VISION REVSION

* Refractive Media of the Eye:

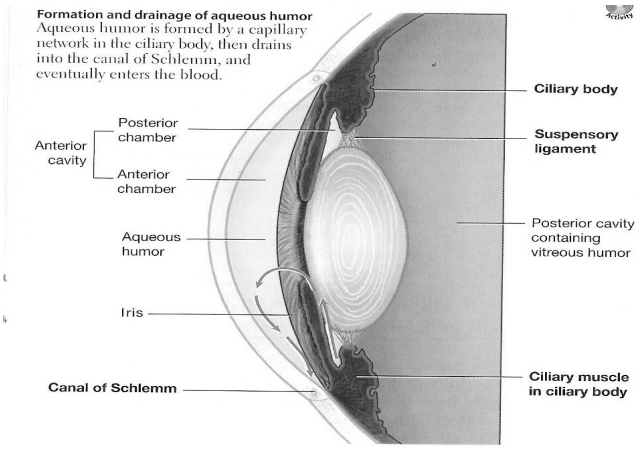
1- **Cornea**:

- most important- (greatest refraction of light), diopteric power is 40- 45 D (2/3 refractive power of the eye)

2- **Aqueous humor:**

its function is to nourish the retina, cause intraocular pressure 10-20 mmHg (fluid produced by ciliary body => pupil => anterior chamber => canal of schlemm at angle of anterior chamber => veins.)

- Anterior chamber → between iris and cornea
- Posterior chamber → between iris and cilliary muscle



**Glaucoma => increase in intraocular pressure more than 20mmHg → increase pressure on optic nerve → cause blindness + cause damage of optic nerve

3- **Lens:**

transparent, biconvex, semisolid, diopteric power 15-20 D, more important than cornea (because it can changes the refractive power -1/3 refractive power-)

4- **Vitrous humor**

- Between retina + lens.
- For nourishing retina.
- Keep spheroid shape. (if it is not present it will render the eye collapsed)

* External Protection of the Eye:

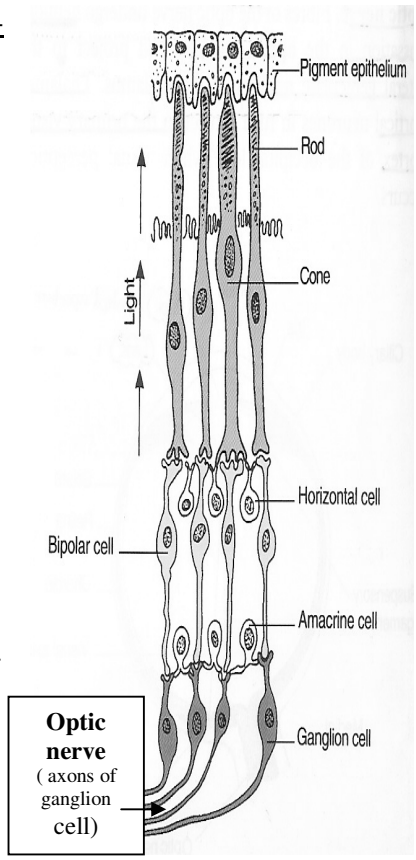
- Bony orbit – lids – blinking – conjuctiva - tears (for washing, lubrication,lysosyme) - lacrimal gland → has antibacterial + lubricating effect keeping cornea moist and clear

* Retina:

- Full of receptor cells (rods + cones) → these are photoreceptor
- Optic disc (blind spot **-MCQ-** because no receptors, place where blood vessels enter and optic nerve exit) 3 mm medial and above posterior pole of the eye (optic nerve leave + blood vessels enter + has no photoreceptors).
- Fovea centralis yellow pigmented depression (in macula lutea at posterior pole of the eye, only cones are present + high visual acuity + color + details).

* **Layers of Retina**: (10 layers), The most imp are :-

1- **Pigment cell layer** (vit A => dim light vision) , is the outermost + pigment absorb light + prevent reflection + blurring of vision.
2- **Rods & cones** (outer and inner segment BUT not cell bodies): 120 millions rods + 6 millions cones. Density of rods increases from outside fovea to peripherally, cones mainly at fovea and decreases to periphery. **–MCQ**-
3- **Outer nuclear layer** (cell body + rods & cones)
4- **Outer plexiform layer** mainly of horizontal cells → attached mainly to Rods
5- **Inner nuclear layer** (bipolar cell).
6- **Inner plexiform layer** (amacrine cells which have no axons but are attached by dendrites to ganglion cell layer horizontally).
7- **Ganglion cell layer**.
8- **Optic nerve fibers** (1.2 millions) optic nerve = axons of ganglion cell layer.
9- **Horizontal cells** (make synaptic connection by their axons with rods).
10- **Amacrine cells** (making synaptic connections by it's processes (no axon) betweent ganglionic cells



- **blood vessels of retina are seen by ophlamoscope, near peripheral layer or retina near vitreous humor, supply only bipolar & ganglionic cells, Rods & Cons supplied by capillaries of choroids**
- **center of retina has mainly → Cones**
- **perephry or retina has mainly → Rods**

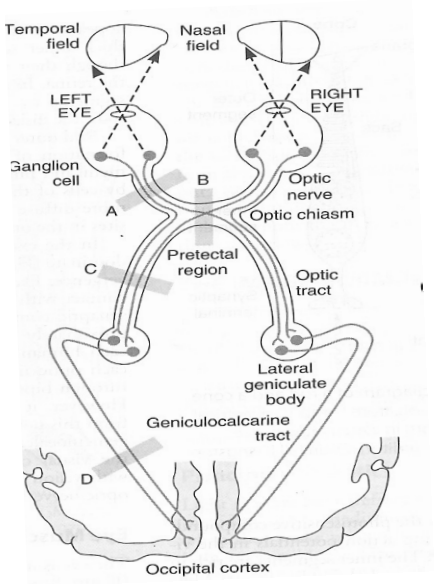
* Explain direction of Light :

- **light absorbed by pigment cell layer that contains melanin pigment that passes through ganglion cells → plexeform → nuclear → finally to Rods & Cones**
- **impulses pass from rods & cones to rest of layers finally to ganglionic cell layer → to optic nerve**
- **at center of retina all layers pulled aside to allow light to enter ganglionic cell directly**

** Neural Pathway(Visual Pathway):

Cones and rods => bipolar cells => ganglion cells => optic nerve (axons of ganglion cell) => optic chiasma => optic tract => lateral geniculate body in thalamus => axons of cells from geniculocalcarine tract => optic radiation => visual cortex (Broadmann area 17 at occipital cortex)

- the nasal fibers of opposite side + temporal fibers of same side axons from geniculocalcrin tract



At Optic Chiasma ONLY nasal fibers of optic nerve cross to the opposite side while temporal fibers of optic nerve pass without crossing.

* **Nasal fibers** conveys temporal field of vision

***Temporal fibers** conveys nasal field of vision

Optic Tract = nasal fibers of the opposite side (i.e. temporal field of other eye) + temporal fibers of the same side (i.e. nasal field of the same eye).

-The **left optic tract** corresponds to the right ½ of the visual field.

-The **right optic tract** corresponds to the left ½ of the visual field.

* some other pathways beside the main pathway :

1- some ganglion cells axons pass from optic tract to pretectal region of midbrain and superior collicus for papillary reflex & eye movement
2- some axons of ganglionic cells from optic chiasma pass directly to suprachiasmatic nerve of hypothalamus for circadian rhythem (light – dark cycle)
3- some axons from lateral geniculate body in the thalamnus (away from pretecal nerve) to superior colliculus in mid brain for accomidation reflex and it's miosis component

* Duplicity Theory of Vision: -V.IMP MCQ-

TWO kinds of vision under different conditions:

1- Photopic vision:

- Bright light vision.
- Served by cones.
- Colors + details.
- Low sensitivity to light (high threshold to produce stimulation). a person doesn't need high sensitivity because the light is too much.
- Higher threshold is needed + greater acuity.

2- Scotopic vision:

- Night vision + dim light vision.
- Served by rods.
- No colors or details + low visual acuity
- Great sensitivity to light, lower threshold, lesser acuity.

N.B. both rods &cones undergo adaptation.

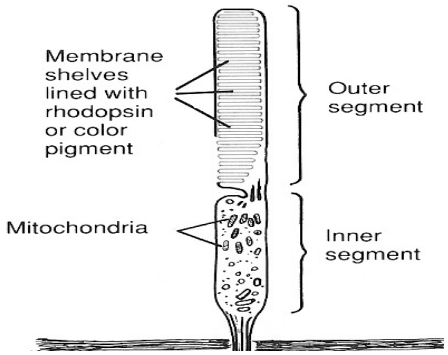
* Binocular Vision: values :

1- large visual field.
2- Cancel effect of blind spot.
3- Stereoscopic vision.
4- One eye lesion doesn't affect vision.

Rods	Cones
Periphery	Fovea
Low light levels	High light levels
Monochromatic	Color
Poor acuity	Good acuity

* Receptors..

1- **Outer segment** (mosified cilia) has disk full of photosensitive pigment react with light it is thin, tall, rod-shaped in rods, BUT short, cone-shaped, thick in cones.
2- **Inner segment** full of mitochondria (energy of Na-K pump) it is thick in cones + tall , WHERE in rods short + thin.



* Convergence: -MCQ-

1- Each foveal cone => one bipolar cell => one ganglion cell => single optic nerve fiber, at periphery 10 cones : 1 bipolar cell + 1 ganglion + 1 fiber.
2- Several rods about 300 synapse with 1 bipolar cell + 1 ganglion cell + 1 nerve fiber.
3- 120 million rods + 6 million cones + 1.2 optic nerve fibers,
4- So convergence is 105 receptor : 1 fiber.

* Principles of Optics:

- **Principle focus:** is a point where parallel light rays striking a biconvex lens and refract to it, behind the lens.
- **Principle of axis**: line passing through the centers of curvature of the lens. The principle focus is on it.
- **Principle focal distance:** the distance between the lens and principle focus.
- (**Biconcave=** diverge, **Biconvex** = converge).

Diopter (measure of refractive power):

If principle focal length = 25 cm

⇨ 100/25 => 4 D

(the greater curvature => greater refractory power of lens)

Emmetropic eye "normal eye" has image on retina.

- lense- retina distance = 15mm (the greater the curvature of lens, the greater the refractive power of eye)

* Errors of Refraction:

- **Hypermetropia** (small eyeball, focus behind retina, continouse accommodation , muscular effort cause headache + blurred vision + prolonged converge by accommodation (sequent حول) correction by biconvex lens).
- **Myopia –MCQ-**(large eyeball , focus infront of retina, correction by biconcave lens).
- **Presbyopia** (eye near point recedes due to loss of accommodation, correction by biconvex lens), so reading and close work are difficult (40-45 years) .
- **Astigmatism** (uneven & ununiformed corneal curvature, very rare ununiform lens curvature, rays refracted to diff focus → blurred vision. correction by cylindrical lens).

* Accomodation:

- At rest (looking at far object): ciliary muscles relaxed, taut ligament, flat lens.
- Near objects parallel ray focus behind retina -ciliary muscle remain relaxed-, blurred vision.
- Solution is to increase curvature + refractive power of lens by accommodation to bring focus on retina.

* Convergence – Accommodation reflex

Look at a close object:

1- Convergence : to bring the image to corresponding point of retina.
2- Pupil constriction : to prevent damage in retina by extra light.
3- Focusing(Accomodation) **–MCQ-**: increase anterior curvature of lens by ciliary muscle contraction, slack ligament, increase anterior surface curvature of lens to bring the image on the retina.

☺ **MCQ : Looking at near object => increase in curvature and refractive power of the lens (Accomodation)

- Test by: Sanson purkinje images.

Look at far object :
1.muscle => relaxed
2.ligament => tout
3.lens => flat

Look at near objects
1.muscle=> contracted
2.ligament => relaxed
3.lens => ⇧ curvature

* Near response :

a- convergence → to bring image on corresponding point on both retinea
b- pupil constriction (miosis) → to decrease amount of light entering eye
c- accommodation → to increase diopteric power on

* Near point:

- Nearest point to eye at which object can be brought into focus on retina by accommodation.
- At 10 years => 9 cm.
- At 60 years => 80 – 100 cm, due to hardness of the lens and loss of accommodation due to steady decrease in degree of curvature of lens.

(**Presbyobia** : due to: **-MCQ-**

- loss of lens elasticity .
- near point recedes .
- loss of accommodation.
- correction by biconcave lens).

* Pathway of accommodation :

- light on eye → retina → optic nerve → optic chiasma → optic tract → lateral geniculate body in thalamus (away from pretectal nerve) to cerebral cortex to superior colliculus in mid brain for → EWN (edenger westefali nerve) → ciliary ganglion to occulomotor nerve → ciliar body for contraction & miosis (accommodation reflex)
- from ciliar body, the pathway of near response is ventral to light reflex.

* Pupillary light reflex:

Light on one eye => constriction of same pupil (**direct**) and the other pupil (**indirect**).

* Pathway of consensual light reflex (indirect):

- light on eye => retina => optic tract => pass through superior colliculus to end in pretecal nucleus=> both oculomotor nerve nuclei=> both ciliary ganglia of both eyes by oculomotor nerves => miosis in both eyes.
- From ciliary ganglion to ciliary body, this pathway on or near response is ventral to light reflex.
- Atropine drops: block parasympathetic supply => mydriasis.

* Argyl Robertson Pupil: -MCQ-

- Is lost light reflex while accommodation reflex is preserved.
- So => pupil constricts in response to accommodation but not to light reflex.
- It occurs in 3rd stage of Tapes Dorsalis (neurosyphilis), where there is a lesion in pretectal region.

*** Visual acuity :**

is the degree to which details of objects are perceived.

- **Visual threshold** : is minimal amount of light that elicit sensation of light.
- 2 lines can be seen as 2 if a visual angle of about 1 minute between them.
- Examined by Snellen's chart.
- Normal acuity = 6/6, so 12/6 better than normal (not hyperopic)
  6/12 less than normal.

- Increased by increasing receptor stimulated **-MCQ-** :
- at least 1 unstimulated between 2 stimulated.
- Nodal angle < 1 min => increased visual acuity.

Genesis of Photoreceptor Potential:

- Rods and cones potential are graded, local potential.
- Ganglion cell potential is all or none action potential transmitted to optic nerve.
- Rods and cones and horizontal cell response to light are hyperpolarization.
- Bipolar cell response is depolarization (dark) or hyperpolarization (light).
- Amacrine cell response is depolarization and produce generator potential for propagated AP in ganglion cell.
- Cones respond to light intensity of high levels of illumination. -MCQ-
- Rods respond to light intensity of levels of illumination below the threshold levels for cones, so rods are more sensitive.
- So, cones respond at high level of illumination when rods response is maximal and cannot change.

- Photosensitive Compounds:

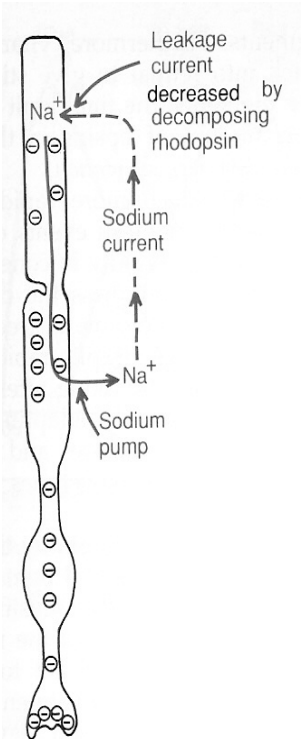
- Opsin protein + retinene 1 (retinal = aldehyde form of vit. A) = rhodopsin (sensitive pigment for light).
- In rods/scotopsin + retinene = rhodopsin has a peak sensitivity to light at wave length of 505 nm, in outer segment rod disks (90% of it protein).
- In 3 types of cones each responds to a certain wave length of light, they have: opsin protein + retinene 1 = rhodopsin.
- In dark rhodopsin is in 11-cisretinal form (inactive form of rhodopsin).

Ionic Basis Photorecepter Potential :

In dark Na channel in rod and cones outer segment are open
So Na flow from inner to outer segment (Na current or dark current) ➔ **Depolarization flow**
to synaptic ending
steady release of neurotransmitter at dark at synaps with bipolar cell get depolarization potential

Electrophysiology of vision (photo transduction)

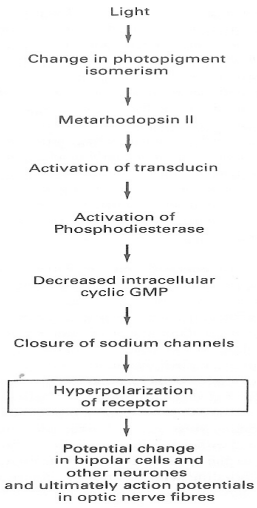
* At Dark (scotopic vision, dimlight vision): -MCQ-



1- Rhodopsin in 11-cisretinal (inactive form , light sensitive form which increase sensitivity of rods to light in dimlight).
2- (5-GMP) in the cGMP form => opening of Na channels at outer segment (at cGMP gated Na channels, cGMP bound to protein at Na channel membrane and keep them open) => Na influx => depolarization.
3- Dark current (Na current): due to Na (from inner segment) re-entered through cGMP gated Na channels (outer segmen t).
4- A wave of depolarization spread to synaptic terminals.
5- Synaptic mediators are continuously (steadily) released (mainly glutamate) + Ach + dopamine + GABA.
6- Response in bipolar cells (depolarization) => ganglion cells => action potential in optic nerve => vision at dark.

N.B. at dark rhodopsin is inactive, cis-retinal needs light for its activation, so at dark
inactive rhodopsin is essential for depolarization, as its inactivation keeps Na. channel open and Na current occur this the causative factor for depolarization
this is the basis of dark adaptation and dim light vision
at dark rohdopsin is regenerated from retnin + scotopsin

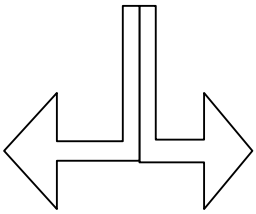
AT light



Scotopic:

- **dim light vision.**
- **No colors + details.**
- **Great sensitive to illumination.**
- **Served by rods.**
- **Peak of its curve at 505 nm.**

Duplicity Theory of Vision



Photopic:

- **bright.**
- **Colors + details.**
- **Less sensitive to illumination.**
- **Served by cones.**
- **at 550 nm.**

Visual cycle :

- light decomposes rhodopsin (11-Cisretinal) to all trans isomers → metarhodopsin that is bleached to retinin (aldehyde form of vit.A + scotopsin)

- retinin + scotopsin ----------> vit.A + scotopsin → rhodopsin regeneration in the dark then decomposed by light

- Nyctalopia: (Night blindness):

Decrease in the ability to see in dim light (rod function is decreased).

- Vit. A deficiency causes rods & cones and retinal degeneration and loss of rods.
- Treated by vit. A if the receptors are well.

* Dark adaptation :

- when person moves from lighted environment to dimly lighted environment then retina becomes more sensitive to light and person will see at dark (accustomed to dark) in about 20min (only gross feature but no details or colors)
- visual threshold is minimal amount of light elicits light sensation
- Rhodopsin in darkness is essential for depolarization of rhods(to see in dark Na channel will be open) and for dark adaptation.
- once light enters the eye metarhodopsin from rhodopsin initiates cycle of events for light vision .

* dark adaptation has 2 components :

1. rapid → about 5min and small in magnitude drop in visual threshold, there is fast dark adaptation of cones only in Fovea, so sensitivity of cones to light increase to see at this time
2. less rapid → till 20mins & large in magnitude drop in visual threshold in which there is dark adaptation for rhods in peripheral retina so that sensitivity of rhods to light increase in 1min increase 10 folds
3. rhods increase their sensitivity to light by convergence 300:1 ganglion cells so summation of ganglion cells potential will increase sensitivity of rodes to light

- N.B : 20mins for dark adaptation are for regeneration of rhodopsin which increase sensitivity of rhods to light and causes drop in visual threshold i.e increase sensitivity to light (because in light all rhodopsin

in rhods and cones decrease and converted into retinal and protein) so sensitivity to rhods and cones to light decrease .

- Q: Radiologist & aircraft pilots should wear red- goggles in bright light?
  Because light wave length in red end of spectrum stimulate the cones reassembly and stimulate rhod to come extent, so red goggles for rhods act as dim light, so with it rhods are adapted to darkness and form large amount of rhodopsin, while the person in bright light .. and when person enter the dark places he can see well and not remain 20min

* Light adaptation :

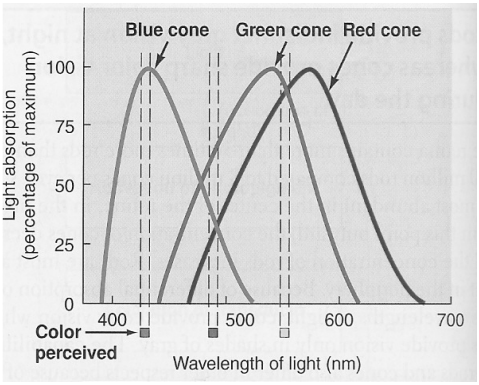
when light is switched on again, the rods are knocked out of action (they stop sending action potential at low level of light) & cones start to function to adjust & adapt to the level of brightness in 5 min.

* Color vision :

- it is the ability to discriminate between different colors.

1. there are 3 primary colors red, green, blue sensed by cones in Fovea centralis & appreciated by photopic vision
2. sensation of extra spectral colors as white, yellow, orange, purple can be produced by mixing properties of blue and red and green in different combination
3. black means absence of light (not darkness because in dark we don't see black)

*Color vision theory: (Young-helmholtz theory):



1- blue cone system : has S pigment (blue sensation pigment) which respons to short wave length 440nm (sense blue color)
2- green cone system : has M pigment (green sensation pigment) which respond to middle wave length 535nm (sense the green color and less to yellow and absorb light at the green portion)
3- red cone system : has L pigment (red sensation pigment) which respond to large wave length at or > 535nm . so sense the red & yellow color & absorb light at red portion .

* Sensation of Color is Determined by:

1- wave length of the light
2- amount of light absorbed by each type of cones
3- frequency of impulses from each cone system to ganglion cells which is determined by wave length of light
4- each cone system respond to it's color at a lower threshold that needed to sense other colors (red cones respond to red or yellow color at a lower threshold than green color).

5- perception of white is due to equal stimulation of blue + red + green cones. There is no wave length correspond to white. White is a combination of all wave lengths
6- Perception of orange is due to stimulation of 99% red cones, 42% of green cones, 0% of blue cones. So ratio is (99:42:0)
7- Perception of yellow : is due to stimulation of 50% red cones & 50% green cones & 0% of blue cones (the ratio is 50:50:0).
8- Perception of blue is due to stimulation of 97% of blue cones only (the ratio is 0:0:97).
9- Color Vision is Coded by:

Different responses in ganglion cells that respond upon the wave length of stimulus which determine frequency of impulses in ganglion cells.

* what is the advantage of color vision ?

Important to distinguish an object from it's background

* Color Blindness:

Gene of Rhodopsin => on chromosome 3
Gene of Blue sensitive S cone pigment => on chromosome 7
Gene of Red + green sensitive cone pigment => on chromosome x

- when a single group of photoreceptive cones is absent (due to absence of theirs gene) the person can't see or distinguish one color from another

* Red green blindness:

- Because green & red cones see different colors between wave length 525-675nm and distinguish them
- If either green & red cones are absent, the person can't distinguish 4 colors (red-green-yellow-orange) can't distinguish red from green
- It is x-linked disease transmitted from females to their son (male).
- Never occurs in females but occurs only in males because they have only one x, whereas females have 2 x. female shows the disease only if both x chromosomes lack the gene, if one x chromosome miss the gene for color vision => get color blindness
- Females shows the disease if both x chromosomes lack the gene, from color blind father are carriers => ½ of sons will be affected.

* Trichromats: have 3 cone pigments (normal or have slight weakness in detecting red or green or blue color).

* Dichromats: have 2 cone pigments only so he is completely blind to red or green or blue so they may have Protanopia or Deutranopia or Tritanopia. (they get color by mixing 2 of primary colors)

(anomaly=>weakness , anopia=>blindness) –MCQ-

- Protanopia => red blindness, no red cone system. The person has shortened spectrum wave length. If only weakness in red vision is called Protanomaly.

- Deutranopia => green blindness, no green cone system, person has normal spectral width because green cones operate in the middle (so a person can see only long & short wave length). If only weakness in green vision is called Deutroanomaly.
- Tritanopia => blue blindness, no blue cone system. If only weakness in blue vision is called Tritanomaly.

* Monochromats: have only one cone system or loss of all so see only white or black or grey or have no color perception.

* Layers of Lateral Geniculate Body (LGB) : it has 6 layers

- 1,2 is magnucellular layer, recives from large ganglion cells, it is rapidly conducting to visual cortex
  - function :
    Concerned with detecting movement
    Stereopsis
    Flickers
    Spatial organization
    Brightness
  - it's color blind transmit only white & black
  - for location

- 3,4,5,6 parvocellular layer, receive from P small ganglion cells, it is moderately conducting pathway to visual cortex
  - function :
  Color vision
  Shapes & texture
  Point to point spatial information cause it sends point by point from retina to visual cortex (point to point= retinotopic arrangement)

- Intralaminal layer → ends in blobs, for color vision only in visual cortex

* Lateral Geniculate Body (LGB) :

- Layers 2,3,5 receive from → temporal part of ipsilateral retina = nasal part of visual field
- Layers 1,4,6 receive from → nasal part of contralateral retina = temporal part of contralateral field
- Left LGB has all layers receive from right 1/2 of visual field & right LGB has all layers receive from left 1/2 of visual field

- Functions of LGB :
  4- Acts as relay station for visual information from optic tract to cortex.
  5- Has spatial fidelity (point to point transmission).
  6- Acts as gate control signal transmission to visual cortex i.e. control number of signals reach visual cortex.
  7- Color vision, shapes and texture