
# Color vision

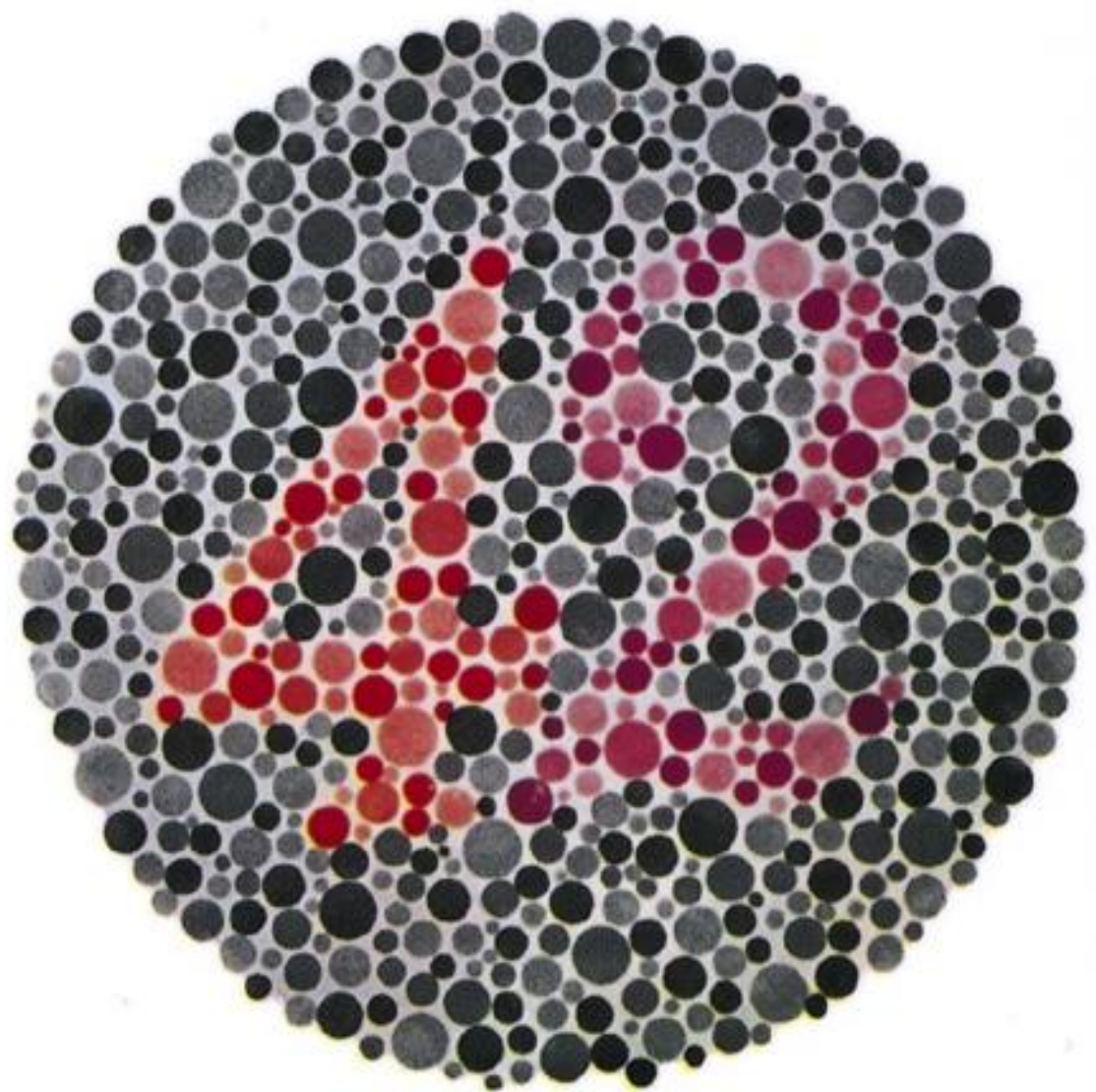
- Each cone type is most effectively activated by a particular wavelength of light in the range of color indicated by its name.
- cones also respond in varying degrees to other wavelengths.
- According to the trichromatic theory of color vision, the perception of the many colors of the world depends on the three cone types' various ratios of stimulation in response to different wavelengths.

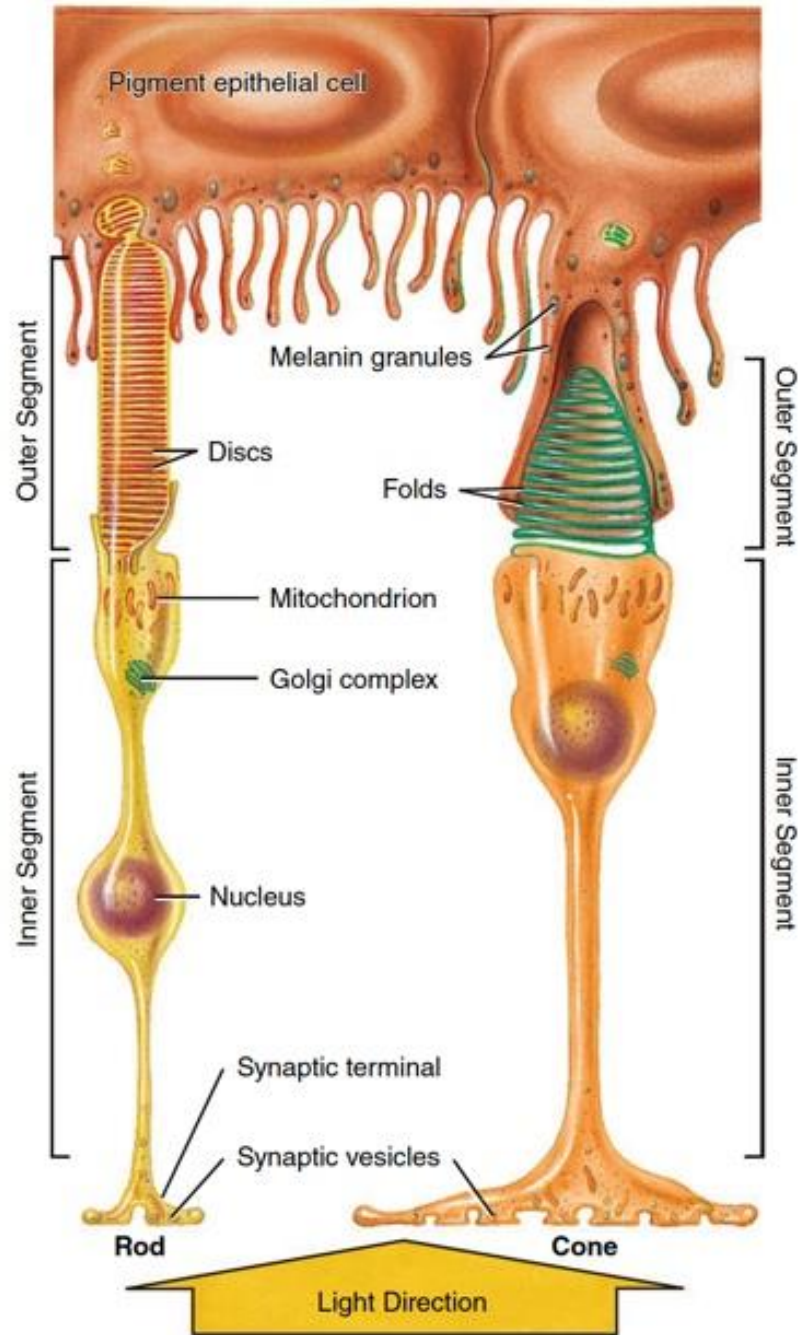


the ratios of stimulation of the three types of cones.

About equal stimulation of all the red, green, and blue cones gives one the sensation of seeing white.







Rods vs cones:

shape

location

number

sensitivity to light

visual acuity

color vision

<b>Photoreceptor</b>	<b>Sensitivity to Light</b>	<b>Acuity</b>	<b>Dark Adaptation</b>	<b>Color Vision</b>
Rods	Low threshold Sensitive to low-intensity light Night vision	Low acuity Not present on fovea	Adapt late	No
Cones	High threshold Sensitive to high-intensity light Day vision	High acuity Present on fovea	Adapt early	Yes



# Dark and light adaptation

- In the dark, the photopigments broken down during light exposure are gradually regenerated.
- As a result, the sensitivity of your eyes gradually increases so that you begin to see in the darkened surroundings.

# Dark and light adaptation

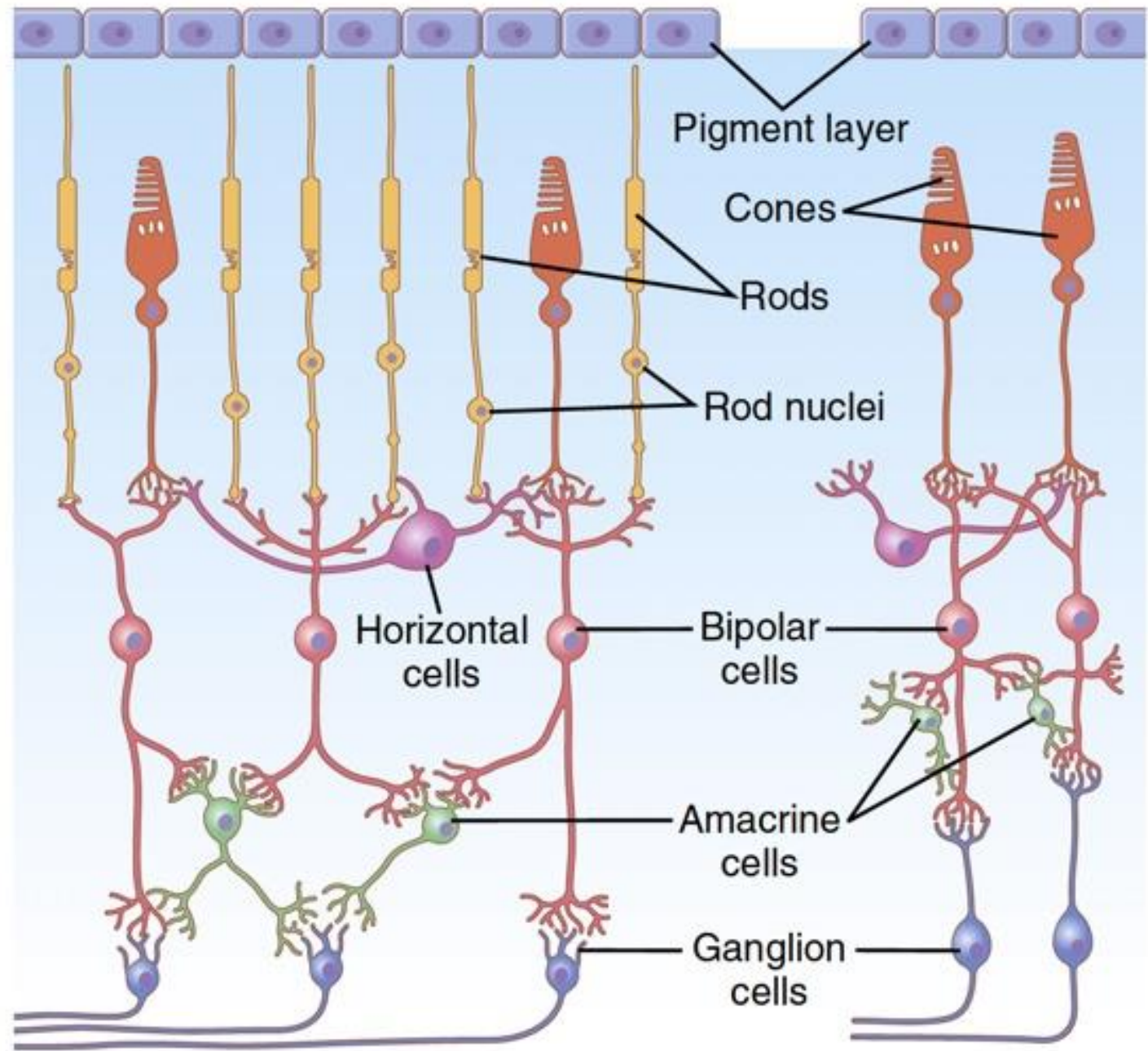
- Conversely, when you move from the dark to the light, at first your eyes are very sensitive to the dazzling light.
- As some of the photopigments are rapidly broken down by the intense light, the sensitivity of the eyes decreases and normal contrasts can again be detected, a process known as light adaptation.

# Night blindness

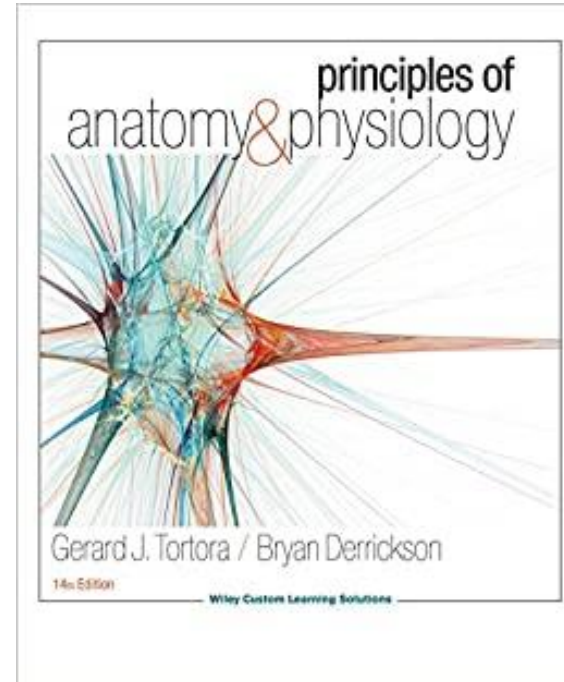
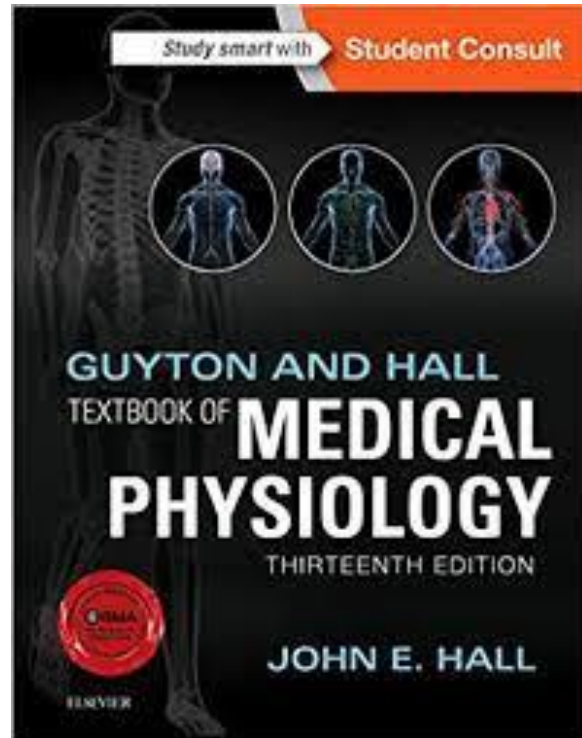
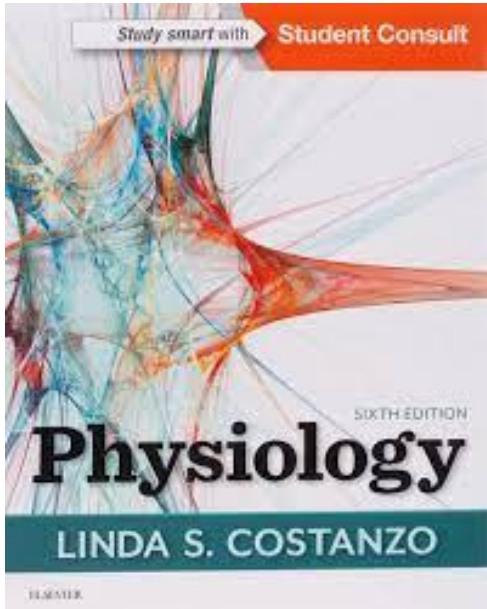
- Our eyes' sensitivity can change as much as 1 million times as they adjust to various levels of illumination through dark and light adaptation.
- Because retinal is a derivative of vitamin A, adequate amounts of this nutrient must be available for synthesis of photopigments.
- Night blindness occurs as a result of dietary deficiencies of vitamin A.

# Adaptation

- These adaptive measures are also enhanced by pupillary reflexes that adjust the amount of available light permitted to enter the eye.
- The other mechanism is neural adaptation, involving the neurons in the successive stages of the visual chain in the retina and in the brain.



# References



9<sup>TH</sup>  
Edition

## Human Physiology From Cells to Systems

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