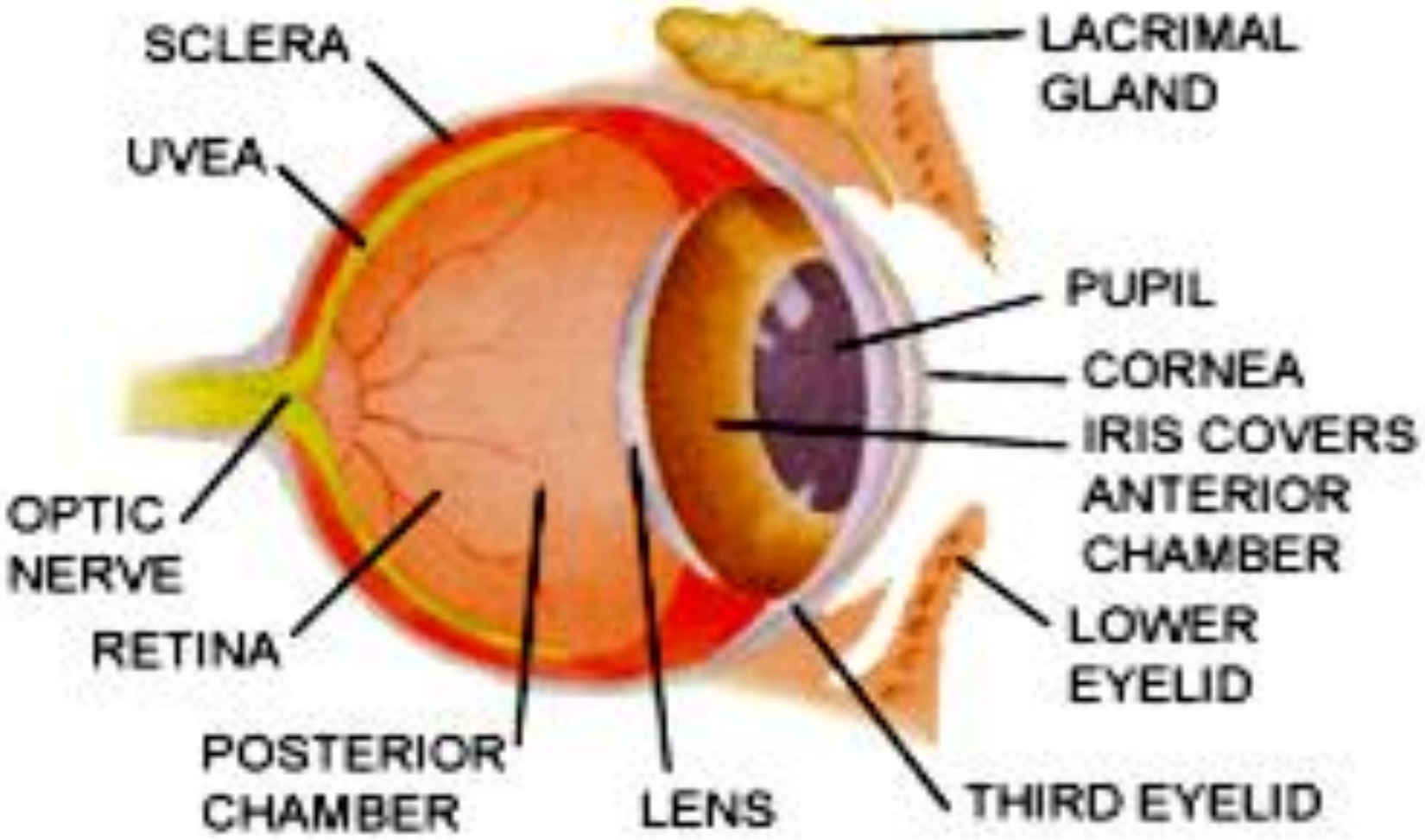
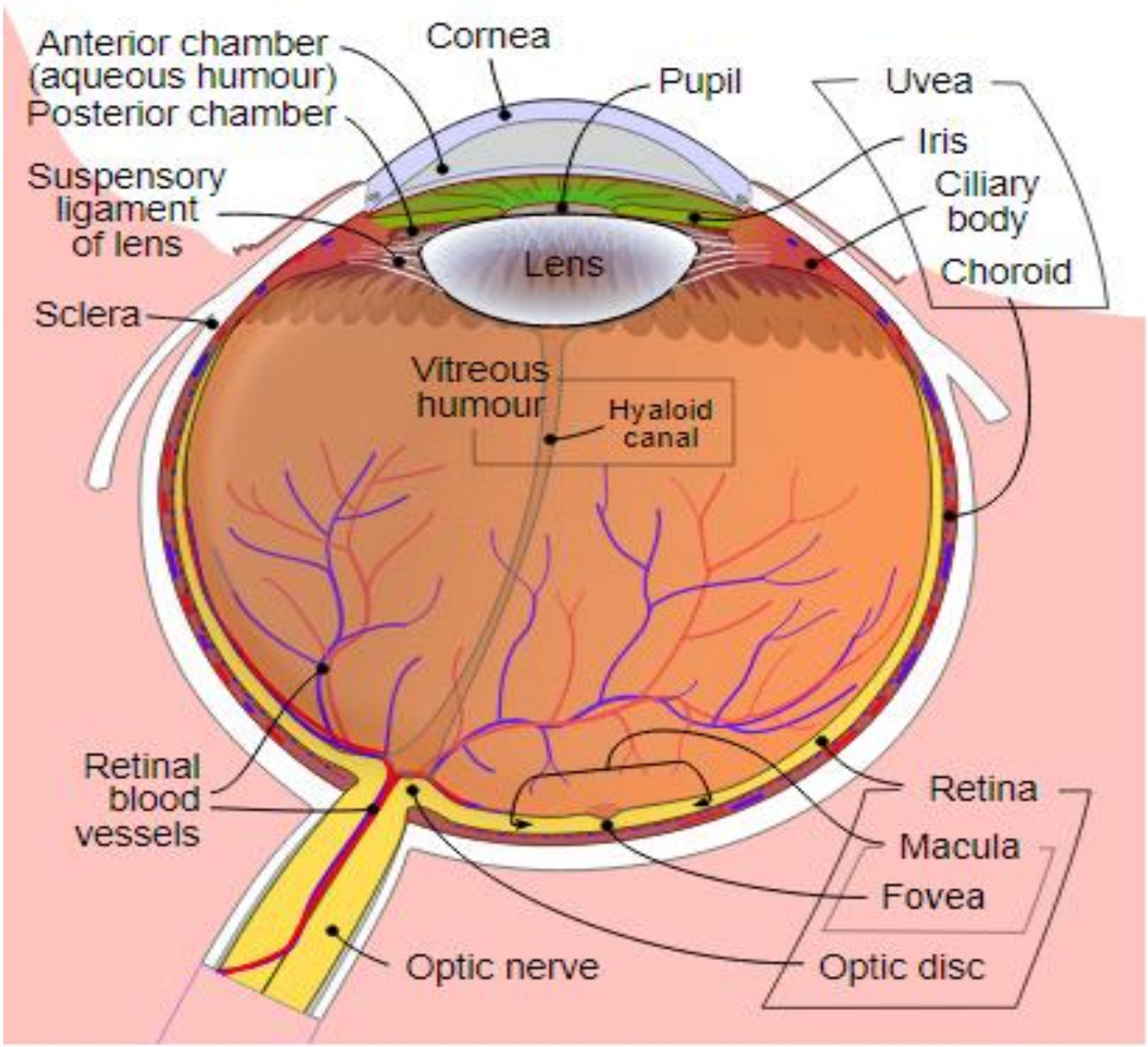
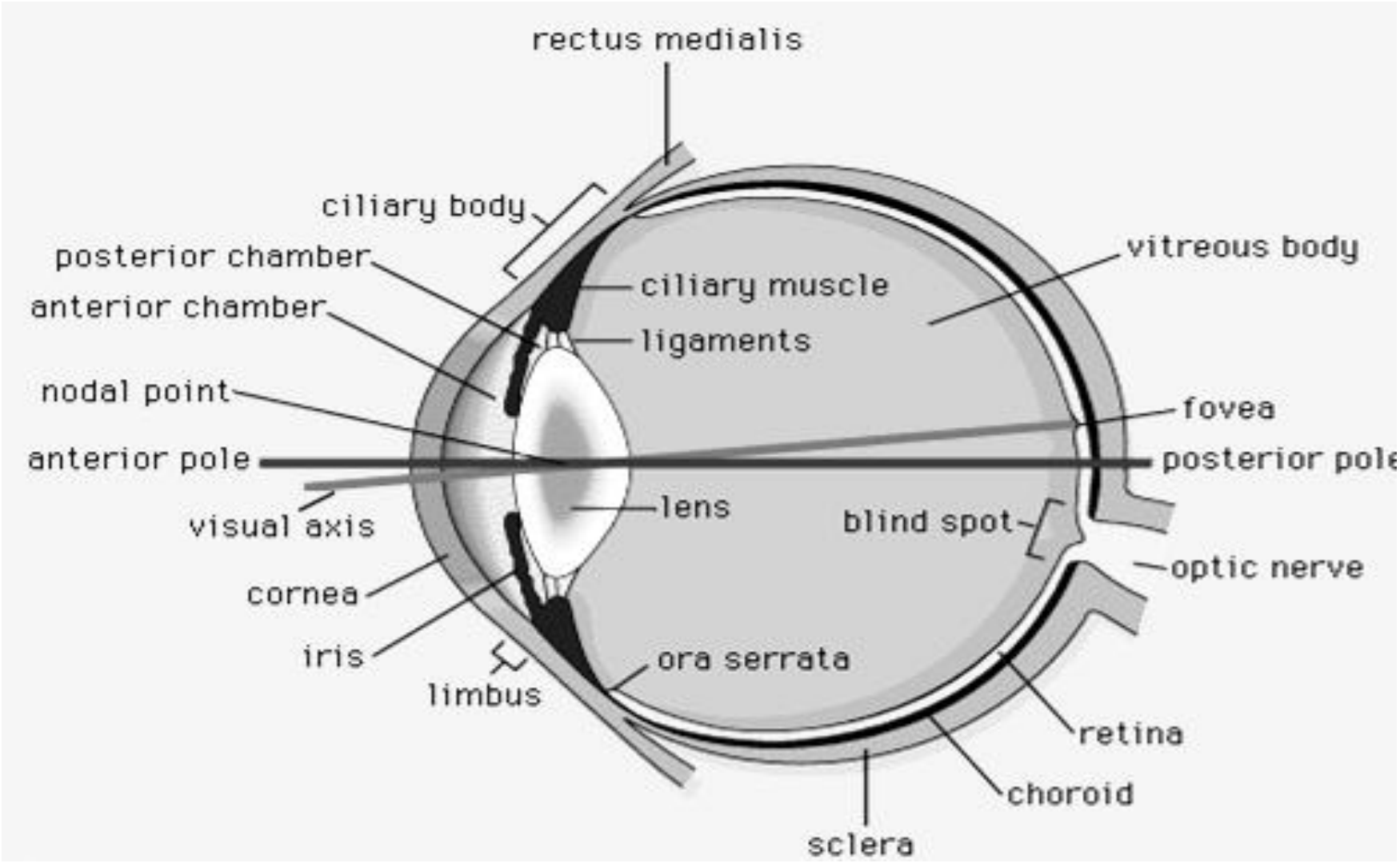
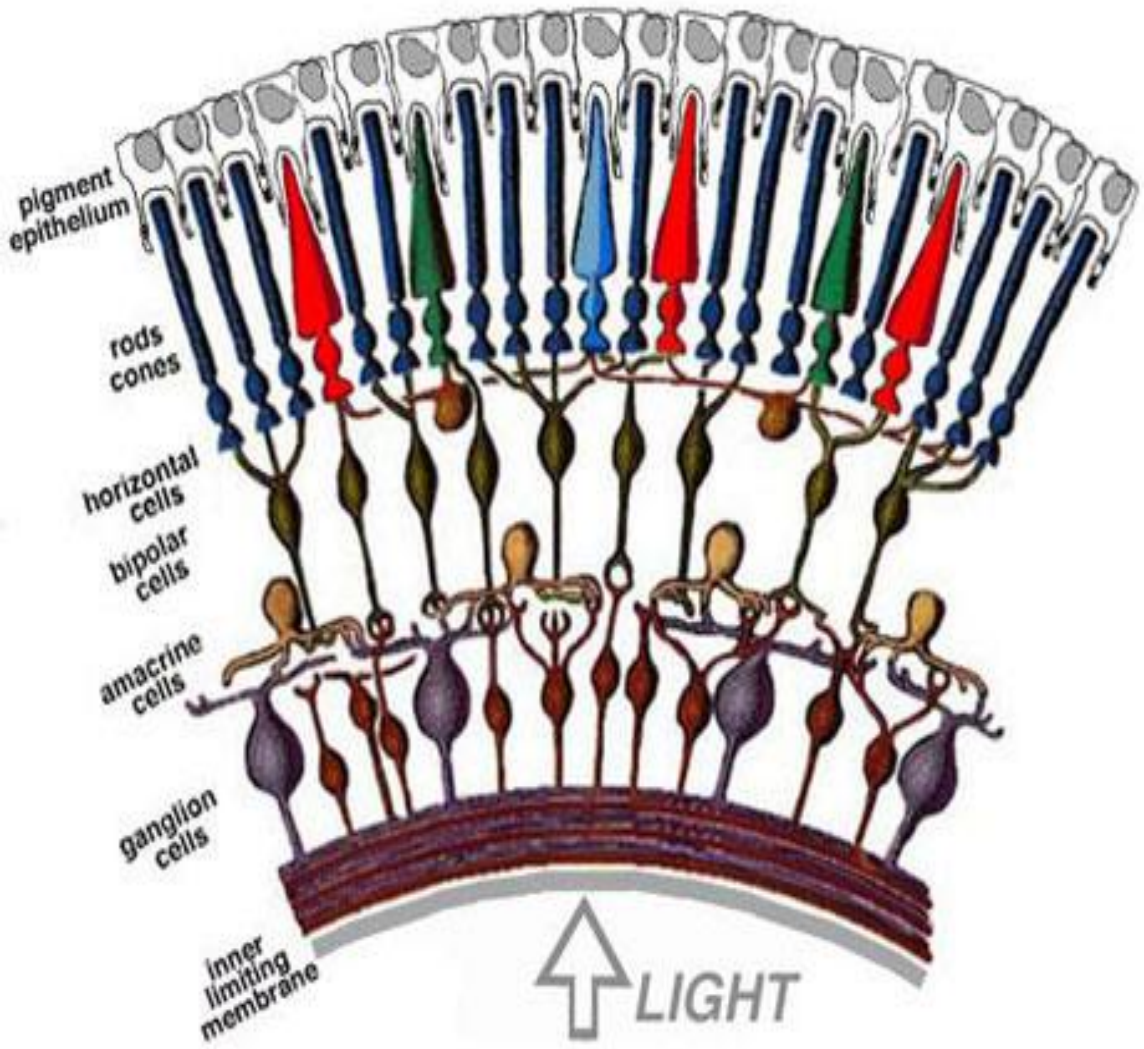
EYE


SCLERA
UVEA
LACRIMAL GLAND
PUPIL
CORNEA
IRIS COVERS ANTERIOR CHAMBER
OPTIC NERVE
RETINA
LOWER EYELID
POSTERIOR CHAMBER
LENS
THIRD EYELID


Anterior chamber
(aqueous humour)
Posterior chamber
Cornea
Pupil
Uvea
Iris
Ciliary body
Choroid
Suspensory ligament of lens
Lens
Sclera
Vitreous humour
Hyaloid canal
Retinal blood vessels
Retina
Macula
Fovea
Optic nerve
Optic disc


rectus medialis
ciliary body
posterior chamber
anterior chamber
nodal point
anterior pole
visual axis
cornea
iris
limbus
ciliary muscle
ligaments
lens
ora serrata
vitreous body
fovea
posterior pole
blind spot
optic nerve
retina
choroid
sclera

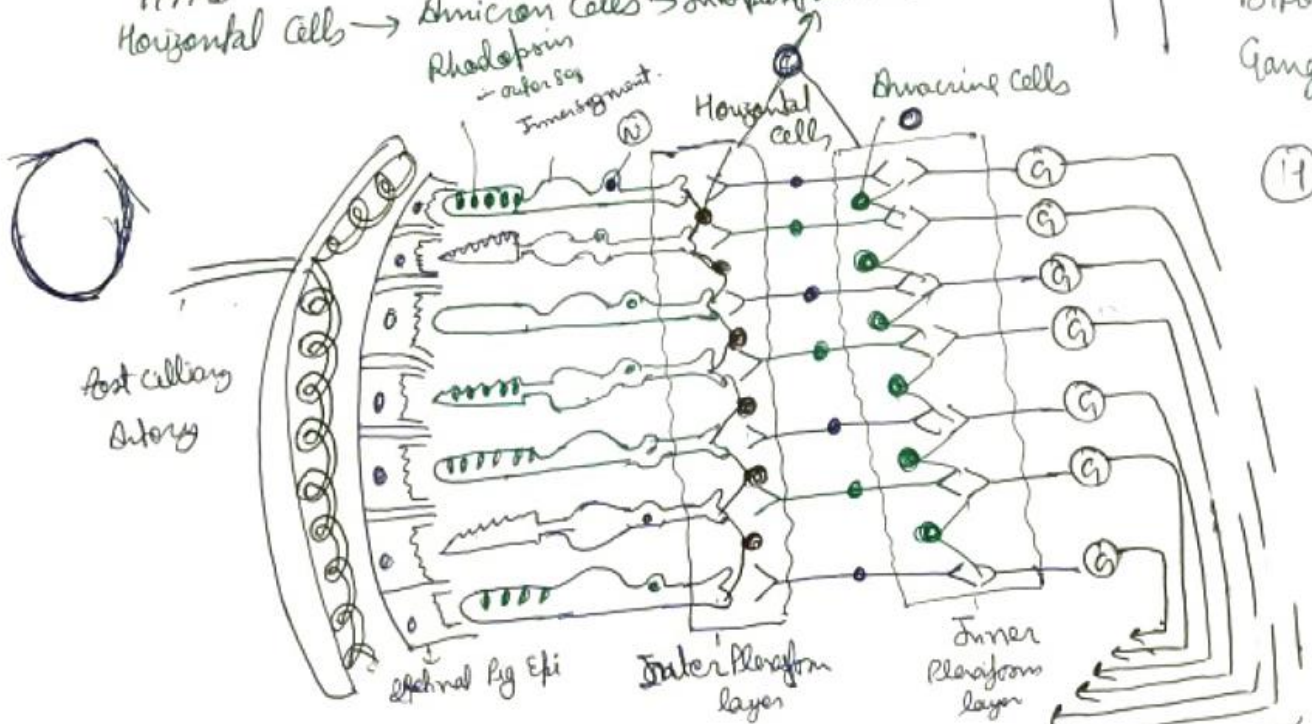

pigment epithelium
rods
cones
horizontal cells
bipolar cells
amacrine cells
ganglion cells
inner limiting membrane
LIGHT

RBG

Receptor Cells → Bipolar Cells → Ganglion Cells

HAI

Horizontal Cells → Amicron Cells → Interplexiform Cells



Central Retinal Artery

NT

Rods & Cones → Glutamate

Bipolar Cells → Glutamate

Ganglion Cells → Glutamate

(H) & (A) → GABA

→ Glycine Also

→ Ach Also

→ Dopamine Also

Rods & Cones

↓

Bipolar Cells

↓

Ganglion Cells

↓

Optic Nerve

↓

Optic Chiasma

Hypothalamus ← Suprachiasmatic (N)

Pineal body

Midbrain

Cerocolicular Superior Colliculus

Lateral Geniculate body

↓

Pretectal Nuclei

↓

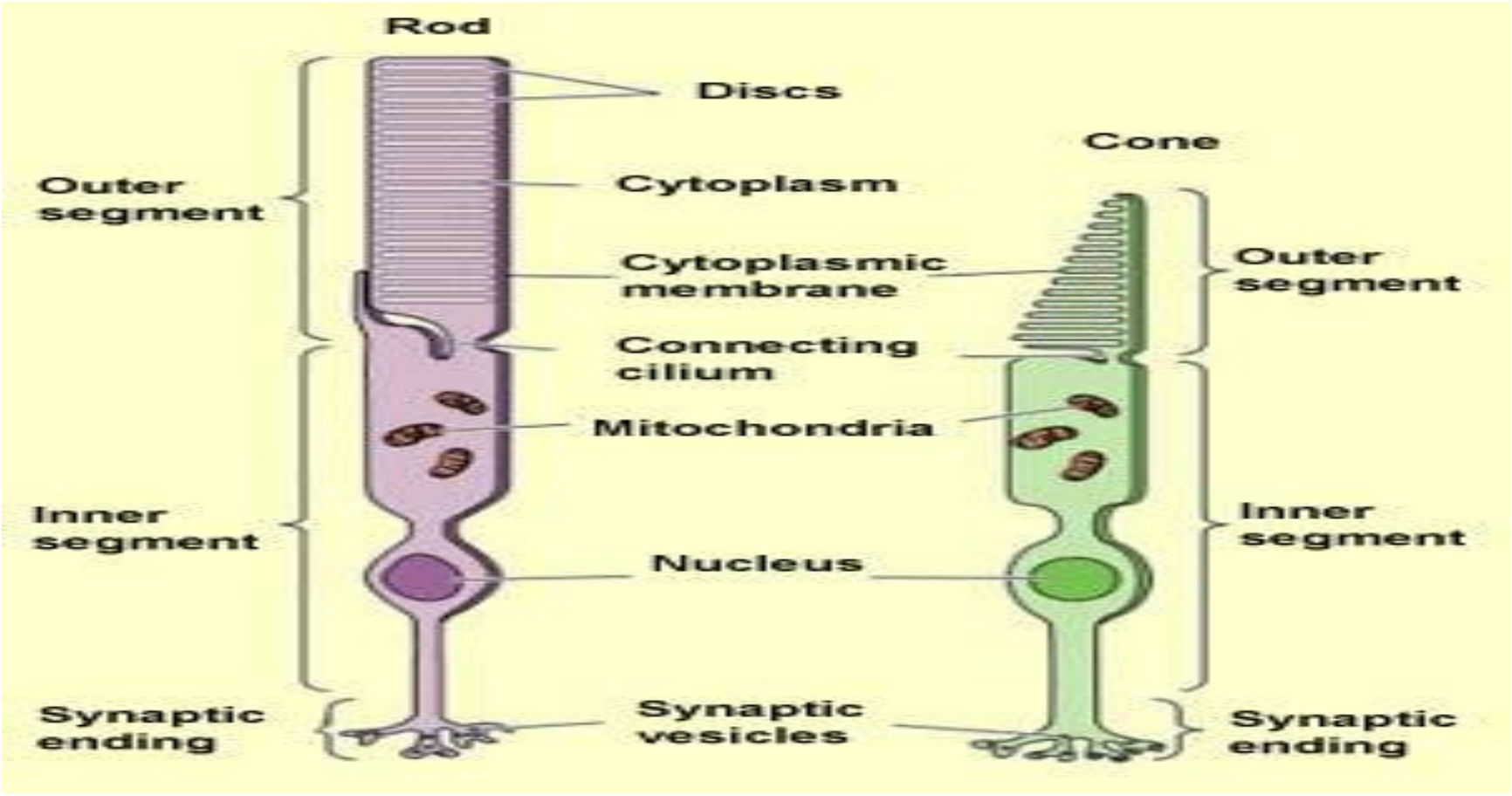
Optic tract of Cerebrum

- Receptors Cells & Bipolar Cells produce Graded potential
- Ganglion Cells produce Action potential.
- Optic Nerve is mainly made of axons of ganglion cells.

For light reflex.

Accomodation ← Ciliary Muscle ← Edinger Wfall (N)

PNS


Rod
Discs
Cone
Outer segment
Cytoplasm
Cytoplasmic membrane
Outer segment
Connecting cilium
Mitochondria
Inner segment
Inner segment
Nucleus
Synaptic ending
Synaptic vesicles
Synaptic ending

- **Photoreceptors**
- Both the rods and cones are divided into three parts
- a synaptic terminal (synapse with bipolar cells),
- an inner segment (contains nucleus, mitochondria and other cytoplasmic structures)
- an outer segment (photoreceptor part, contains stacked membranous disks which contain light sensitive photopigment)
- Rods contain a photosensitive pigment **called *rhodopsin* (visual purple).**
- Photopigments are made up of proteins called ***opsins*** (in rods the opsin is called ***scotopsin***) and an aldehyde of vitamin- A called *retinal* (retinene).
- The photopigment of cones is ***iodopsin,*** which is composed of **retinal and opsin (protein).**
- The iodopsin is different from scotopsin only in the opsin component.
- There are three kinds of cone opsins - **blue cone (sensitive at 430nm), green cone (535 nm) and red cones (575 nm).**

In the dark

- In the dark, cGMP levels are high and keep cGMP-gated Na^+ channels open

↓

- Na^+ ions enter the cell through these channels

↓

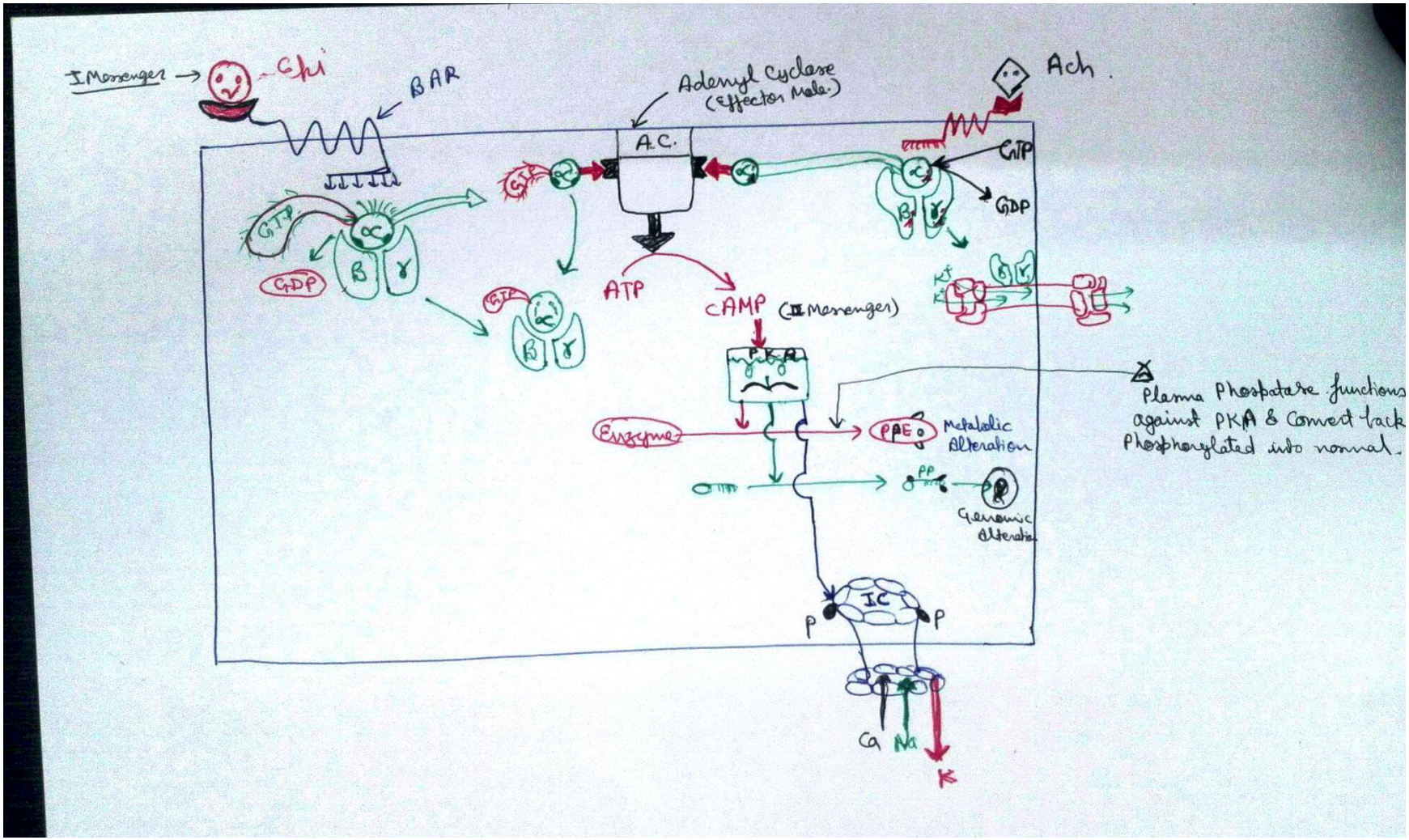
- Making the resting membrane potential of photoreceptor cells less negative (-44mV) than most sensory cells

↓

- The Na^+ moves to the inner segment and pumped out by Na^+-K^+ pump to the outside

↓

- Thus, in the dark, there is a *Na^+ current* "in" through the outer segment and "out" through the inner segment (**known as *dark current*)**


I Messenger
Epi
BAR
Adenyl Cyclase
(Effector Mole.)
A.C.
Ach
GTP
GDP
ATP
cAMP
(II Messenger)
PKA
Enzyme
PPE
Metabolic
Alteration
PP
Genomic
Alteration
IC
P
P
Ca
Na
K
Plasma Phosphatase functions
against PKA & Convert back
Phosphorylated into normal.

PHOTORECEPTION (Visual Cycle)

- Visual cycle (visual phototransduction) is a process by which light is converted to electrical signals in the photoreceptor cells of the retina
- Photoreceptor cells are depolarized in the dark, i.e. light hyperpolarizes and "*switches off*" these cells, and it is this 'switching off' that activates the next cell and sends an excitatory signal down the neural pathway.
- In the unstimulated photoreceptor cell, the photopigment opsin and retinal are tightly bound together. The retinal is an elongated molecule which becomes angular when bound to opsin and this shape is caused by *cis*-configuration of one of the double bonds in retinal; the retinal with this shape is known as **11-*cis*-retinal.**
- When photon of light strikes the photopigment, retinal absorbs the light, the *cis*- double bond configuration isomerizes to *trans*- configuration and the shape of retinal becomes straight called **as all-*trans*-retinal** and this shape does not fit the opsin protein and the photopigment is cleaved.
- **This transformation of the photopigment is called *bleaching*.**

The opsin split from the photopigment changes its configuration

↓

Activates a **cytosolic G-protein** (***transducin)***

↓

Activates phosphodiesterase enzyme

↓

Breaks down the intracellular second messenger cGMP.

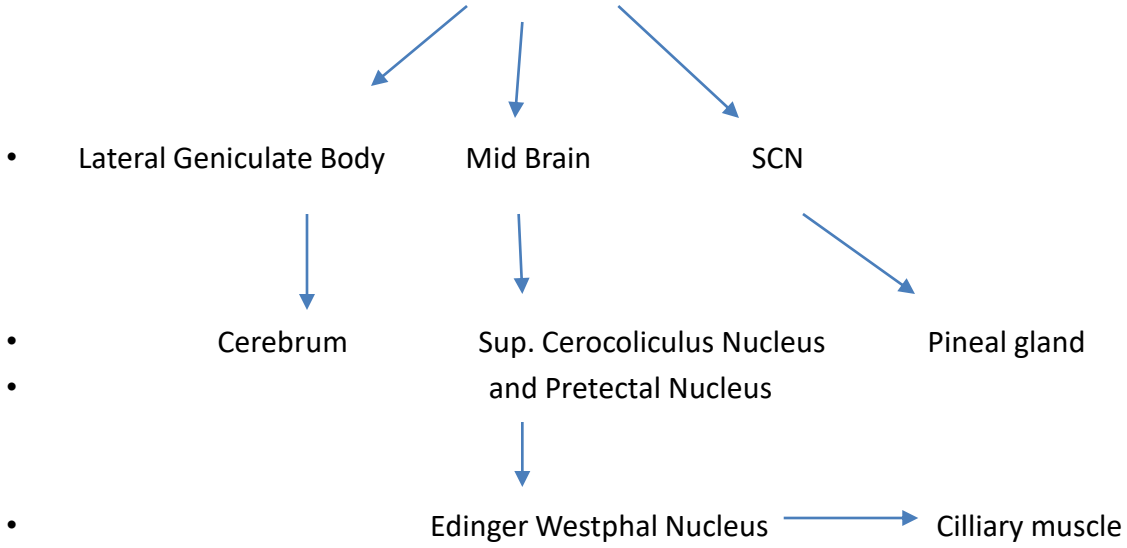
↓

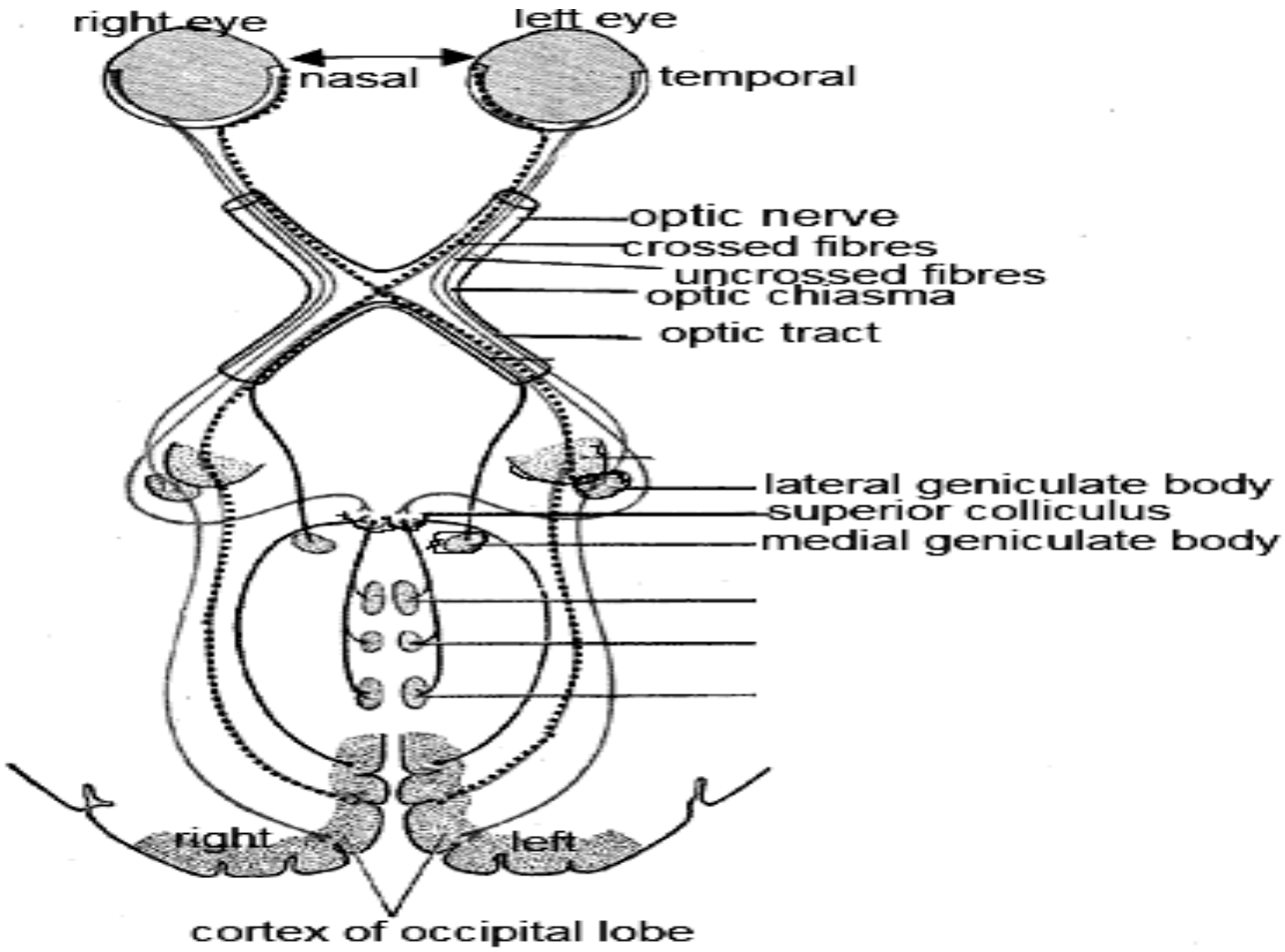
Ion channels are closed and hyperpolarization occurs

- When light strikes the photoreceptor, photons breakdown the photopigment releasing the opsin and cGMP is broken down; hence, the ion channels in the outer segment closes.
- The inward current is "*switched off*" and the membrane becomes more negative, i.e. the rods and cones are *hyperpolarized* when stimulated by light.

Fate of information forward to Ganglionic cells

- Retinal cells
- Bipolar cells
- Ganglione cells
- Optic Chiasma



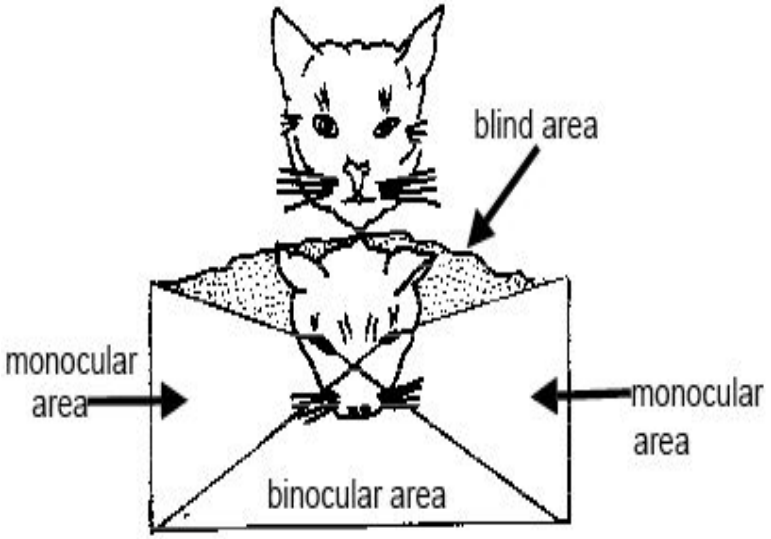

right eye
left eye
nasal
temporal
optic nerve
crossed fibres
uncrossed fibres
optic chiasma
optic tract
lateral geniculate body
superior colliculus
medial geniculate body
right
left
cortex of occipital lobe

Types of vision:

- Primates, birds and reptiles, amphibians and fish perceive colour to a greater extent than do domestic animals.
- *Visual field*refers to the physical objects and light sources in the external world that impinge the retina

Monocular vision or periscopic vision

- Animals with laterally placed eyes view the objects with one eye at a time independently of the other eye. This is due to wider visual angle between optic axis and median line of the eye. E.g. amphibians, reptiles, domestic herbivorous animals



Binocular vision:

- Primates, carnivores and birds have the power of converging of the eyes, thus view the same object simultaneously with both eyes. This is due to parallel optic axis and median line, which provide overlap of field of vision.

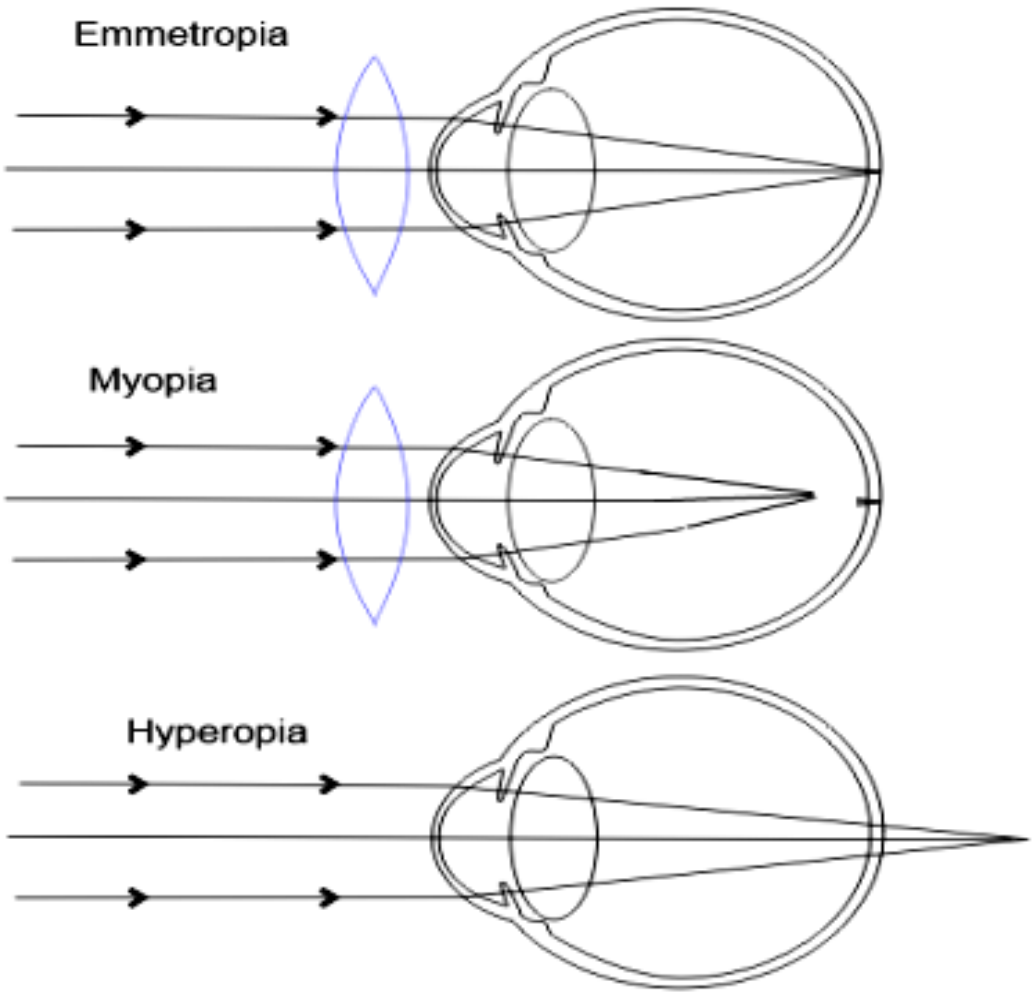
Accommodation of eye

- Light is refracted both by the cornea and lens. The cornea accounts for approximately 2/3rd of this refractive power and the crystalline lens contributes the remaining 1/3rd. The curvature of cornea is constant however, the lens can change its curvature
- The ability of the eye lens to adjust its focal length by changing its curvature for focussing the image on the retina for both near and distant vision is known as ***accommodation*.**
- For near vision the anterior curvature of the eye lens is increased by the action of the ciliary muscles.
- Contraction of the ciliary muscles of the ciliary body reduces the tension in the suspensory ligament, causes bulging of the anterior curvature of the eye lens towards the less resistant anterior chamber of eye.
- On the other hand, relaxation of ciliary muscle creates tension in the suspensory ligament, cause flattening of the eye lens and this helps in distant vision.

- In horse the retina is placed at different distances from the cornea because of the "***ramp shaped***" retina.
- The ciliary muscles are weak and are unable to alter the curvature of the lens to change the focal length.
- The animal simply raises or lowers its head or eye to allow the image to fall on the retina.
- Generally, predators have better accommodation power than ungulates; humans, other primates and cats among the domestic animals have greater accommodation power.

- The focussing power of a lens is expressed as *dioptres*. The reciprocal of focal length of lens in metres is dioptre (1/m); e.g.a 3-dioptre lens brings parallel rays of light to focus at $^{1}/_{3}$ metre
- If the eye lens is unable to adjust its focusing capacity to focus the image on the retina, it is called as ***ametropia*.** It is of three types.
- **Myopia**: (Short or near vision) Abnormal increase in the anterio-posterior diameter of the eye ball or the excessive refraction of the eye lens causes focusing of the image just before the retina.
- It can be corrected by **concave lens** which reduces the refractive power of the eye lens thus focus the image exactly on the retina.
- **Hypermetropia: (Long or Far sight)**
- It is a common defect **in wild animals**; shortening of the anterio-posterior diameter of the eyeball or less refraction of the eye lens focuses the image beyond the retinal layer.
- The convex lens increases the refractive power of the eye lens, thus focus the image to fall on the retina and correct the defect.

- **Astigmatism:**
- The difference in the radius of curvature of the cornea causes the light to focus not to a common point on the retina, which results in both myopic and hypermetropic visions. This defect can be corrected by the **cylindrical lens.**


Emmetropia
Myopia
Hyperopia

Presbyopia

- It is the condition of the eye characterised by gradual loss of power of accommodation which is associated with the loss of *emmetropia* (ability to focus parallel rays of light on the retina).
- This is due to reduced elasticity of the eye lens with increasing age.

AVIAN EYE

- Birds have the most advanced visual system among the vertebrates
- Near the area of blind spot in optic disk, a vascularised comb-shaped structure called ***pecten*** **projects into the vitreous humor which supplies O_2 to the retina.**
- Both the ciliary muscles and iris musculature are striated and contracts much faster than the smooth muscles in mammals
- **The two eyes can accommodate independently of each other**
- Nictitating membrane in birds is pulled in front of the eye by a striated muscle (in mammals, retractor muscles indirectly pushes the membrane in front of eye)
- **Some birds have one area centralis and some have two area centralis (birds of prey)**
- Photoreceptor cells are in high density in avian retina than in mammals. Cones are more in diurnal birds than in mammals and have better colour vision.

THE AVIAN EYE