Special sense

By

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Olfaction

- Olfaction is a sense of smell.

- Olfactory epithelium is the organ of smell *not the nose*. Which is thin sheet of cells high up in the nasal cavity.

- Size of the olfactory epithelium is proportionate to olfactory acuity, Man has 10 cm^2 while dog has 170 cm^2, Dogs also have 100 times receptors per cm^2 more than man.

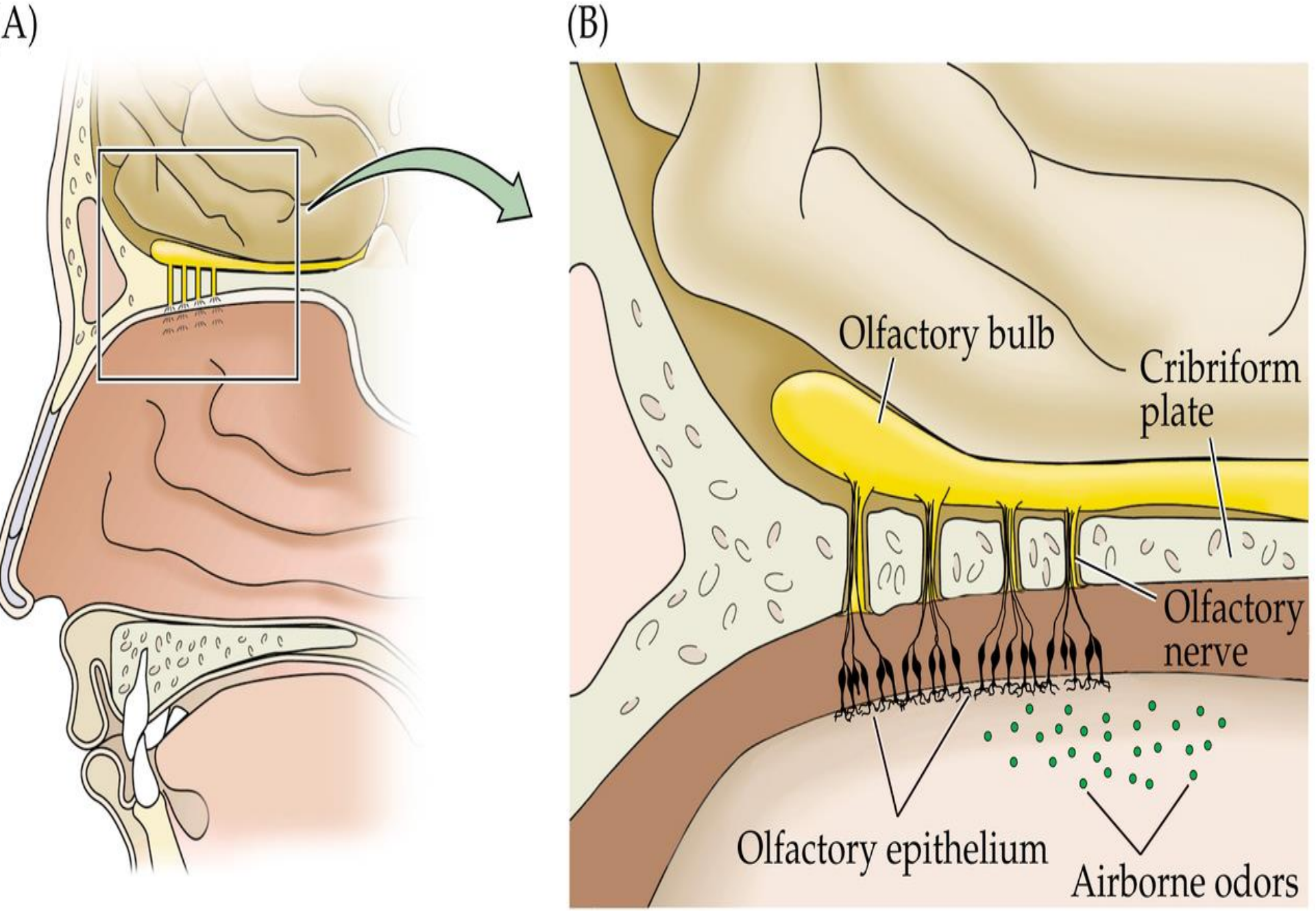
Olfactory Pathway

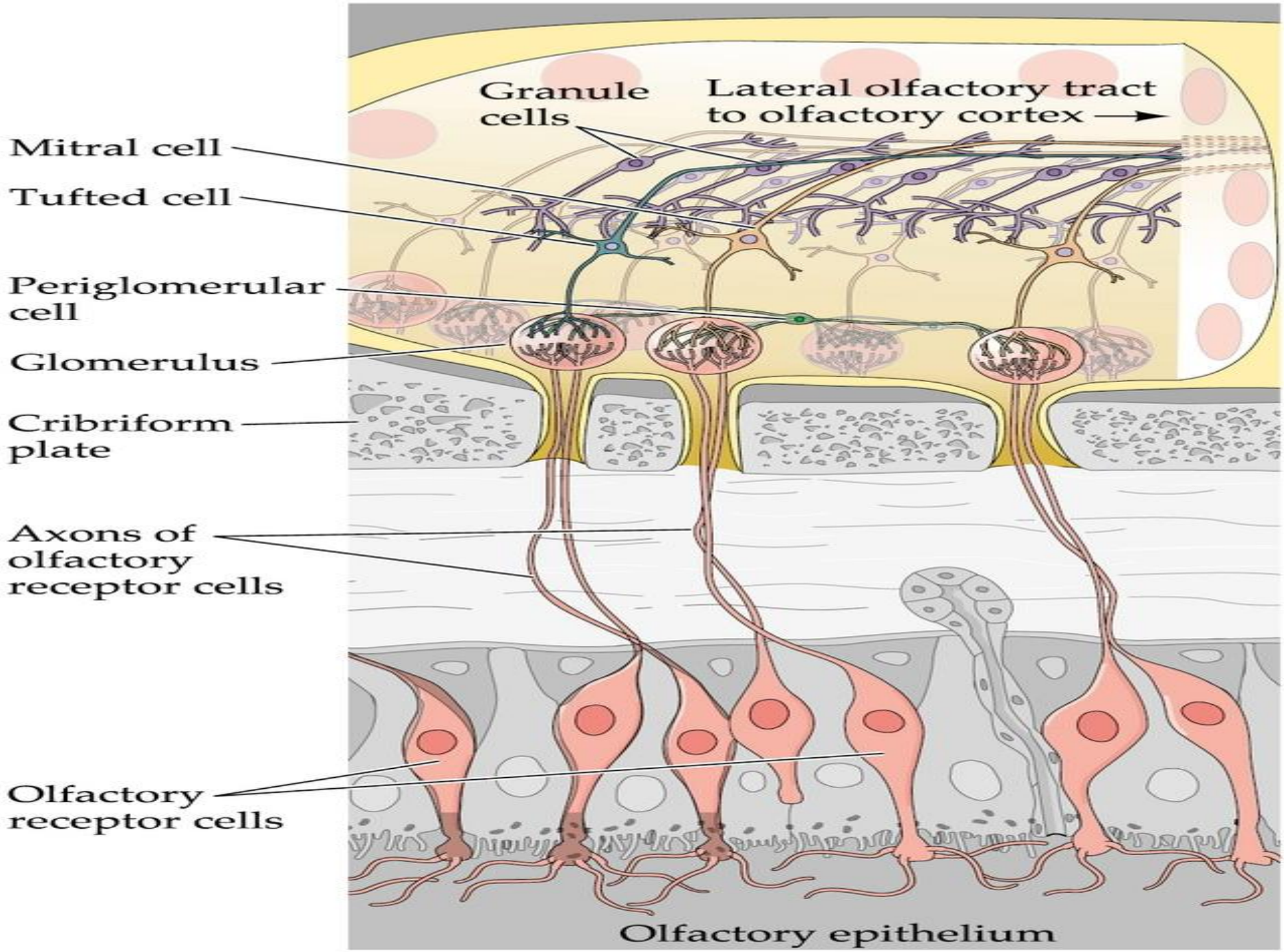
Olfactory receptor cell axons leave the olfactory epithelium, collected to form the olfactory nerve (cranial nerve I) which run directly into the olfactory bulb.

In the olfactory bulb, there is a primary synapses between the olfactory receptor axons and mitral cells

Axons of the mitral cells form a bundle known as the lateral olfactory tract which projects primarily to the pyriform cortex.

Pyramidal cells in the pyriform cortex in turn project to the thalamus, neocortical regions, the hippocampus and the amygdala


(A)
(B)
Olfactory bulb
Cribriform plate
Olfactory nerve
Olfactory epithelium
Airborne odors


Granule cells
Lateral olfactory tract to olfactory cortex
Mitral cell
Tufted cell
Periglomerular cell
Glomerulus
Cribriform plate
Axons of olfactory receptor cells
Olfactory receptor cells
Olfactory epithelium

- Olfactory receptors are the only neurons in the nervous system that are replaced regularly (every 4-8 weeks) throughout life.

- Ends of the olfactory receptors are water soluble which contains cells of the immune system and is shed every ten minutes (individual with an infection like cold, flu, etc. has a runny nose where mucus is shed more frequently to protect the olfactory receptors from infection).


Vision
Just Ahead

VISION:

processes in which light energy is transduced into neural activity (Phototransduction) and the neural activity is processed by the brain .

Light entering the eye is focused on the retina which converts light energy into neuronal activity.

Axons of the retinal neurons are bundled to form the optic nerves and, visual information is distributed to several brain structures that perform different functions

Structures of eye

a. Pupil: Opening that allows light to reach the retina

b. Iris: Circular muscle that controls the diameter of the pupil

c. Aqueous humor: Fluid behind the cornea

d. Sclera: Outermost layer that forms the eyeball

e. Extraocular muscles: Attached to the eye and skull and allow movement

f. Conjunctiva: Membrane inside the eyelid attached to the sclera

g. Optic nerve: Axons of the retina leaving the eye

h. Cornea: Transparent surface covering the iris and pupil

i. Optic disk (blind spot): area of no vision due to that blood vessels originate here, also optic nerve fiberes exit here and no photoreceptors are present.

j. Macula: Area of the retina responsible for central vision

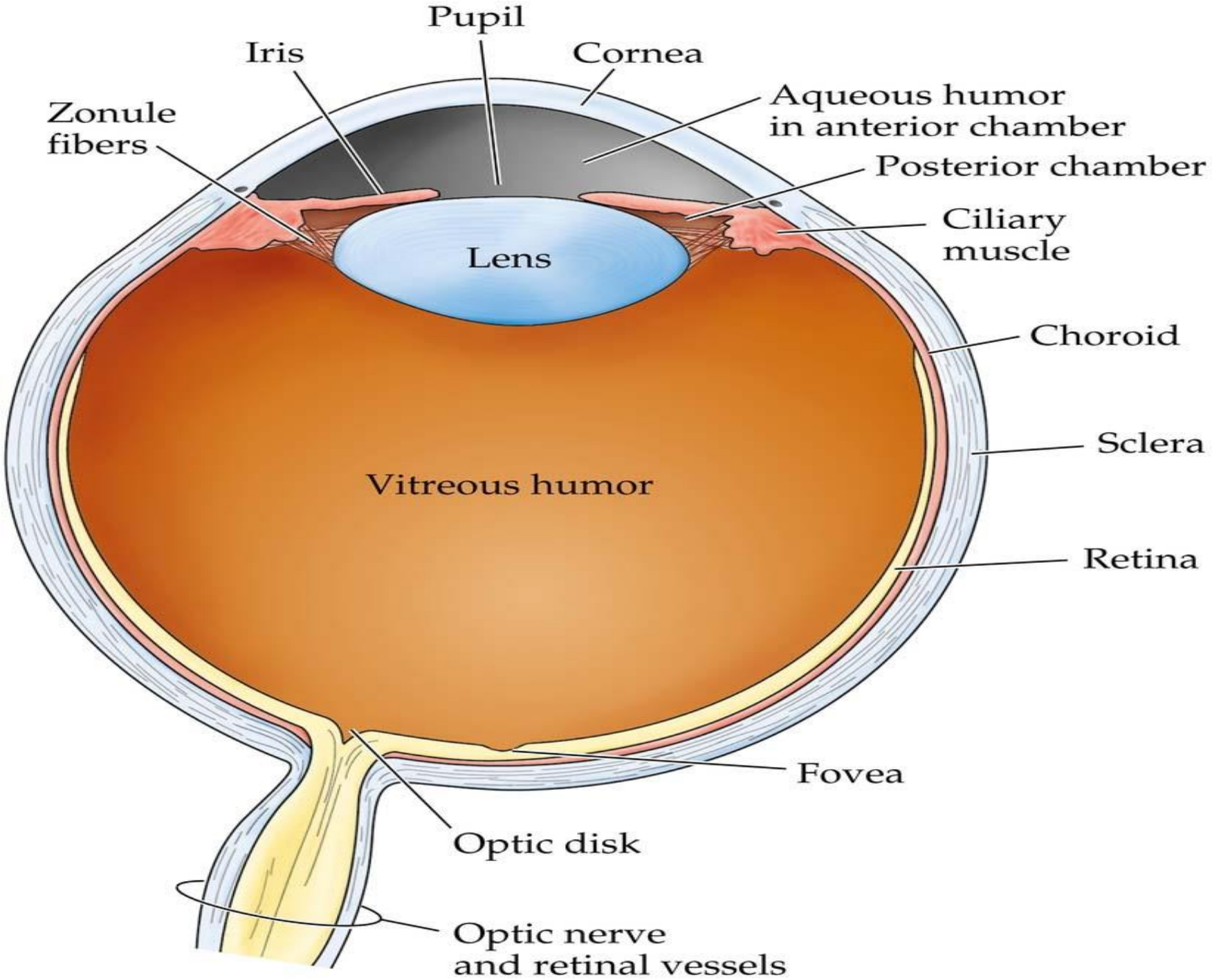
k. Fovea: Center of the retina (where most of the cones are)

l. Lens: Transparent stracture that contributes to the formation of images by refraction the light and focuses it on retina

m. Ciliary muscles: Attached to lens and change its shape and allow focusing

n. Vitreous humor: Liquid which is more viscous than the aqueous humor. It lies between the lens and the retina and provides the spherical shape of the eye.

o. Retina: Is the inner most layer, at the back of the eye. It transduces light energy into neural activity


Pupil
Iris
Cornea
Zonule fibers
Aqueous humor in anterior chamber
Posterior chamber
Ciliary muscle
Lens
Choroid
Sclera
Vitreous humor
Retina
Fovea
Optic disk
Optic nerve and retinal vessels

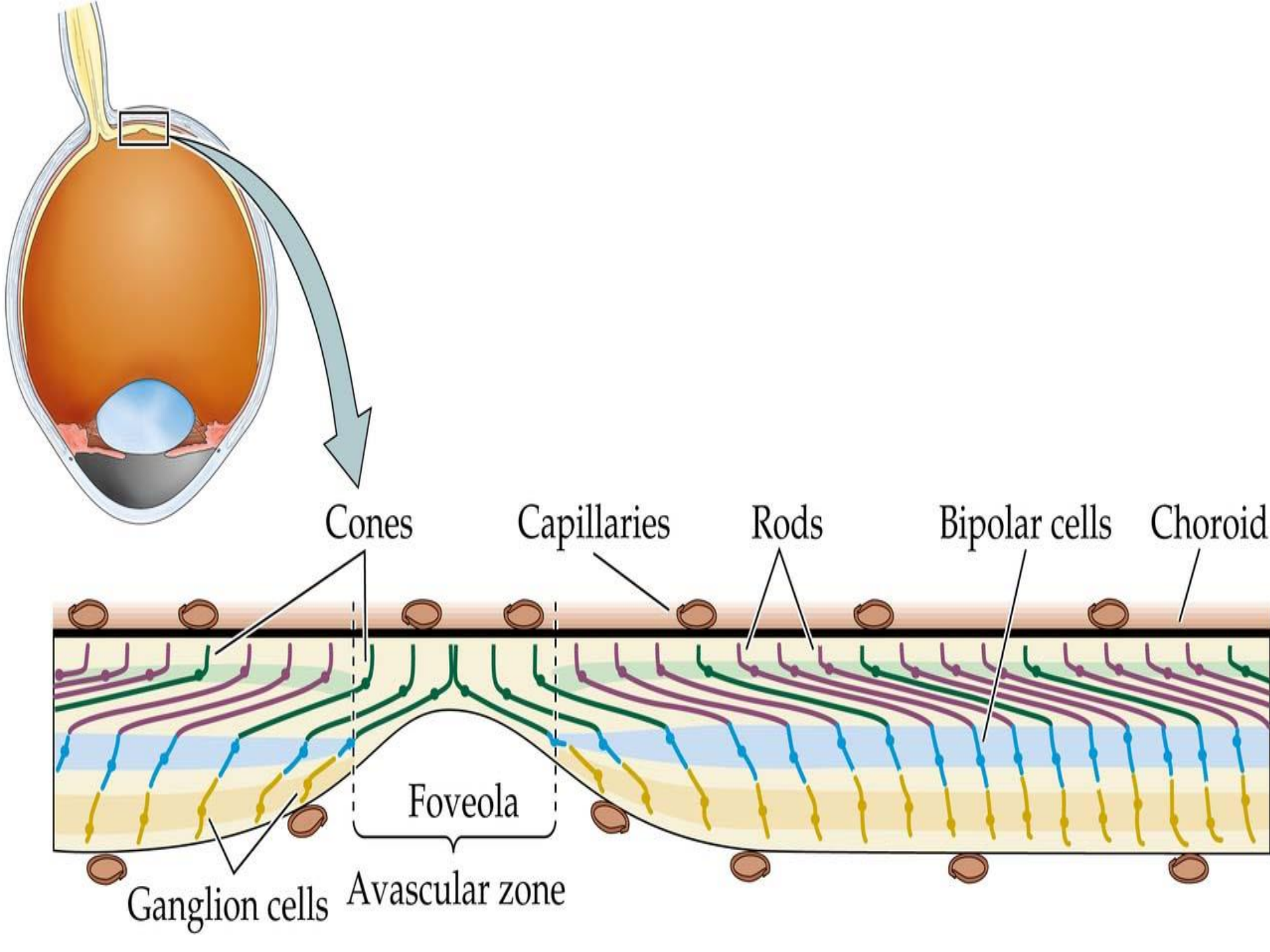

Cones
Capillaries
Rods
Bipolar cells
Choroid
Foveola
Avascular zone
Ganglion cells

Image Formation

Image formed on the retina is reversed and inverted.
From distant objects, light rays run in parallel and they slow down as they cross the cornea and aqueous humor.

- Light rays bend perpendicular to the tangent of the corneal curvature to run as the radii of the cornea.

- The lens adds refractive power provided by changing its shape, becomes rounded with greater curvature .
- Contraction of ciliary muscles causes the tension on the suspensory ligaments to release . ⟶ Round lens

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The Eye is a camera

The human eye is a camera!

- **Iris** - colored annulus with radial muscles
- **Pupil** - the hole (aperture) whose size is controlled by the iris
- What's the "film"?
  - photoreceptor cells (rods and cones) in the **retina**

Clinical view

Emmetropia (normal vision)

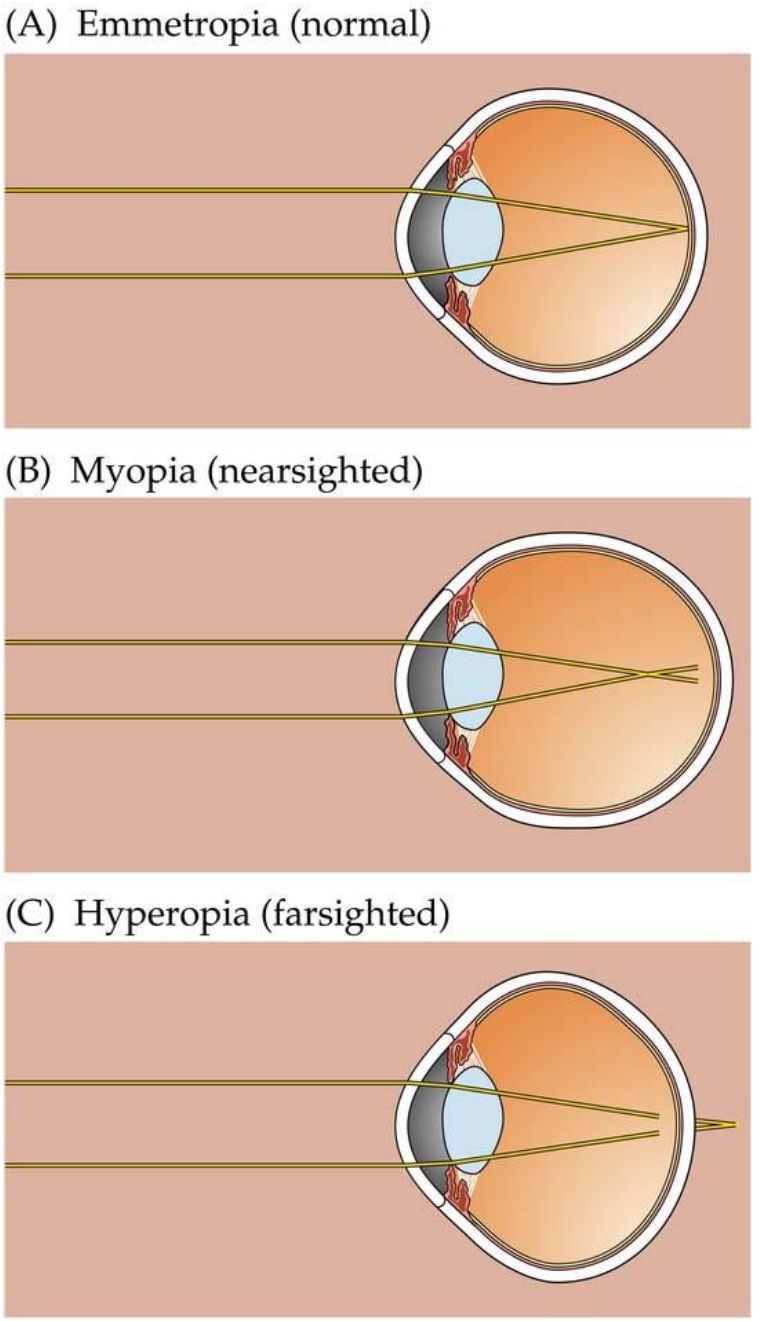
Parallel light rays are focused on the retina without accommodation

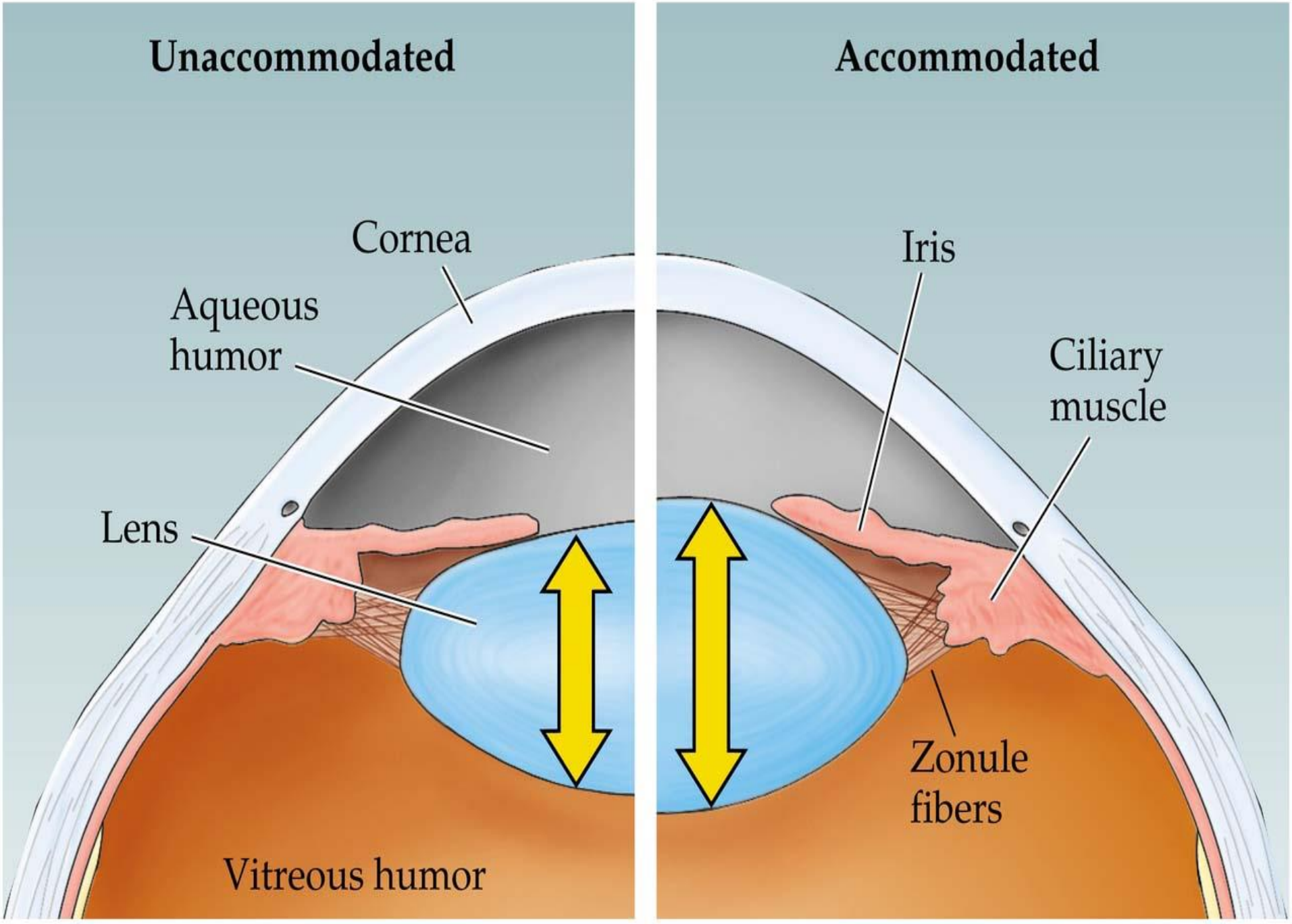
Myopia (nearsightedness)

Eye ball is too long. Light rays converge in front of the retina. Lens can accommodate for near objects but not distant. Condition can be corrected with a concave lens

Hyperopia (farsightedness)

Eye ball is too short. Image is focused at a point behind the retina. Lens can accommodate for distant objects but not for near. Condition can be corrected with a convex lens (to increase refractive power)




Unaccommodated
Accommodated
Cornea
Aqueous humor
Lens
Vitreous humor
Iris
Ciliary muscle
Zonule fibers

Layers of the Retina.

from the outside to the inside as follows:

(1) pigmented layer,

(2) layer of rods and cones projecting to the pigment,

(3) outer nuclear layer containing the cell bodies of the rods and cones,

(4) outer plexiform layer,

(5) Inner nuclear layer,

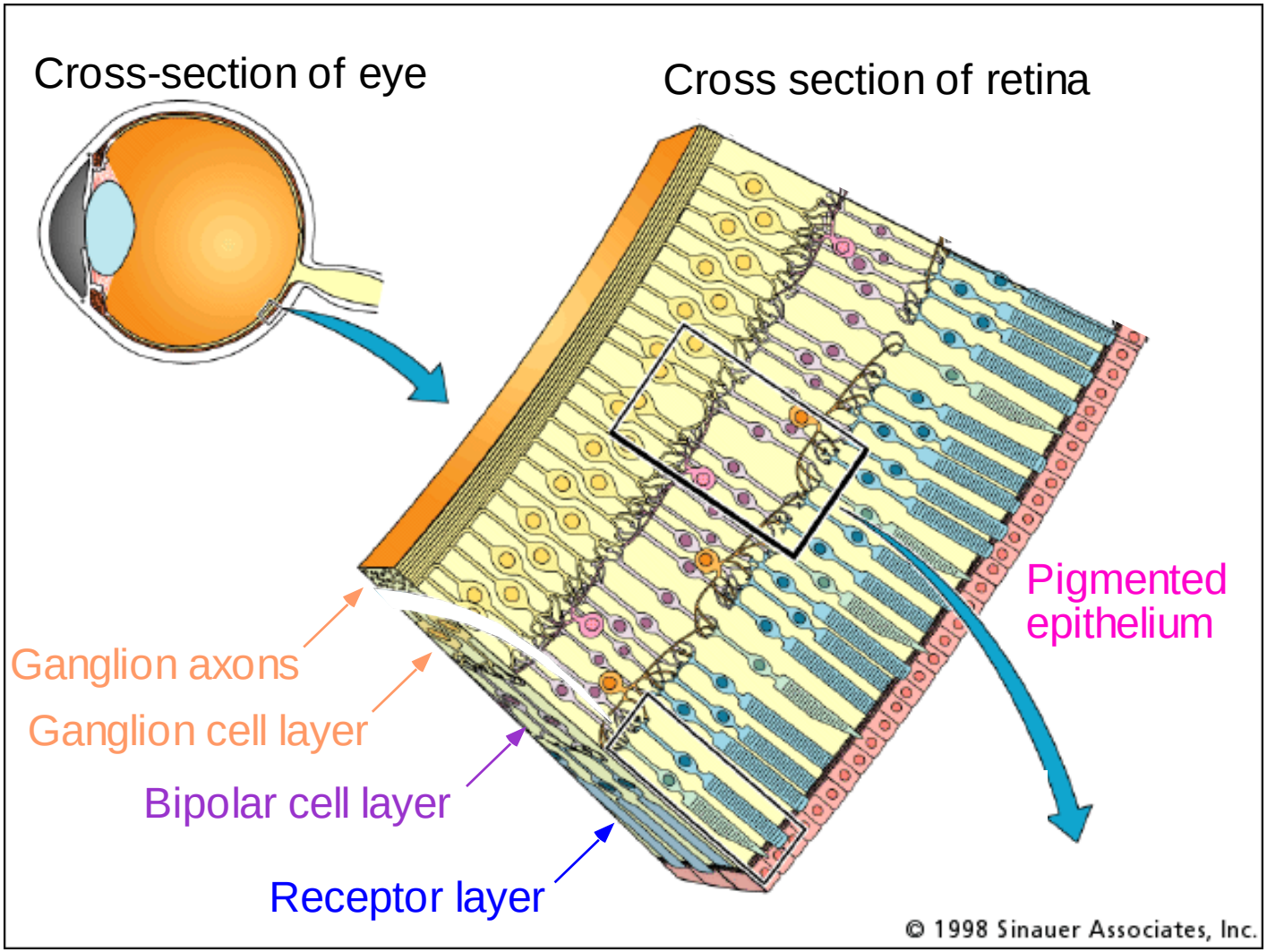
(6) inner plexiform layer,

(7) ganglionic layer,

(8) layer of optic nerve fibers, and

(9) inner limiting membrane.

The Retina


Cross-section of eye
Cross section of retina
Pigmented epithelium
Ganglion axons
Ganglion cell layer
Bipolar cell layer
Receptor layer
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Cell types in retina:

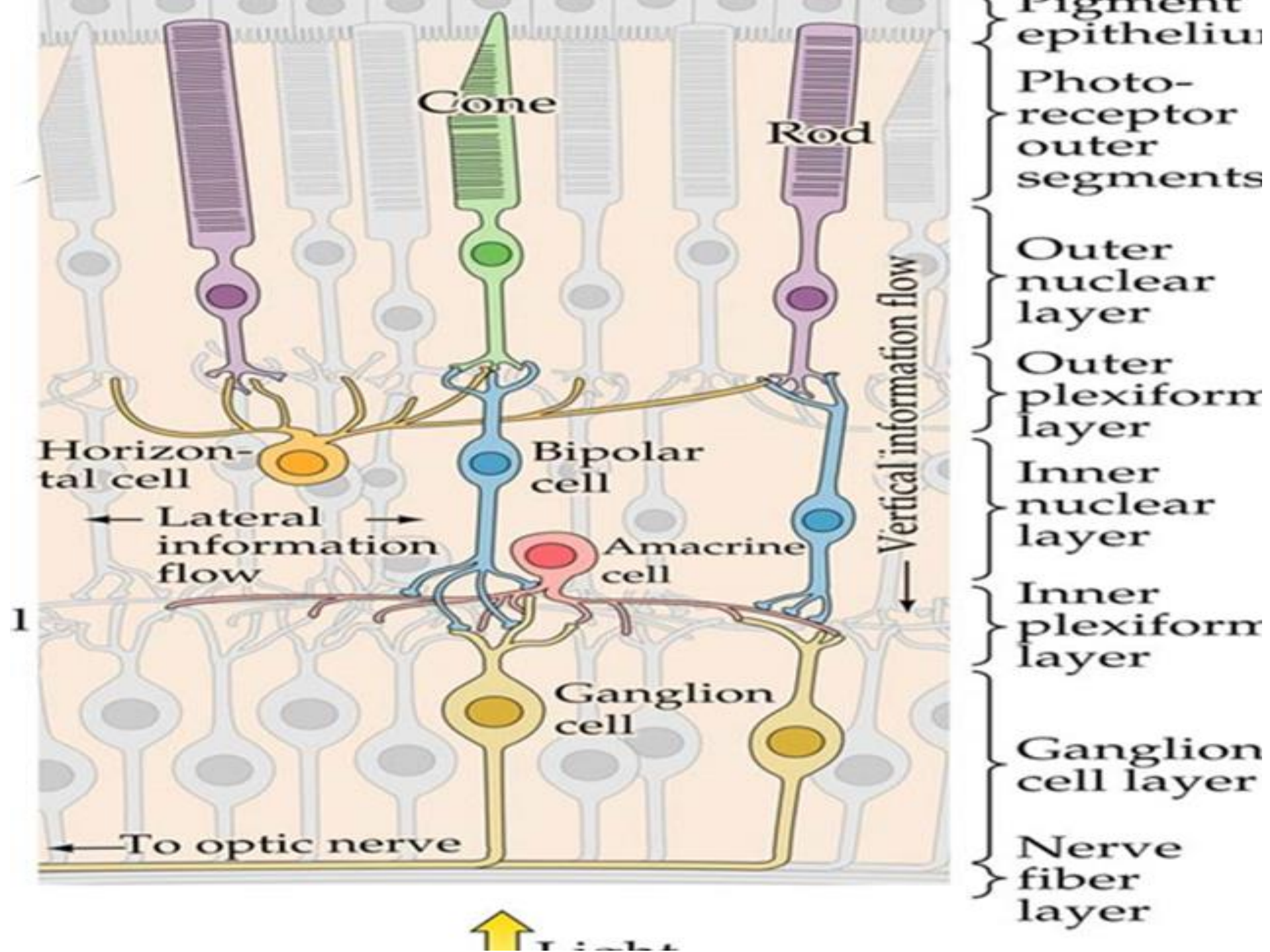
1-Photoreceptors: Are the only light sensitive cells in the retina (rod , cone).

2-Bipolar cells: Connect photoreceptors to ganglion cells

3-Ganglion cells: Fire action potential and send signals to the brain. They are the only output cells

4-Horizontal cells: Receive inputs from photoreceptors and project laterally to bipolar cells

5-Amacrine cells: Receive inputs from bipolar cells and project laterally to ganglion cells


Cone
Rod
Horizon-
tal cell
Bipolar
cell
Lateral
information
flow
Amacrine
cell
Vertical information flow
Ganglion
cell
To optic nerve
Light
Pigment
epitheliu
Photo-
receptor
outer
segments
Outer
nuclear
layer
Outer
plexiform
layer
Inner
nuclear
layer
Inner
plexiform
layer
Ganglion
cell layer
Nerve
fiber
layer

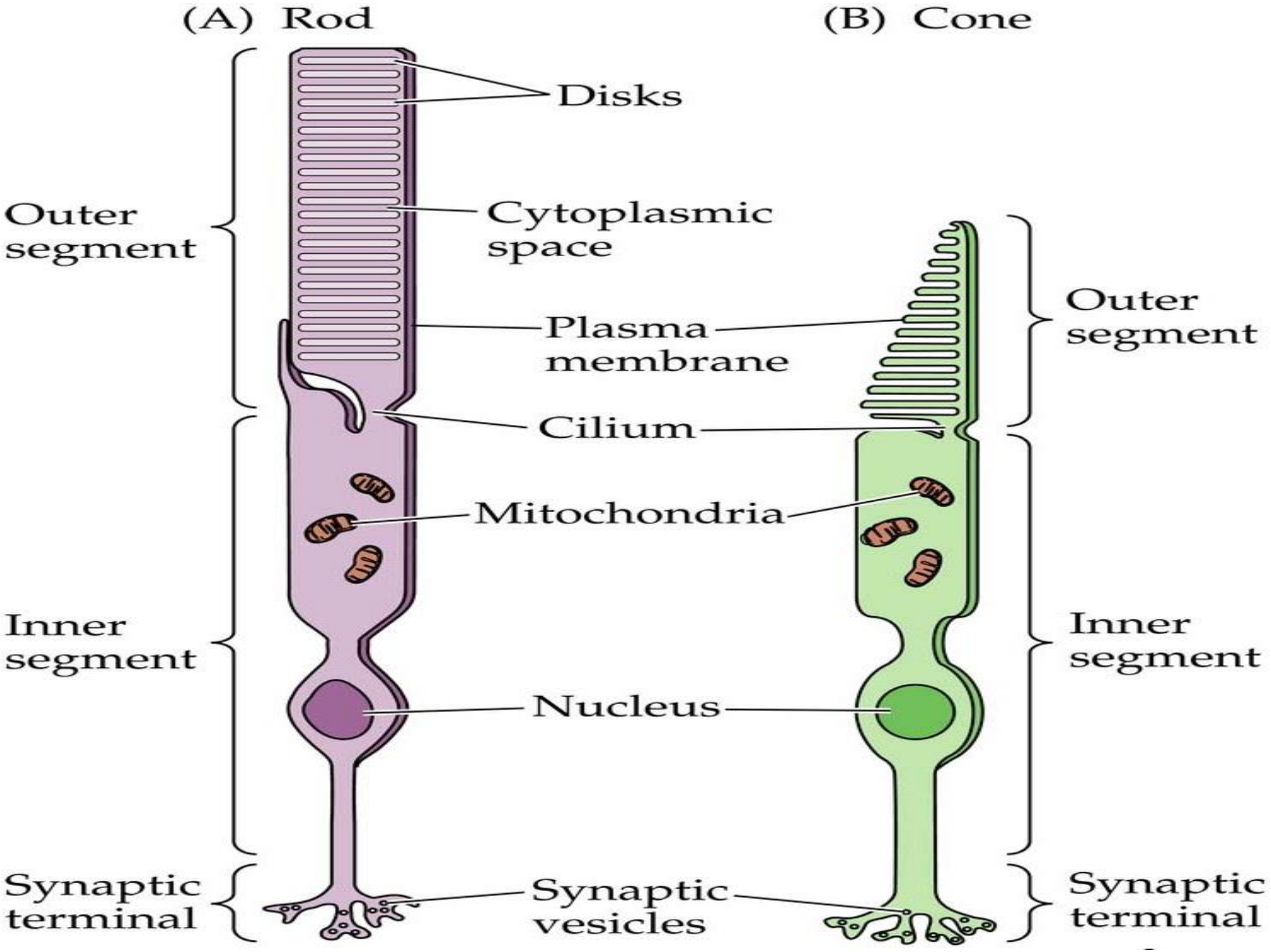
NEUROTRANSMETERS

1-Glutamin –by rods & cons.
2-Amacrine cells produce 5 inhibitory NT:
GABA, Glycine, Dopamine, Ach, Indolamine
3-Cholinesterase by amecrine, ganglionic and Horizontal cells.
4-Carbonic anhydrase by cone

Photoreceptors

Rods

- are long, cylindrical with many disks.
- Photopigment is in the disks.
- Rods have a much higher pigment concentration. They are 1000 times more sensitive to light than cones.
- They function, mainly, in *scotopic* conditions (nighttime lighting).
- All rods have the same pigment which is *rhodopsin*

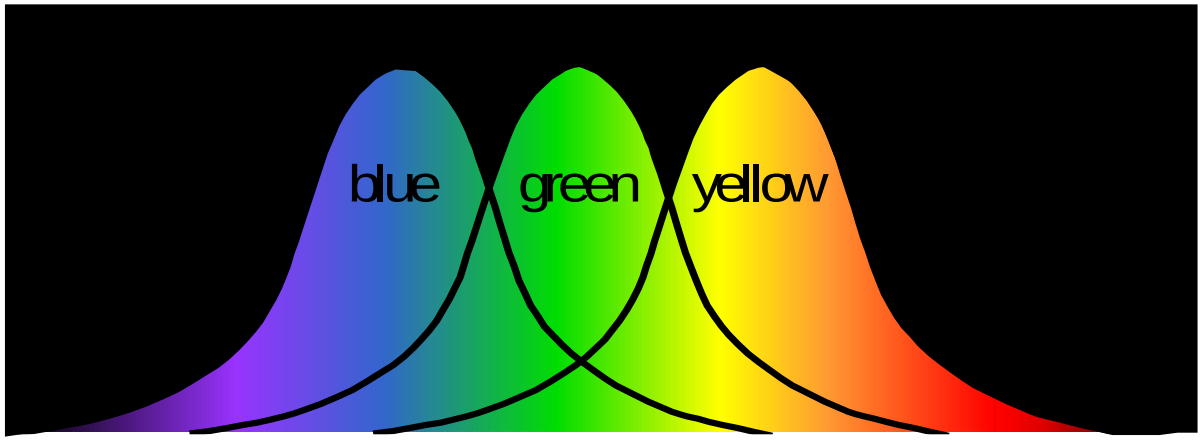

(A) Rod
(B) Cone
Disks
Outer segment
Cytoplasmic space
Plasma membrane
Cilium
Mitochondria
Inner segment
Nucleus
Synaptic terminal
Synaptic vesicles
Outer segment
Inner segment
Synaptic terminal

Cones

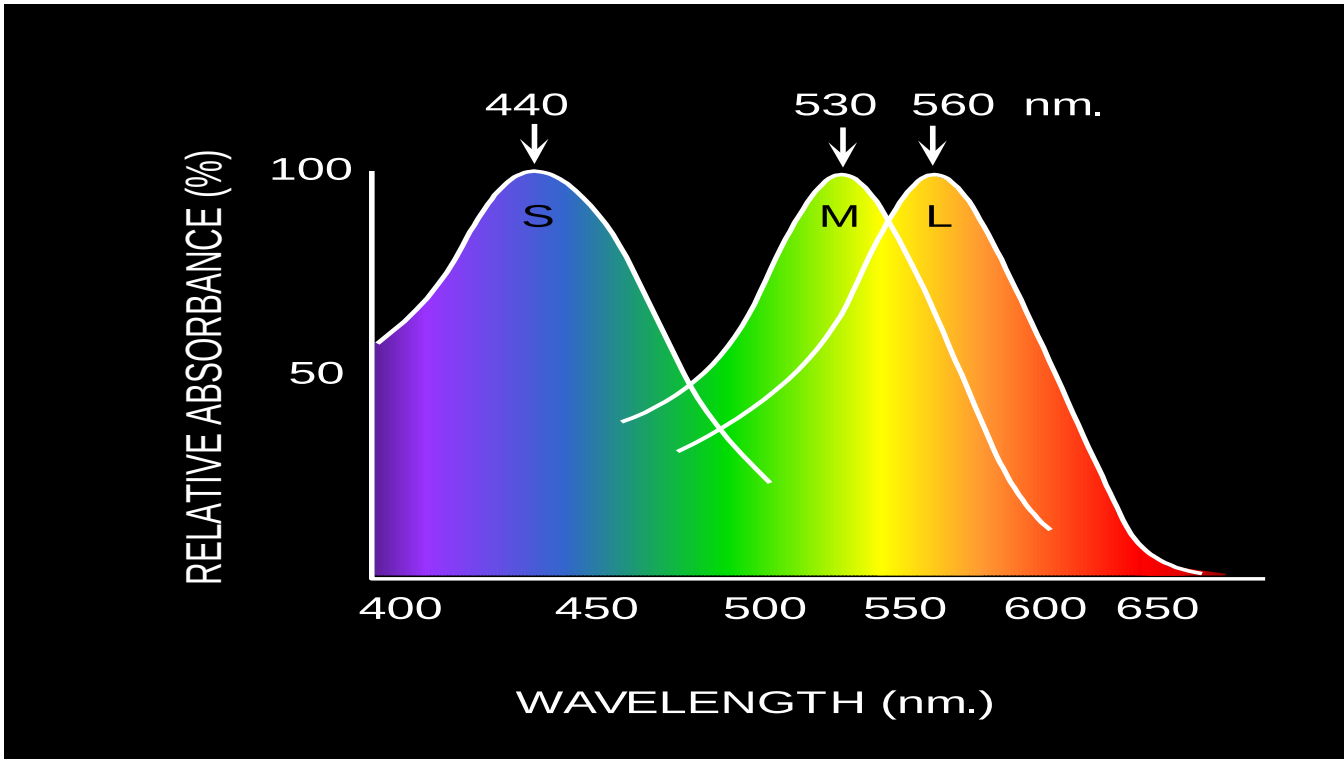
- are shorter with tapering outer segment and relatively few disks.
- They function in photopic conditions (daytime lighting).
- There are three different types of cones based on type of photopigment.
- The photopigments are differentially sensitive to wavelength of light.
- Cones contain three different opsins. Each maximally activated by different wavelengths of light:

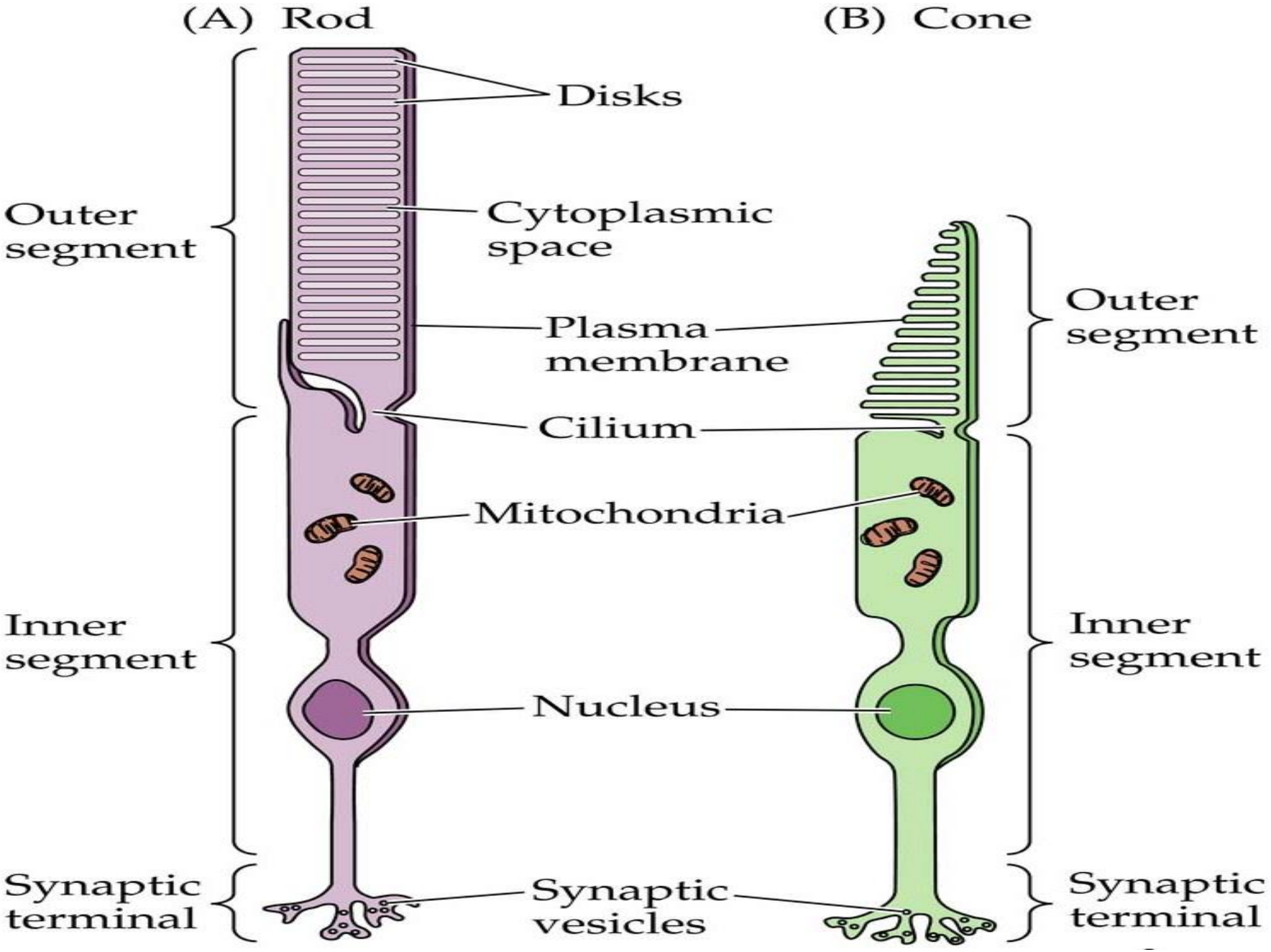
    a. Blue: 430 nm
    b. Green: 530 nm
    c. Red: 560 nm

Photons



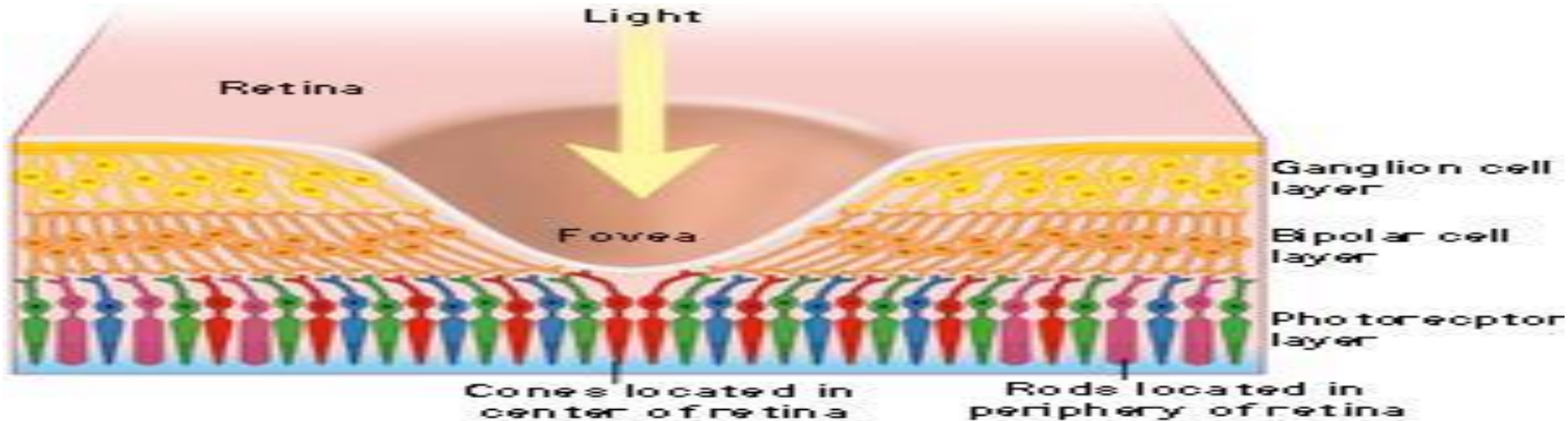
Wavelength



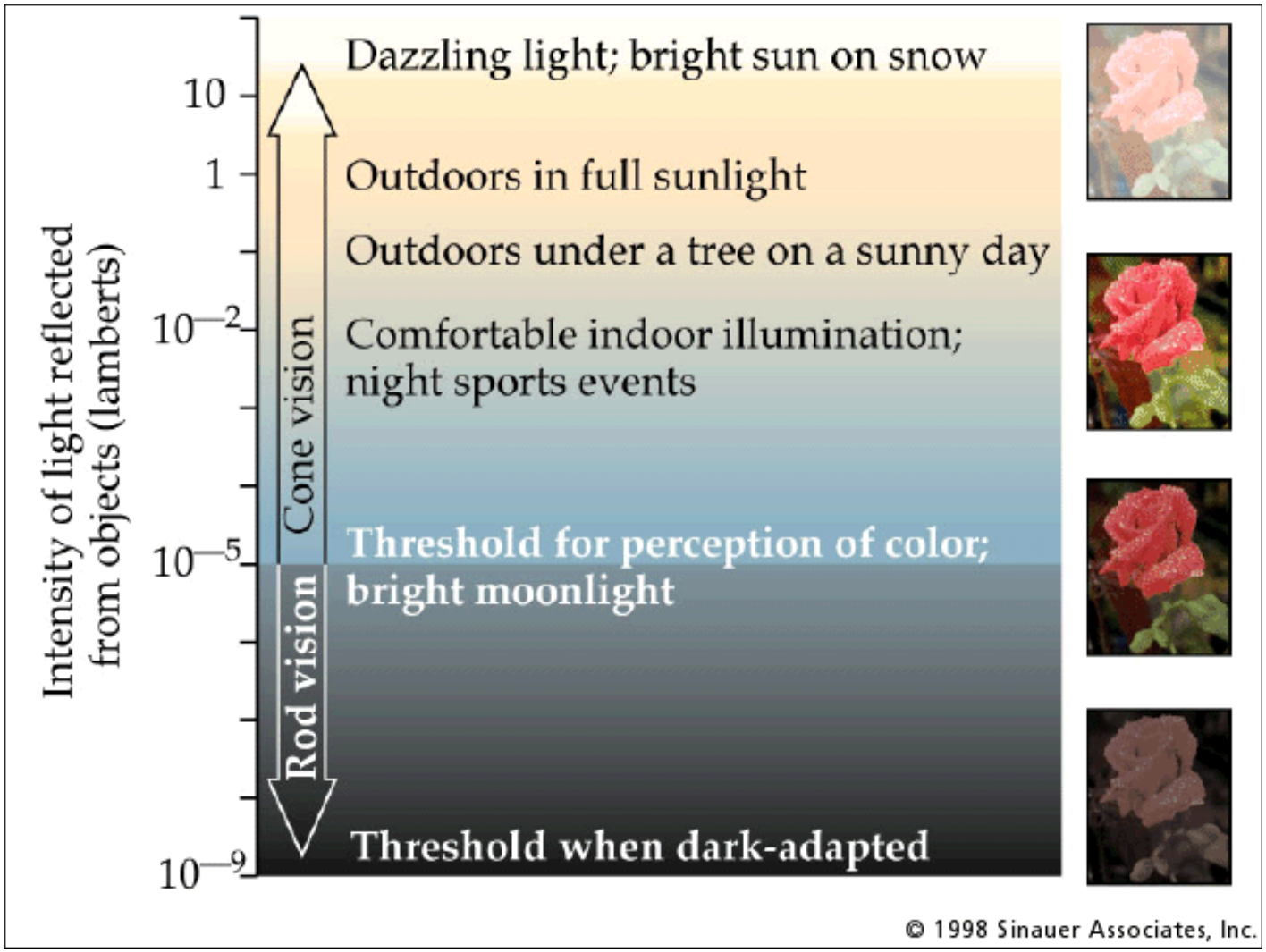

(A) Rod
(B) Cone
Disks
Outer segment
Cytoplasmic space
Plasma membrane
Cilium
Mitochondria
Inner segment
Nucleus
Synaptic terminal
Synaptic vesicles
Outer segment
Inner segment
Synaptic terminal

- All colors are created by mixing the proper ratio of red, green and blue.
- Colors are assigned by the brain based on a comparison of the readout of the three cone types.
- White color results from equal activation of all three.

- *<u>Rods and cones are distributed regionally.</u>*
- -the *fovea* contains only cones, area of the sharpest image formation , it has approximately the same number of photoreceptor and ganglion.
- *Peripheral retina* has many photoreceptors (rods) converge on a single output ganglion cell.
- So, peripheral retina is more sensitive to light.



Rod / Cone sensitivity



ON – OFF mechanism;

In response to dark, photoreceptors are depolarized and release glutamate NT. Photoreceptors make synaptic contact with bipolar cells either directly or indirectly via horizontal cells. Bipolar cells, in response to the glutamate released by photoreceptors, are either depolarized or hyperpolarized.

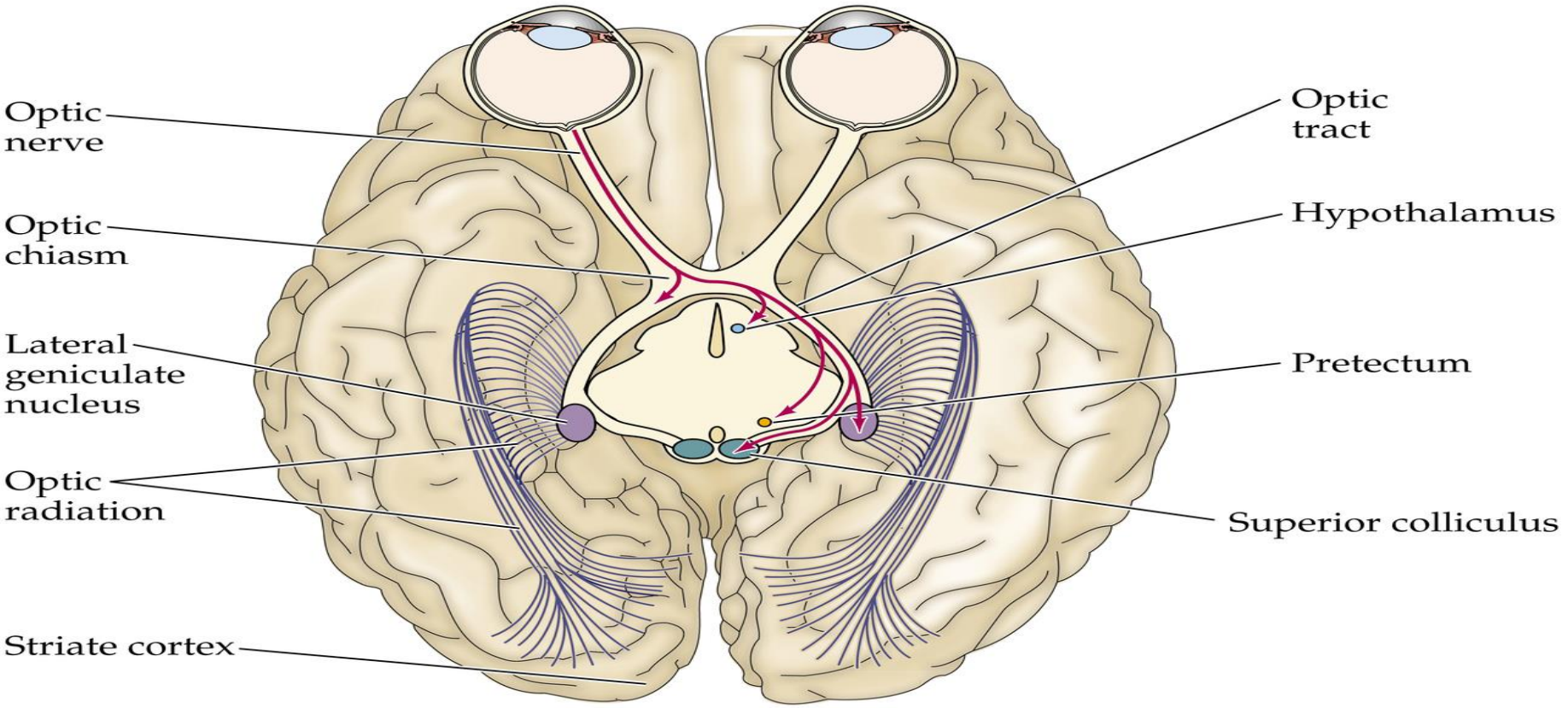
Based on their response to glutamate, bipolar cells can be classified as:

a. **OFF cells** ("off" refers to light being off) depolarize when there is no light. In darkness, the glutamate released by the photoreceptor causes an EPSP in the bipolar cell

b. **ON cells** ("on" refers to light being on) hyperpolarize when there is light. In daytime, the glutamate released by the photoreceptor causes an IPSP in the bipolar cell.

Neural Circuitry

From retina to optic nerve to optic chiasm (partial decussation) to optic tract to LGN (lateral geniculate nucleus of the thalamus) to primary visual cortex to other cortical areas.

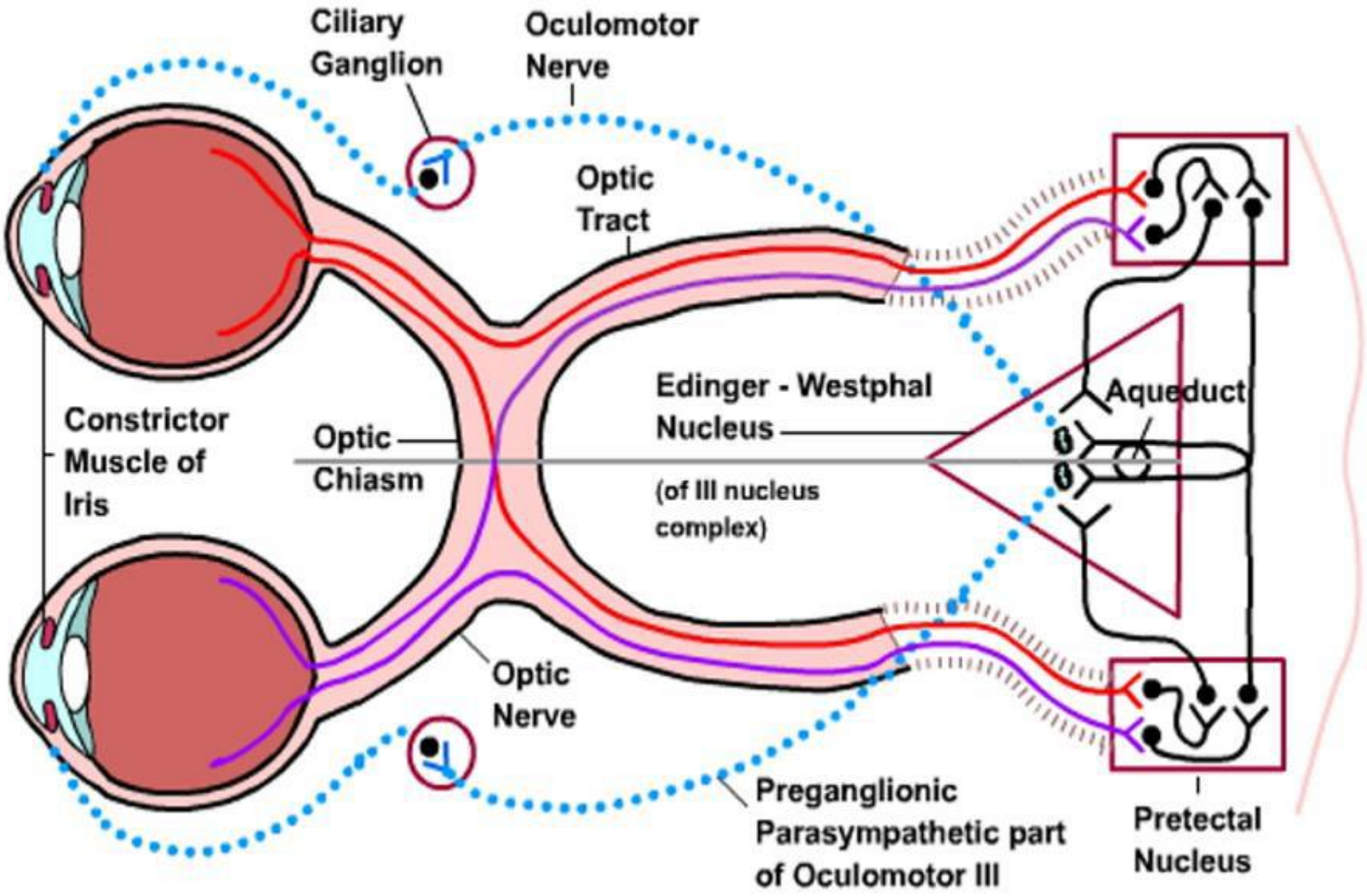


Collaterals from optic tract are sent:

- to **suprachiasmatic nucleus of hypothalamus** (which is responsible for controlling circadian rhythms),
- to **pretectum** (which is a midbrain structure involved in pupillary light reflex),
- to **superior colliculus** (which controls movement and orientation of eye)
- to **LGN** (which passes information about color, contrast, shape, and movement to the visual cortex in the occipital lobe).

Pupillary reflexes

- When light pass into eye, pupil contracts. In darkness pupil dilates. This is Direct pupillary light reflex, which helps to adaptation to light conditions.
- Reflex arc: light receptors - optic nerve- optic tract - pretectal area - Edinger-Westphal nucleus - parasympathetic fibers of n. oculomotorius (from n. trigeminus) - n. ciliaris - m. sphincter pupillae - decrease of pupillary diameter.
- Consensual pupillary light reflex: reaction of eye pupil to light irritation of opposite eye. It is possible due to diverging of nerve fibers from one pretectal nucleus to both Edinger-Westphal nuclei.


Ciliary Ganglion
Oculomotor Nerve
Optic Tract
Constrictor Muscle of Iris
Optic Chiasm
Edinger - Westphal Nucleus
(of III nucleus complex)
Aqueduct
Optic Nerve
Preganglionic Parasympathetic part of Oculomotor III
Pretectal Nucleus


Questions???