

RECEPTOR AND NEURAL FUNTION OF THE RETINA

By

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Objectives

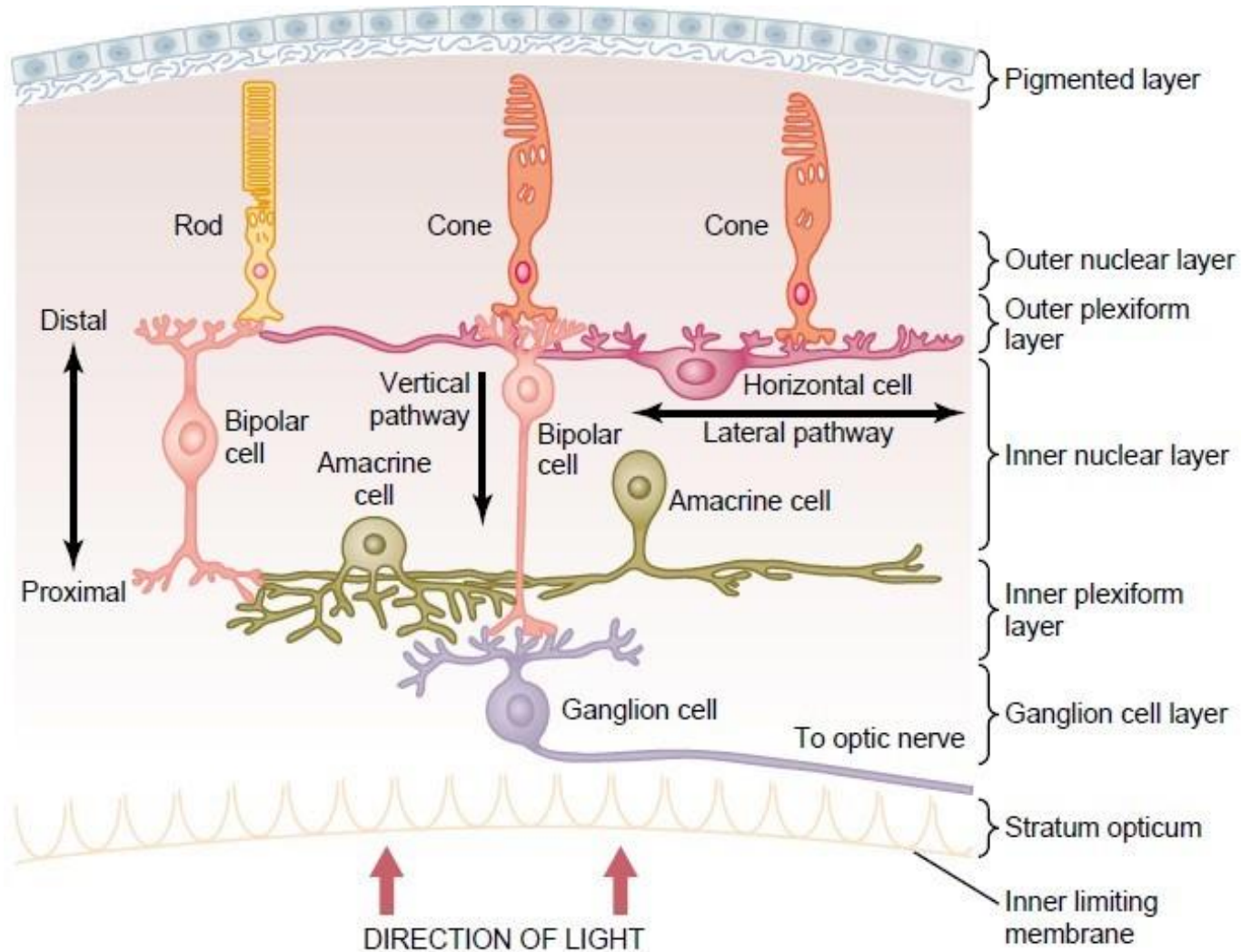
- Name the neuronal cells in retina
- Name the neuronal layers of retina
- Describe the physiological mechanism of neuronal transmission
- Through these cells
- Differentiate the functions of every cell layer in retina.

ANATOMY AND FUNCTION OF THE STRUCTURAL ELEMENTS OF THE RETINA

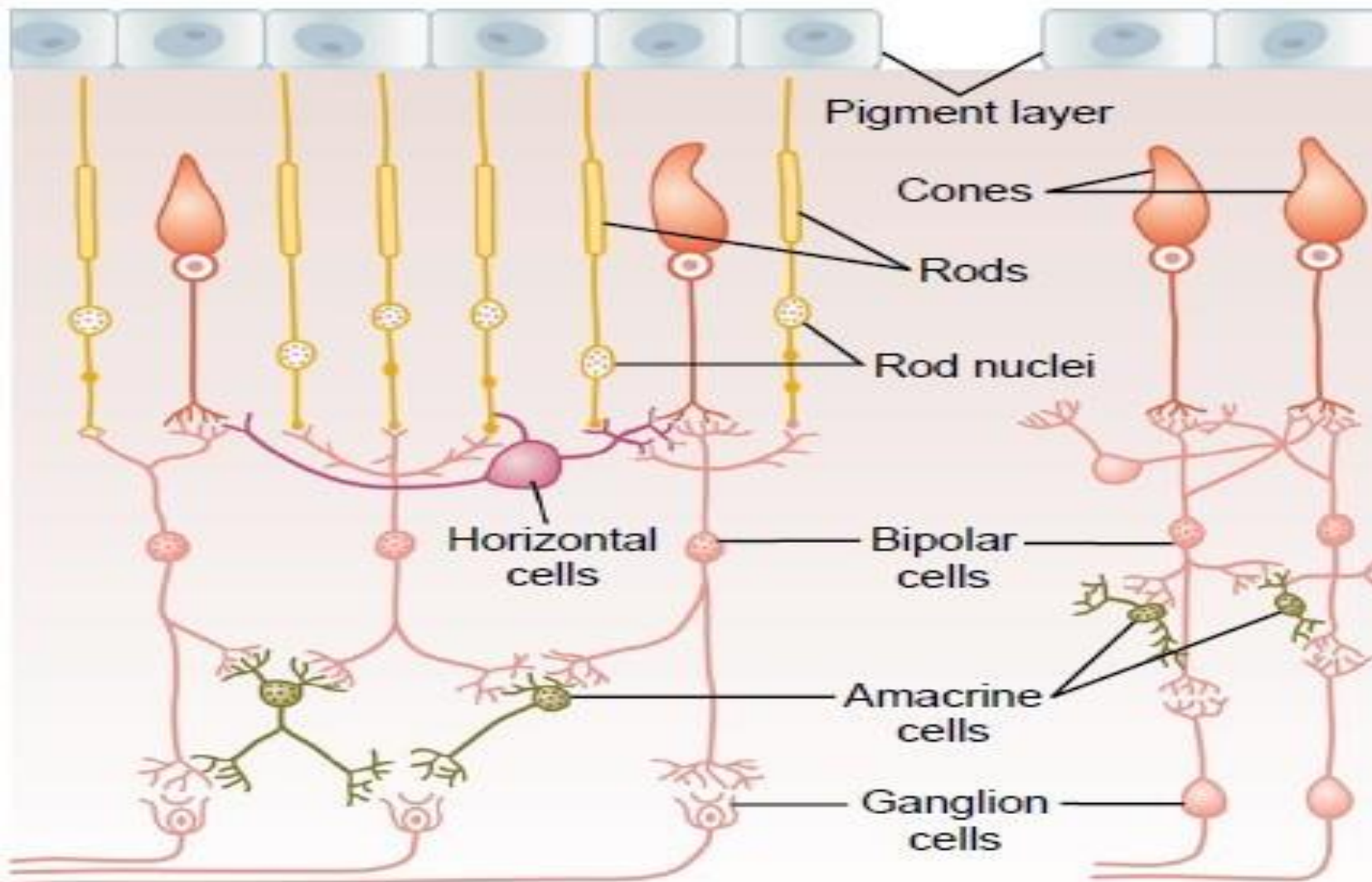
LAYERS OF RETINA

- 1 LAYER OF PIGMENT EPITHELIUM
- 2 LAYERS OF RODS AND CONES
- 3 EXTERNAL LIMITING MEMBRANE
- 4 OUTER NUCLEAR LAYER
- 5 OUTER PLEXIFORM LAYER
- 6 INNER NUCLEAR LAYER
- 7 INNER PLEXIFORM LAYER
- 8 GANGLION CELL LAYER

LAYERS OF RETINA



NEURAL ORGANIZATION OF THE RETINA



NUERONAL CELL TYPES

1. The photoreceptors themselves—the *rods and cones*—which transmit signals to the outer plexiform layer, where they synapse with bipolar cells and horizontal cells
2. The *horizontal cells*, which transmit signals horizontally in the outer plexiform layer from the rods and cones to bipolar cells
3. The *bipolar cells*, which transmit signals vertically from the rods, cones, and horizontal cells to the inner plexiform layer, where they synapse with ganglion cells and amacrine cells
4. The *amacrine cells*, which transmit signals in two directions, either directly from bipolar cells to ganglion cells or horizontally within the inner plexiform layer from axons of the bipolar cells to dendrites of the ganglion cells or to other amacrine cells
5. The *ganglion cells*, which transmit output signals from the retina through the optic nerve into the brain

NEUROTRANSMITTERS RELEASED BY RETINAL NEURONS.

- Cones release *glutamate* at their synapses with the bipolar cells.
- Amacrine cells secreting;
 - *gamma-aminobutyric acid*
 - *glycine*
 - *dopamine*
 - *Acetylcholine and*
 - *indolamine*

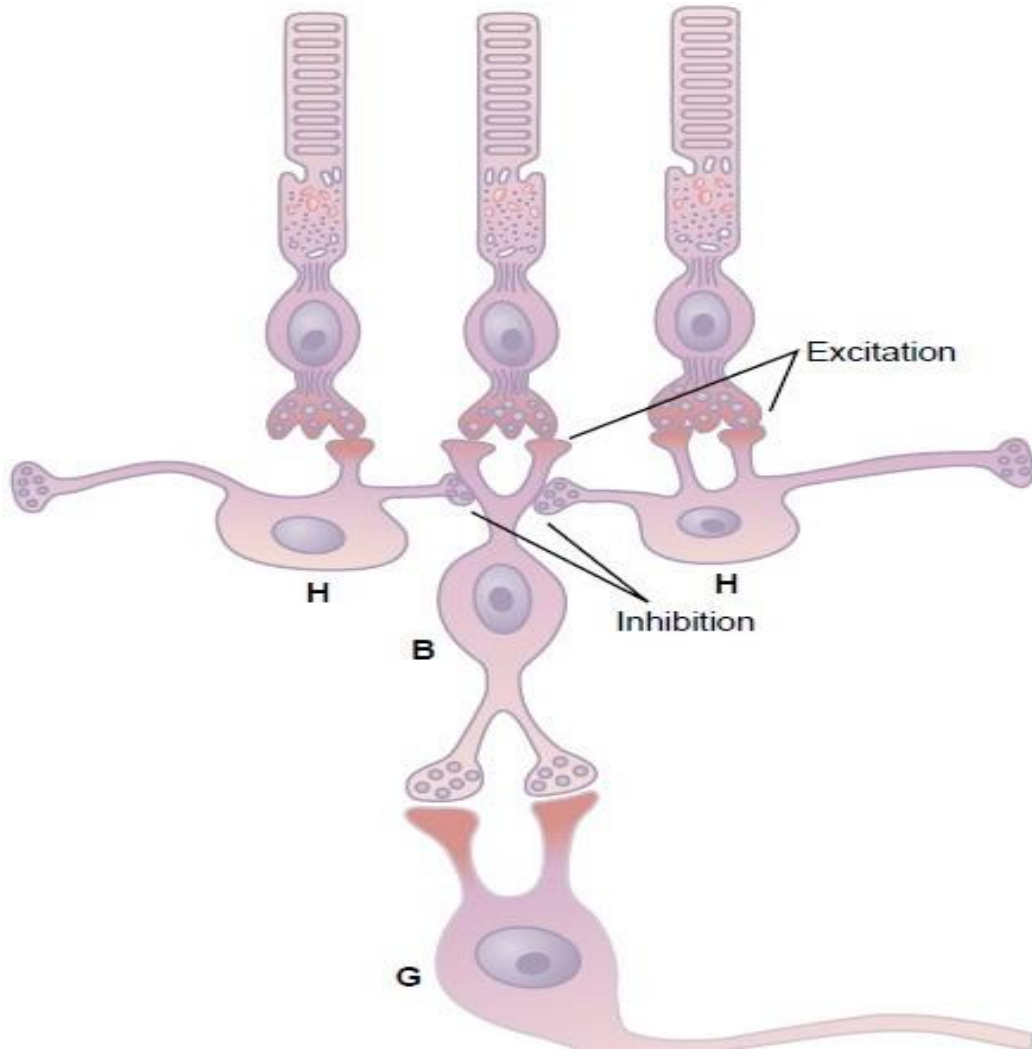
all of which normally function as inhibitory transmitters.

LATERAL INHIBITION TO ENHANCE VISUAL CONTRAST—FUNCTION OF THE HORIZONTAL CELLS

Horizontal cells connect laterally between the synaptic bodies of the rods and cones, as well as connecting with the dendrites of the bipolar cells. The outputs of the horizontal cells *are always inhibitory*.

Two types of bipolar cells

- Provide opposing excitatory and inhibitory signals in the visual pathway:
- the *depolarizing bipolar cell* and
- the *hyperpolarizing bipolar cell*.
- That is, some bipolar cells depolarize when the rods and cones are excited, and others hyperpolarize when they are inhibited.



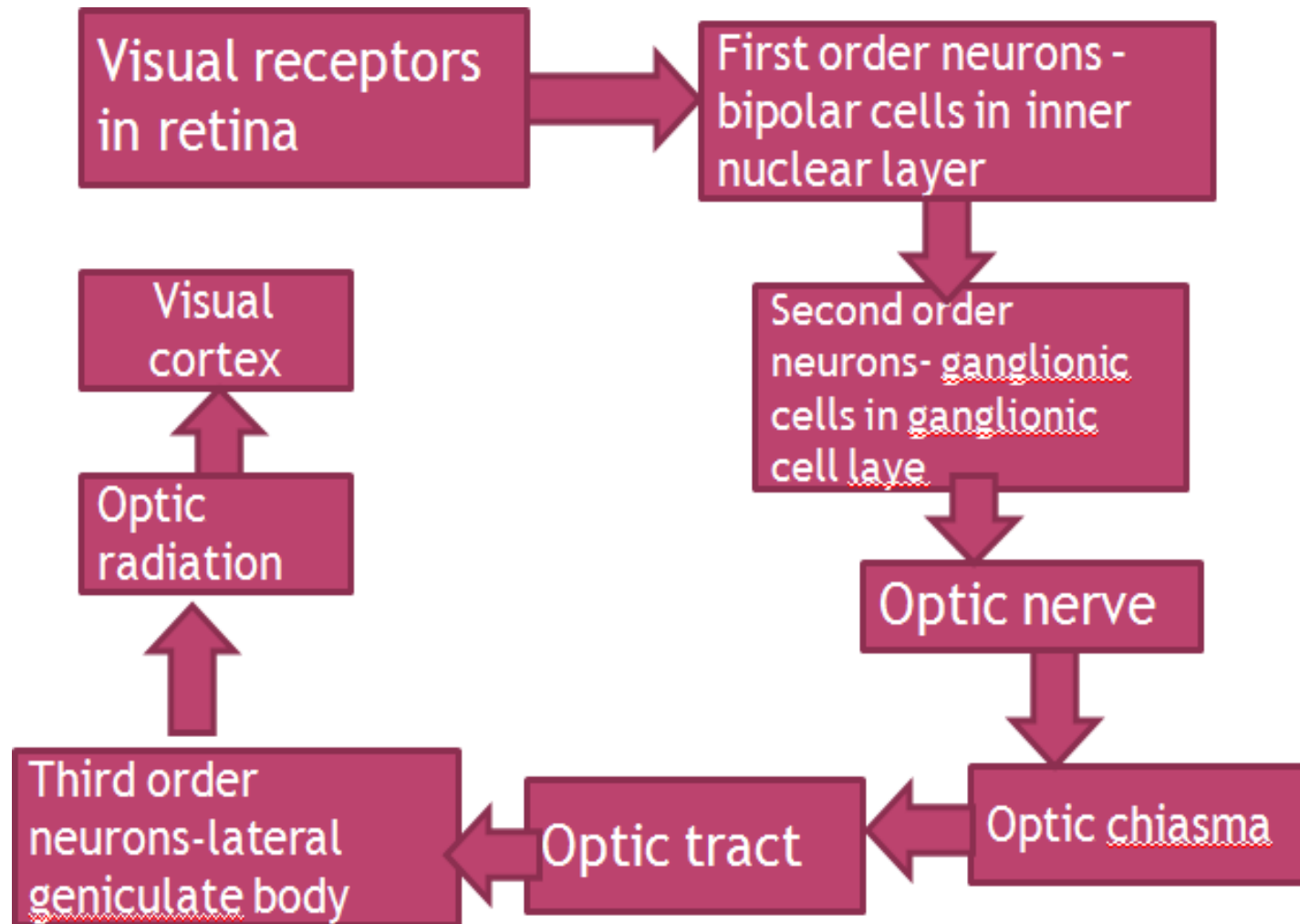
AMACRINE CELLS AND THEIR FUNCTIONS

- **Amacrine cell** responds strongly at the onset of a continuing visual signal, but the response dies rapidly.
- Respond strongly at the offset of visual signals.
- Respond when a light is turned either on or off, signalling simply a change in illumination.
- Responds to movement of a spot across the retina in a specific direction; therefore, these amacrine cells are said to be *directional sensitive*.

THREE TYPES OF RETINAL GANGLION CELLS AND THEIR RESPECTIVE FIELDS

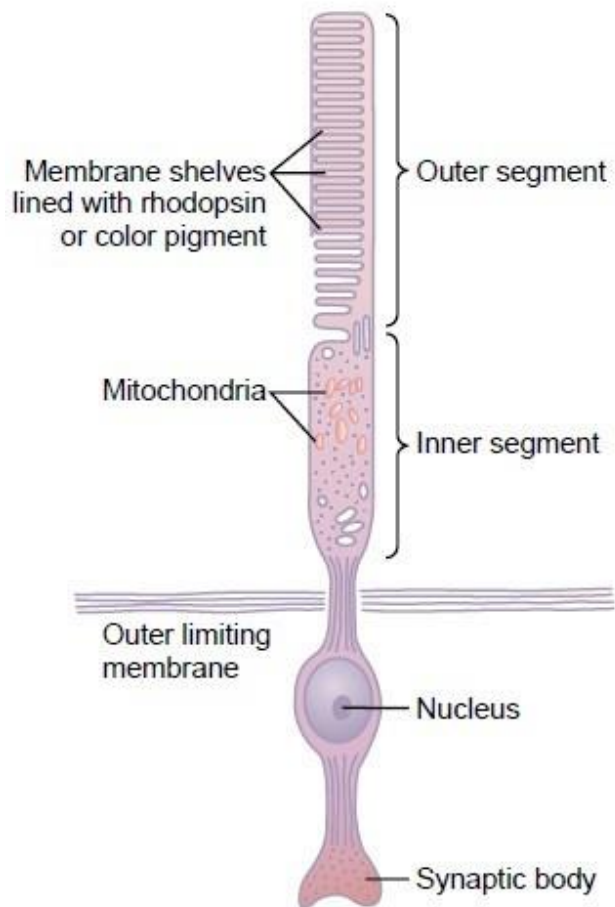
1. **W cell**- These ganglion cells receive most of their excitation from rods, transmitted by way of small bipolar cells and amacrine cells.
2. **X cell**- Have small fields because their dendrites do not spread widely in the retina, so their signals represent discrete retinal locations. Therefore, it is mainly through the X cells that the fine details of the visual image are transmitted.
3. **Y cell**- transmit their signals to the brain at 50 m/sec or faster. They are the least numerous of all the ganglion cells, representing only 5 per cent of the total. Also, they have broad dendritic fields, so that signals are picked up by these cells from widespread retinal areas.

SCHEMATIC REPRESENTATION OF VISUAL PATHWAYS



RODS AND CONES

- The outer segment which are light-sensitive photochemical.
 - a. Rhodopsin- occur in the rod cell of the retina which are responsible for vision in poor light.
 - b. Color pigment- occur in cones, that function almost exactly the same as rhodopsin except for differences in spectral sensitivity.
- The inner segment of the rod or cone contains cytoplasmic organelles. Particularly important are the mitochondria; 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



Functional parts of the rods and cones

1. Outer segment
2. Inner segment
3. Nucleus
4. Synaptic body

BLOOD SUPPLY OF THE RETINA

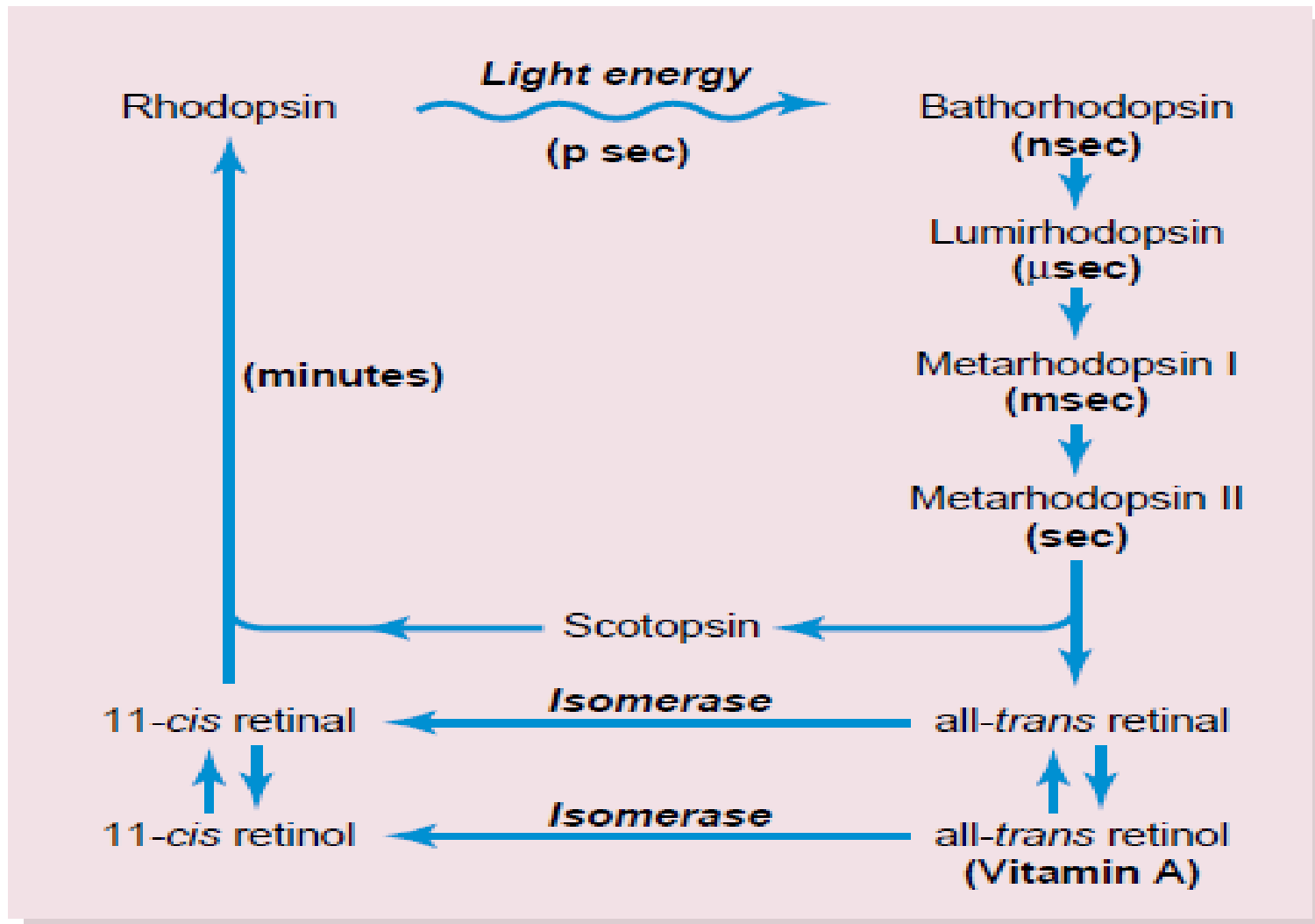
1. Central retinal artery

- supply for the internal layers of the retina is derived from the central retinal artery, which enters the eyeball through the center of the optic nerve and then divides *to supply the entire inside retinal surface.*

2. Choroid artery

- Supply highly vascular tissue lying between the retina and the sclera. The outer layers of the retina, especially the outer segments of the rods and cones, depend mainly on diffusion from the choroid blood vessels for their nutrition, especially for their oxygen.

RHODOPSIN-RETINAL VISUAL CYCLE, AND EXCITATION OF THE RODS



Rhodopsin and Its Decomposition by Light Energy.

When light energy is absorbed by rhodopsin, the Rhodopsin -----

bathorhodopsin,

lumirhodopsin.

metarhodopsin I,

metarhodopsin II,

scotopsin and all-trans retinal. metarhodopsin II, also called *activated rhodopsin*, that excites electrical changes in the rods, and the rods then transmit the visual image into the central nervous system in the form of optic nerve action potential.

ROLE OF VITAMIN A

- Vitamin A is present both in the cytoplasm of the rods and in the pigment layer of the retina.
- Role in the physiologic mechanism of vision, rhodopsin occur in the rod cells of the retina, which are responsible for vision in poor light.
- Large quantities of vitamin A are normally stored in the liver and can be made available to the eyes to avoid night blindness to occur

MECHANISM BY WHICH RHODOPSIN DECOMPOSITION DECREASES MEMBRANE SODIUM CONDUCTANCE—THE EXCITATION “CASCADE.”

- 1. The *photon activates an electron* in the 11-*cis* retinal portion of the rhodopsin; this leads to the formation of *metarhodopsin II*, which is the active form of rhodopsin.
- 2. The *activated rhodopsin* functions as an enzyme to activate many molecules of *transducin*, a protein present in an inactive form in the membranes of the discs and cell membrane of the rod.
- 3. The *activated transducin* activates many more molecules of *phosphodiesterase*.

- 4. *Activated phosphodiesterase* is another enzyme; it immediately hydrolyzes many molecules of *cyclic guanosine monophosphate (cGMP)*, thus destroying it. Before being destroyed, the cGMP had been bound with the sodium channel protein of the rod's outer membrane in a way that “splints” it in the open state.
- 5. Within about a second, another enzyme, *rhodopsin kinase*, which is always present in the rod, inactivates the activated rhodopsin (the metarhodopsin II), and the entire cascade reverses back to the normal state with open sodium channels

AUTOMATIC REGULATION OF RETINAL SENSITIVITY—LIGHT AND DARK ADAPTATION

- ***light adaptation.*** *Reduced* photosensitive chemicals remaining in the rods and cones and reduced sensitivity of the eye to light.
- ***dark adaptation.*** *Conversely*, if a person remains in darkness for a long time, the retinal and opsins in the rods and cones are converted back into the light-sensitive pigments.

COLOR VISION

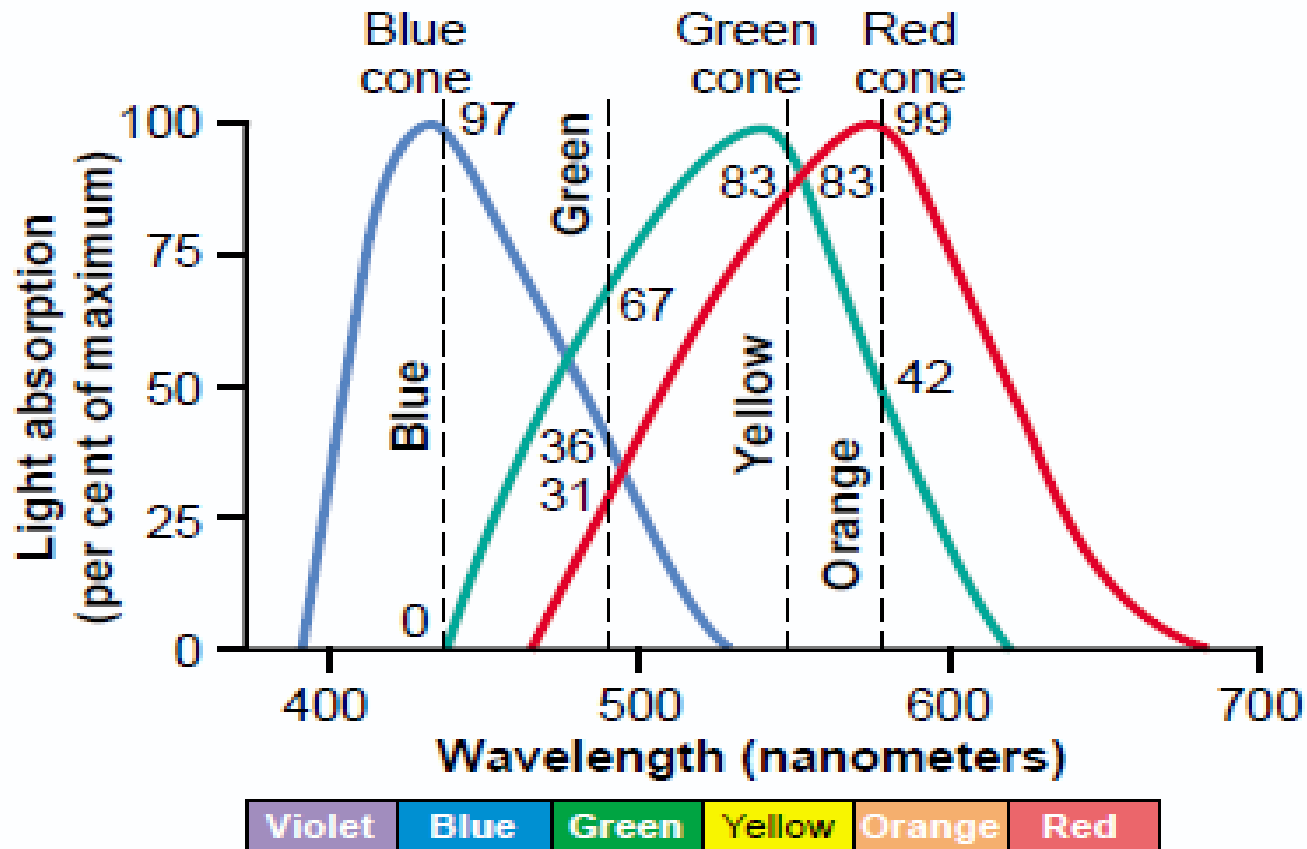
❑ Tricolor Mechanism of Color Detection

- Human eye can detect almost all gradations of colors when only *red, green, and blue* monochromatic lights are appropriately mixed in different combinations.

❑ Interpretation of Color in the Nervous System.

- ❑ light with a wavelength of 580 nanometers stimulates the red cones to a stimulus value of about 99 (99 per cent of the peak stimulation at optimum wavelength); it stimulates the green cones to a stimulus value of about 42, but the blue cones not at all. Thus, the ratios of stimulation of the three types of cones in this instance are 99:42:0.

DEMONSTRATION OF THE DEGREE OF STIMULATION OF THE DIFFERENT COLOR SENSITIVE CONES BY MONOCHROMATIC LIGHTS





THANKS