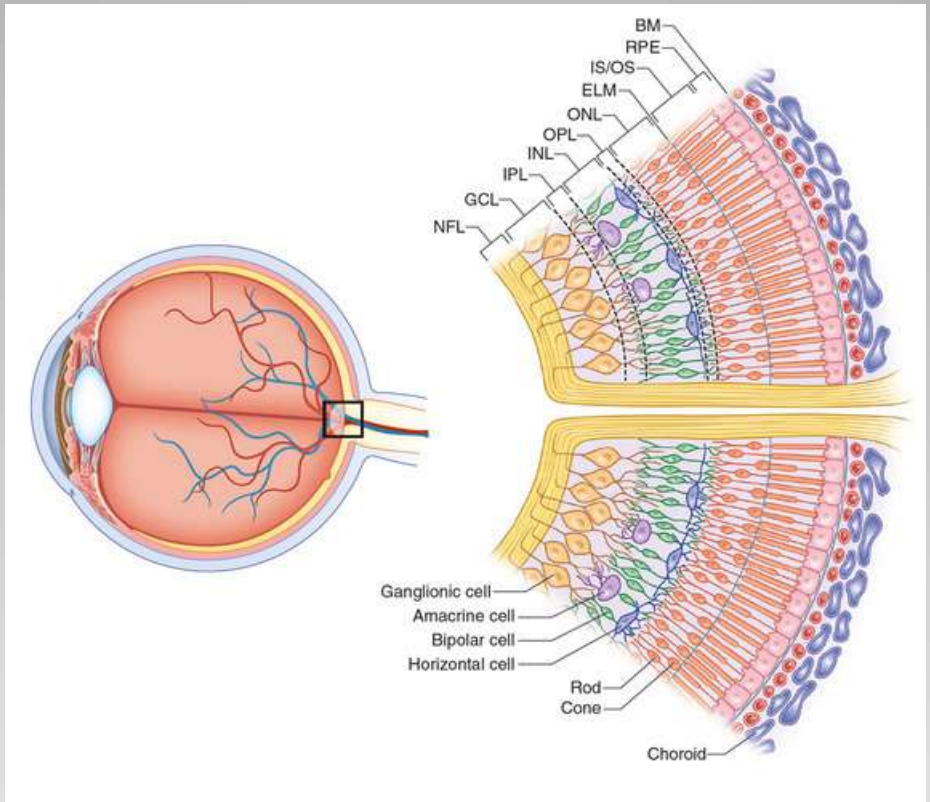
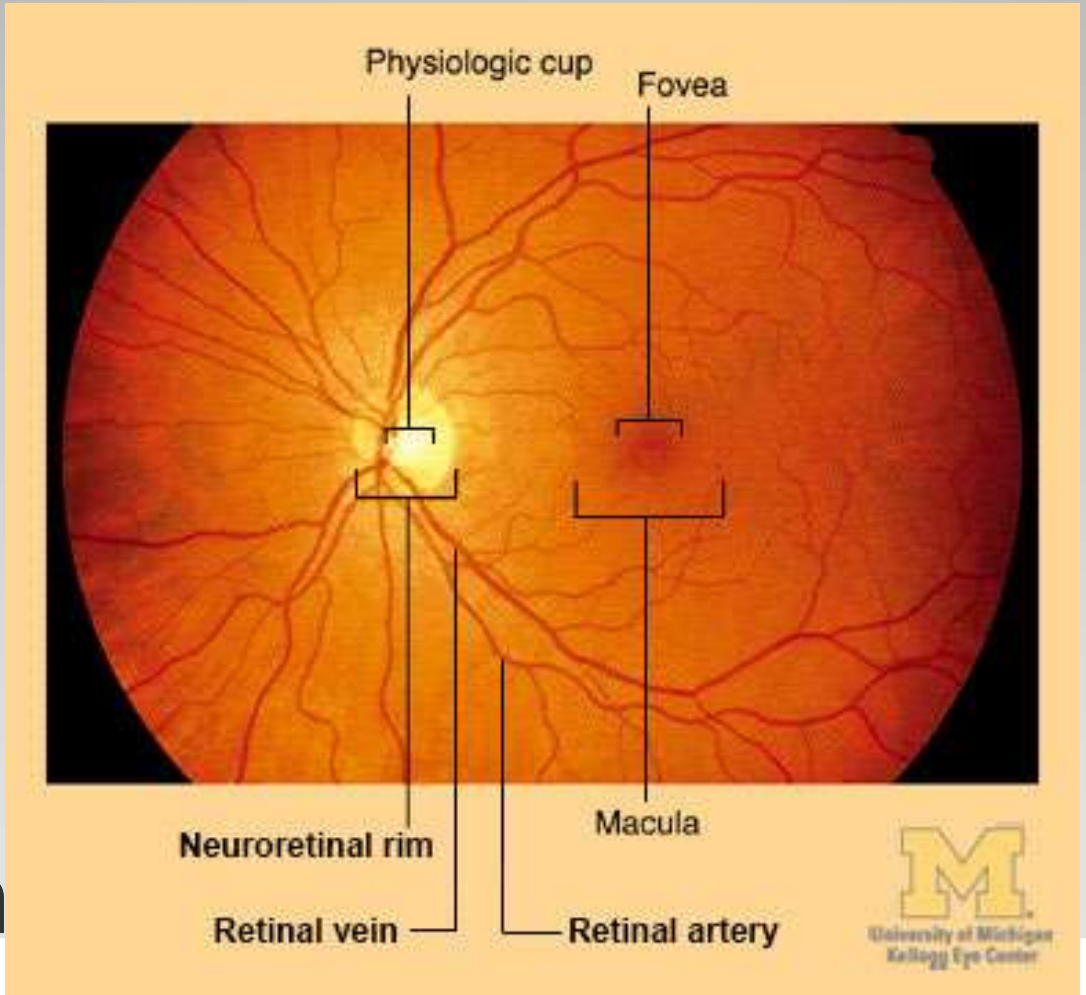
Retina

DR.BIRVA DAVE


BM
RPE
IS/OS
ELM
ONL
OPL
INL
IPL
GCL
NFL
Ganglionic cell
Amacrine cell
Bipolar cell
Horizontal cell
Rod
Cone
Choroid

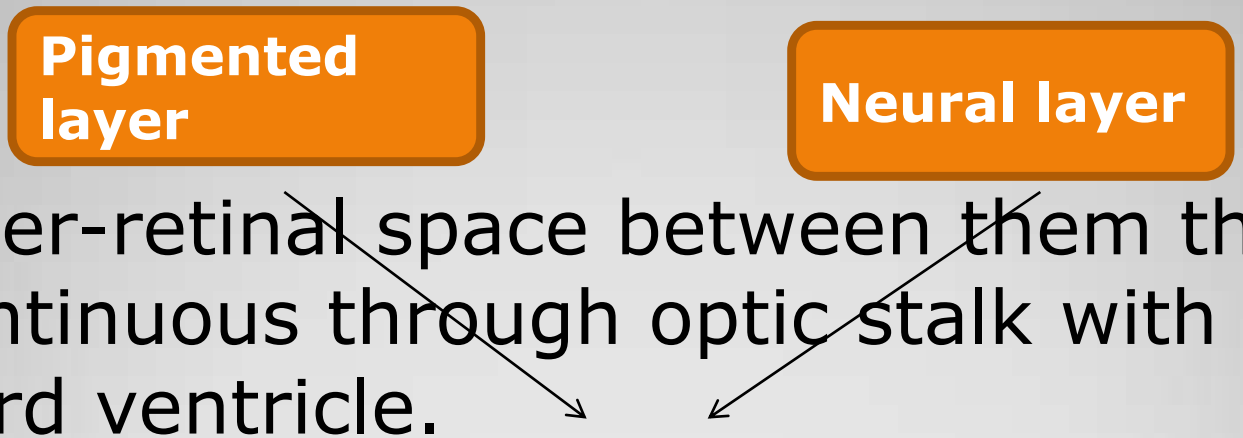
Norm


Physiologic cup
Fovea
Neuroretinal rim
Macula
Retinal vein
Retinal artery
University of Michigan
Kellogg Eye Center

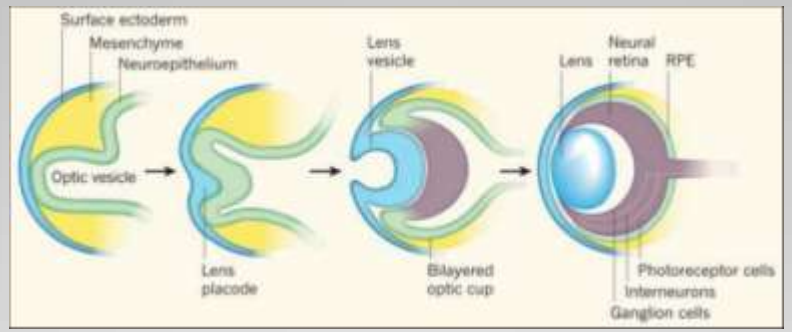
- Retina is a thin, delicate and transparent innermost membrane of the eyeball.
- It is the most highly developed tissue of the eye.
- It extends from the optic disc to the ora serrata and surface area of about 266 $mm^{2.}$

Embryology

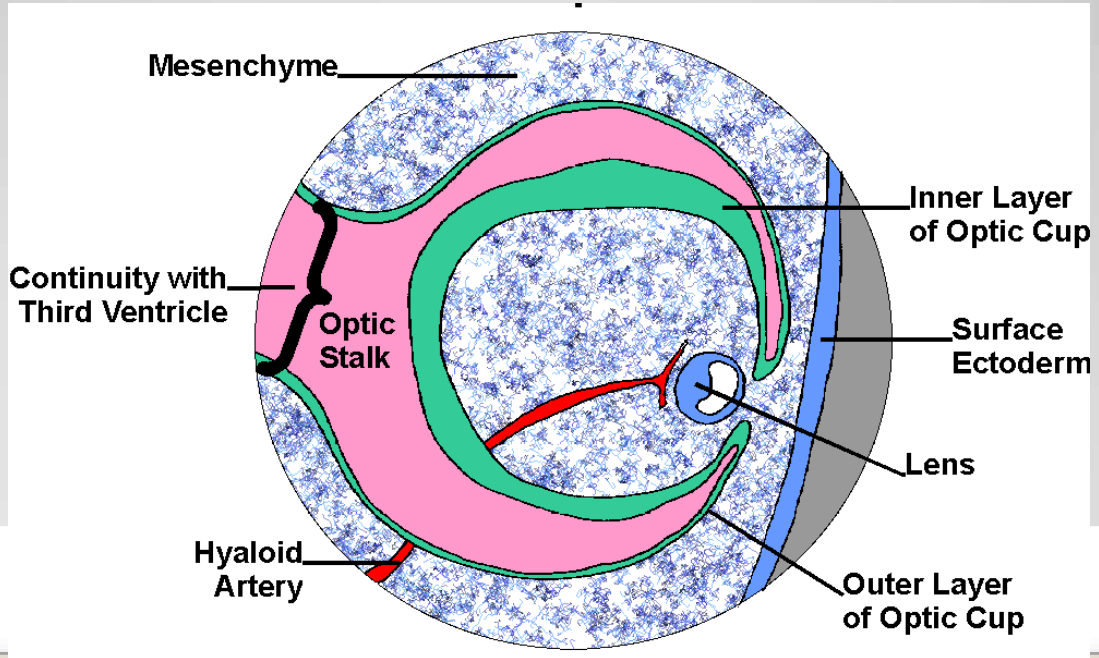
- Retina consists of two layers developed from optic cup



- Inter-retinal space between them that is continuous through optic stalk with the third ventricle.


Surface ectoderm
Mesenchyme
Neuroepithelium
Optic vesicle
Lens placode
Lens vesicle
Bilayered optic cup
Lens
Neural retina
RPE
Photoreceptor cells
Interneurons
Ganglion cells

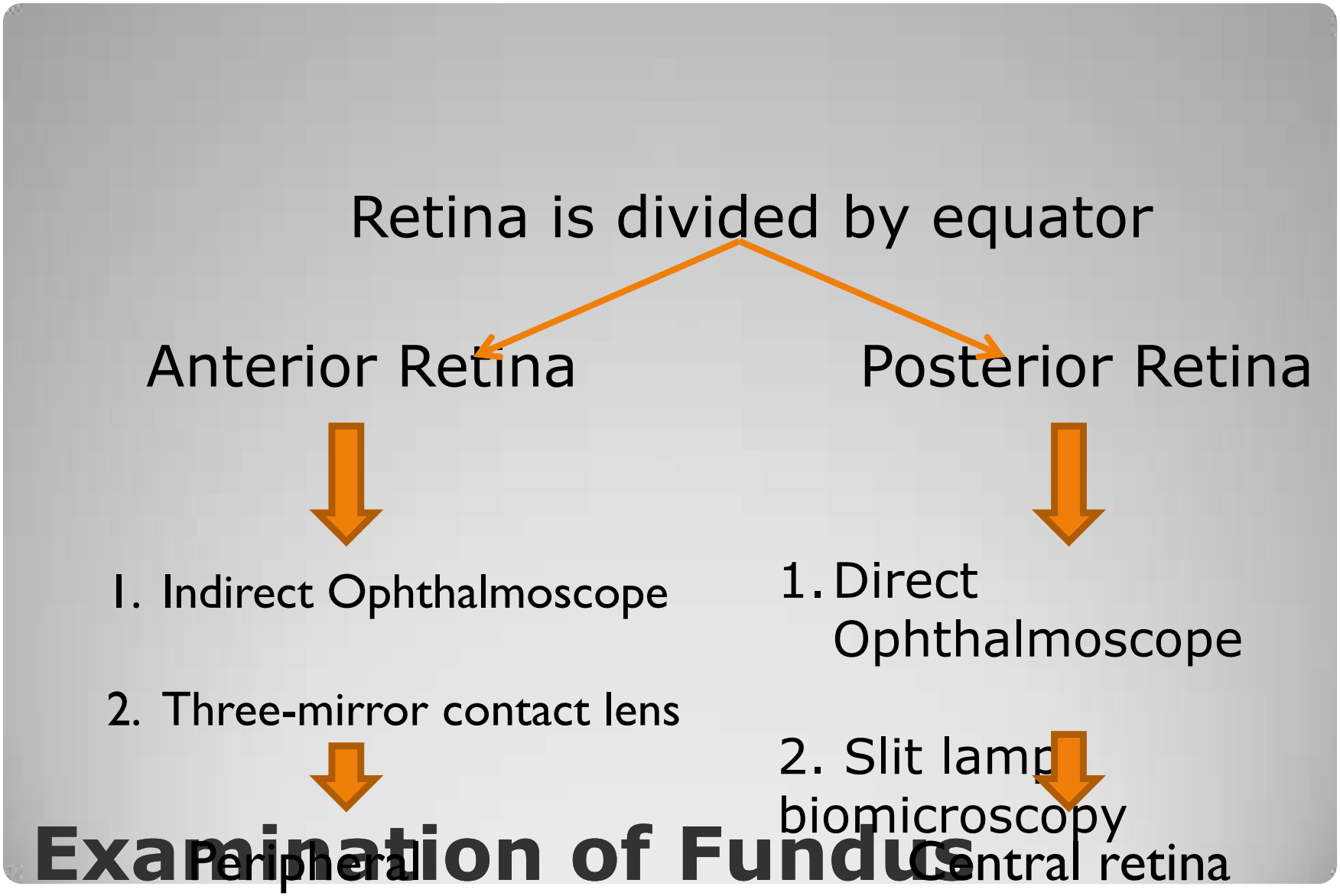
1. **Pigmented layer**(External): formed from the outer thinner layer of optic cup. By 6th week.
2. **Neural layer**(Internal): formed from the inner layer of optic cup. Start by 40 days continue until 7th month.



Retinal detachment

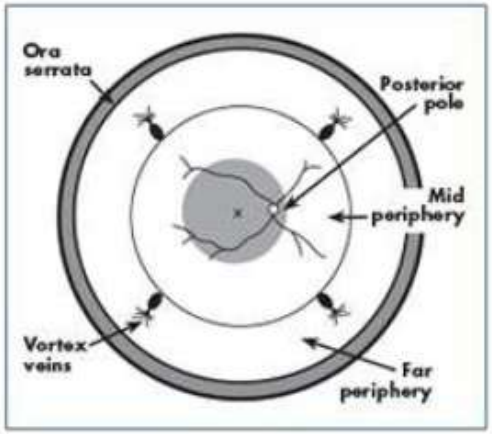
- Fluid accumulation between the two layers of optic disc vesicle (potential space) wherein there is a separation of RPE and neurosensory retina causes retinal detachment.
- Types: rhegmatogenous (break), exudative (tumor), tractional (diabetic).
- Treatment: surgery

Examination of Fundus

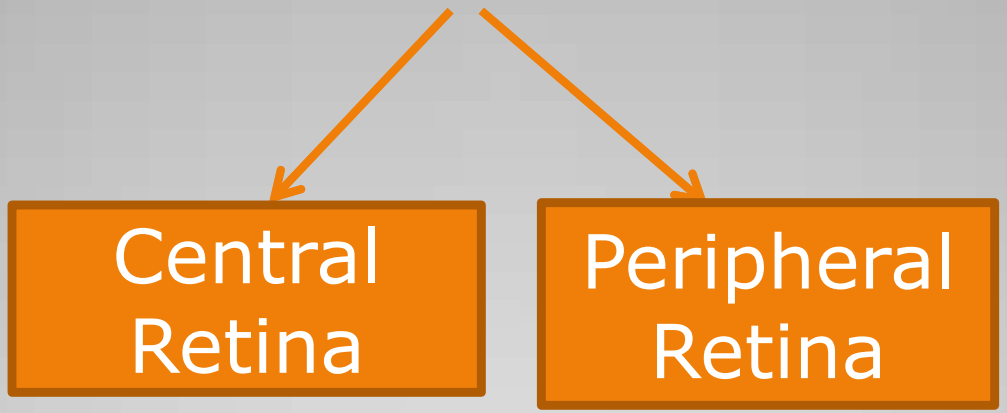


Retinal Equator

- Retinal Equator – Line where 4 vortex veins exit , retina posterior to this is known as posterior retina.



Gross Anatomy



1. Foveola
2. Fovea
3. Perifovea
4. Parafovea
5. Macula

Rich in cones

1. Near periphery
2. Mid periphery
3. Far periphery
4. Ora serrata

Rich in Rods

Clinical functions

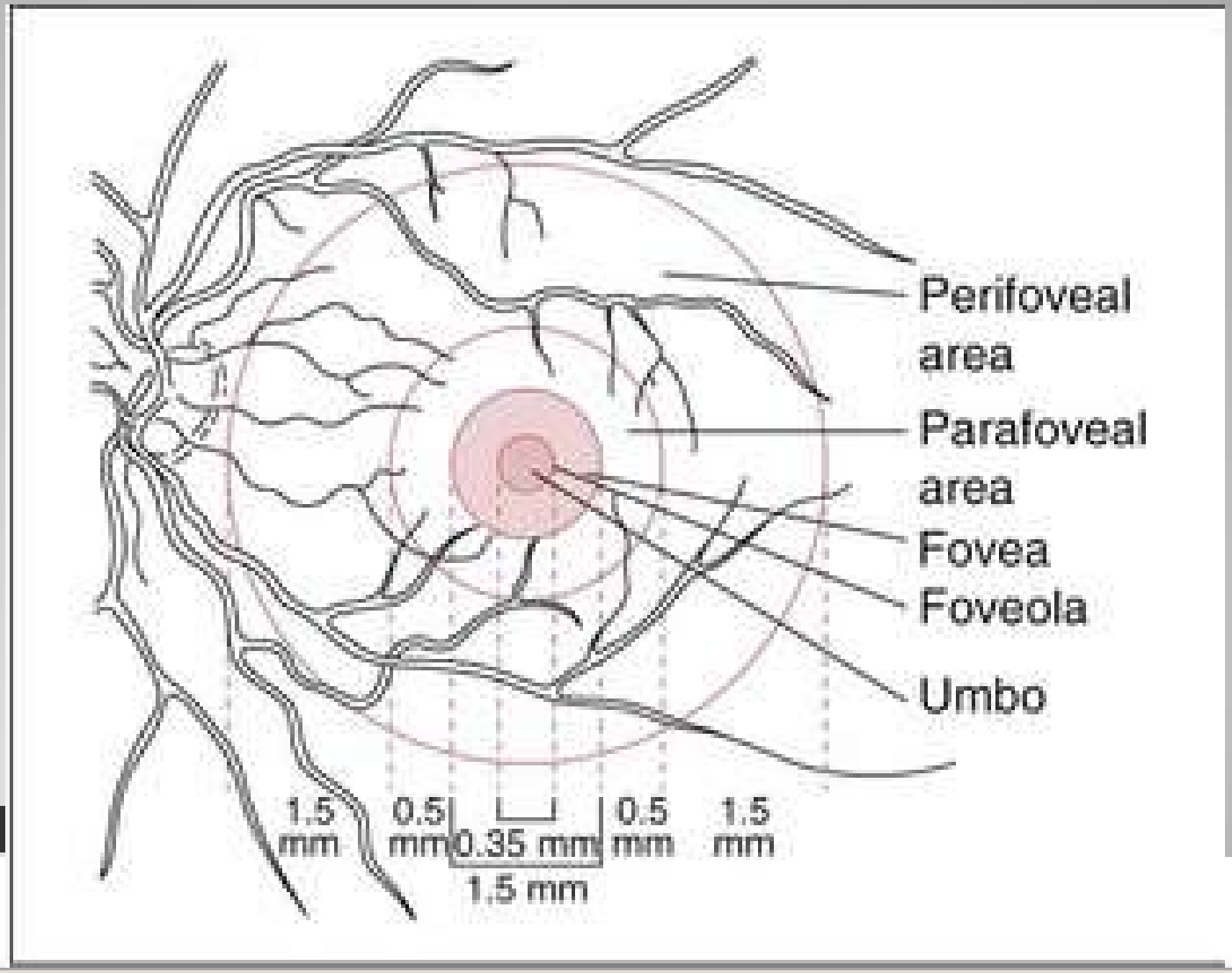
Central Retina

1. Fine visual acuity
2. Photopic vision
3. Stereopsis
4. Color vision

Peripheral retina

1. Gross vision
2. Scotopic/night vision
3. Sensitive to motion and stimulates turning of eye/head

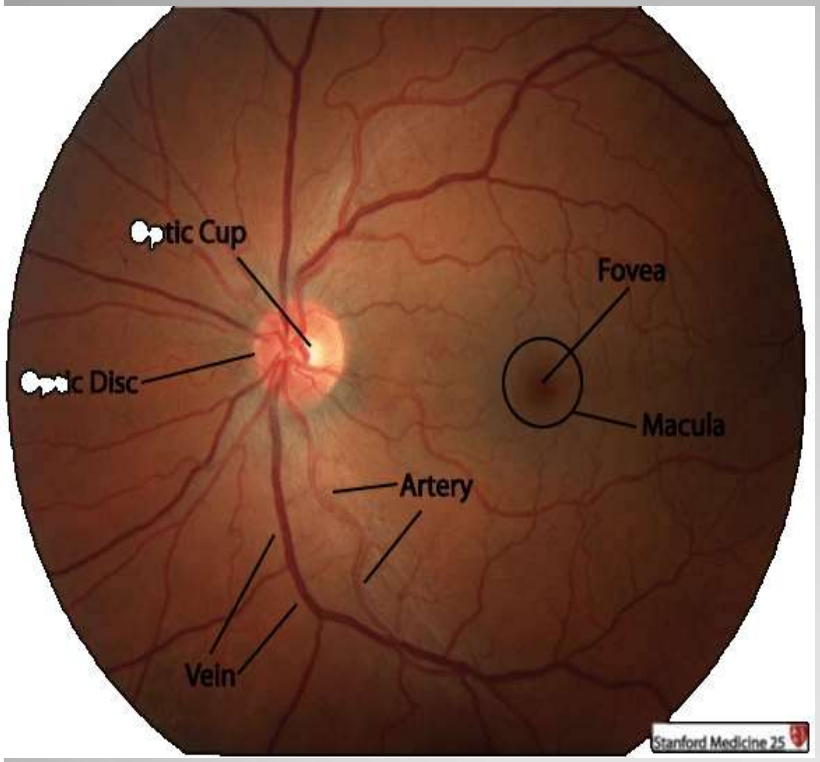
Centr


Perifoveal area
Parafoveal area
Fovea
Foveola
Umbo
1.5 mm
0.5 mm
0.35 mm
0.5 mm
1.5 mm
1.5 mm

Area centralis / Macula

- Specialised region of retina
- Demarcated by superior and inferior temporal arterial arcuate

- Diameter- 5.5 mm
- Location- 2 DD – temporal margin of disc
- Color- Yellow; deep pigmented
- Corresponds 15º of visual field
- Responsible for photopic and color vision

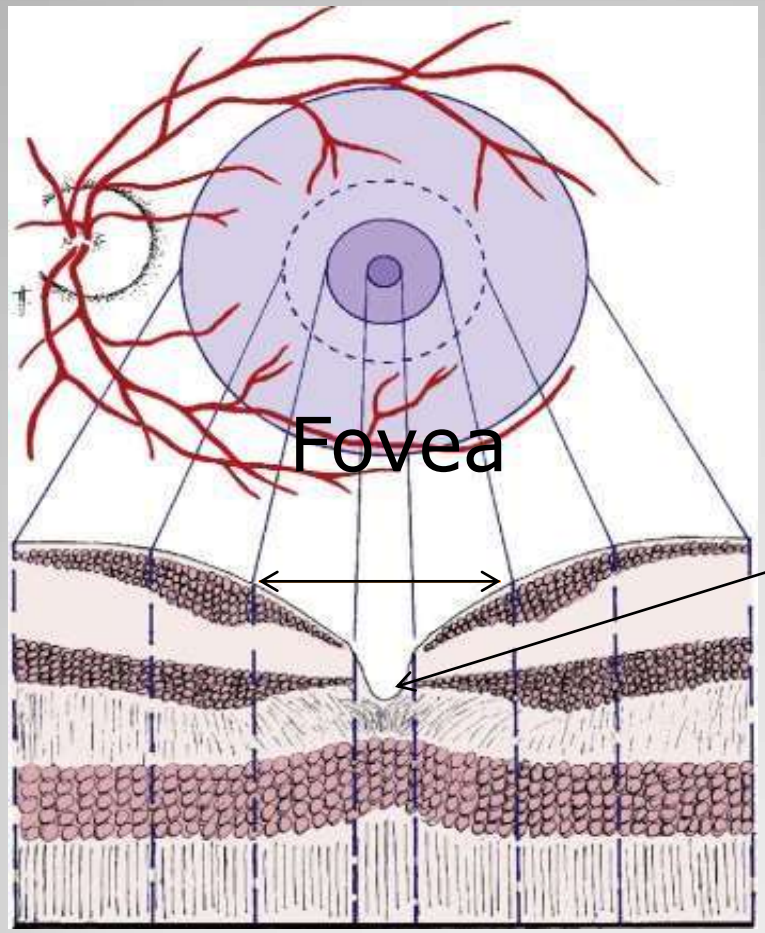


- Macula-Dark area in the central retina
- Protects central vision by following characteristics;

1. Highly pigmented tall epithelial cells of RPE(highest pigmentation of entire retina)- which give dark macula.
2. Dense pigmentation helps to reduce scattering of light.
3. The choroidal capillary bed also is thickest in the macula.
4. It has also yellowish hue due to highest concentration of xanthophyll pigments.

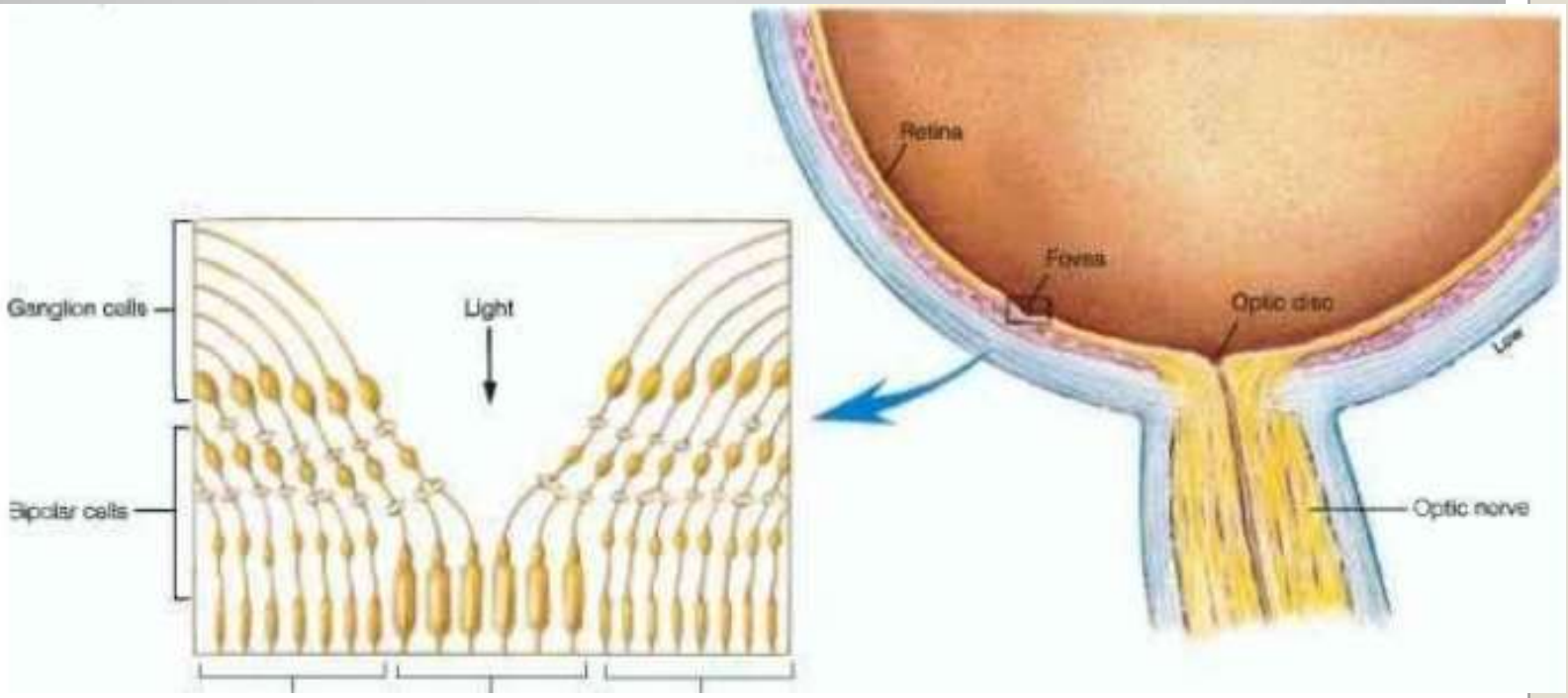
Fovea

- Centre of area centralis
- Appx. 4 mm temporal to optic disc and 0.8 mm below horizontal meridian
- Diameter --1.55 mm (5° visual field)
- Thickness -- 0.25 mm

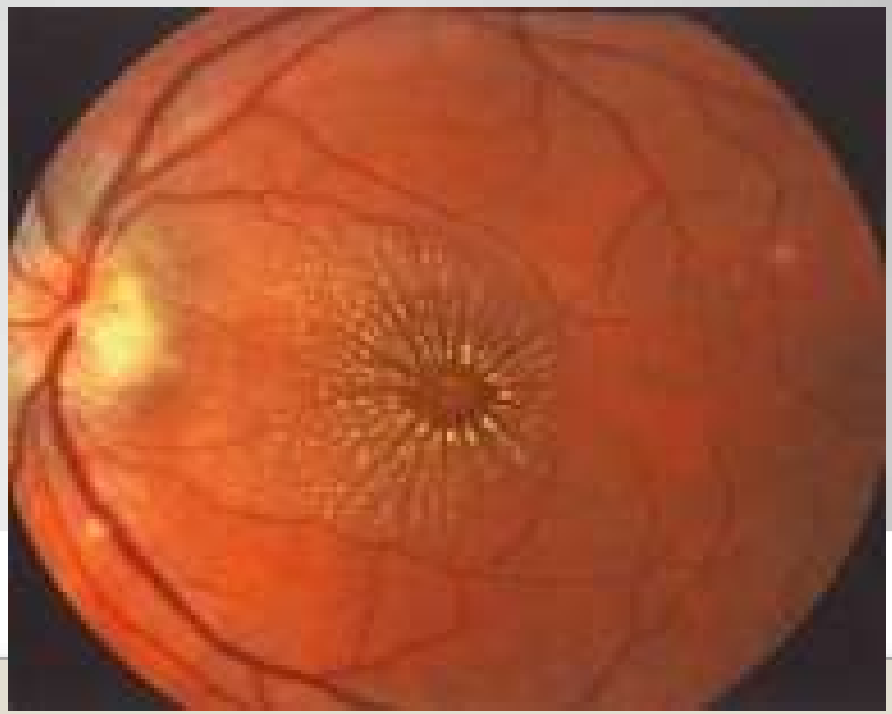


At the centre of the fovea, the layers of the retina are thinner so that a Central concave indentation – **foveola** produced

- The inner nuclear layer and ganglion cell layer are displaced laterally and accumulate on the curved walls of the fovea called Clivus



- The photoreceptor fibers(cones) become longer as they deviate away from the center; these fibers are called Henle's fibers
- Chronic retinal oedema may result in the deposition of hard exudates around the fovea in the layer of Henle with a macular star configuration.



Six layers present in the foveola are ;

(1)Internal limiting membrane

(2)outer plexiform layer.

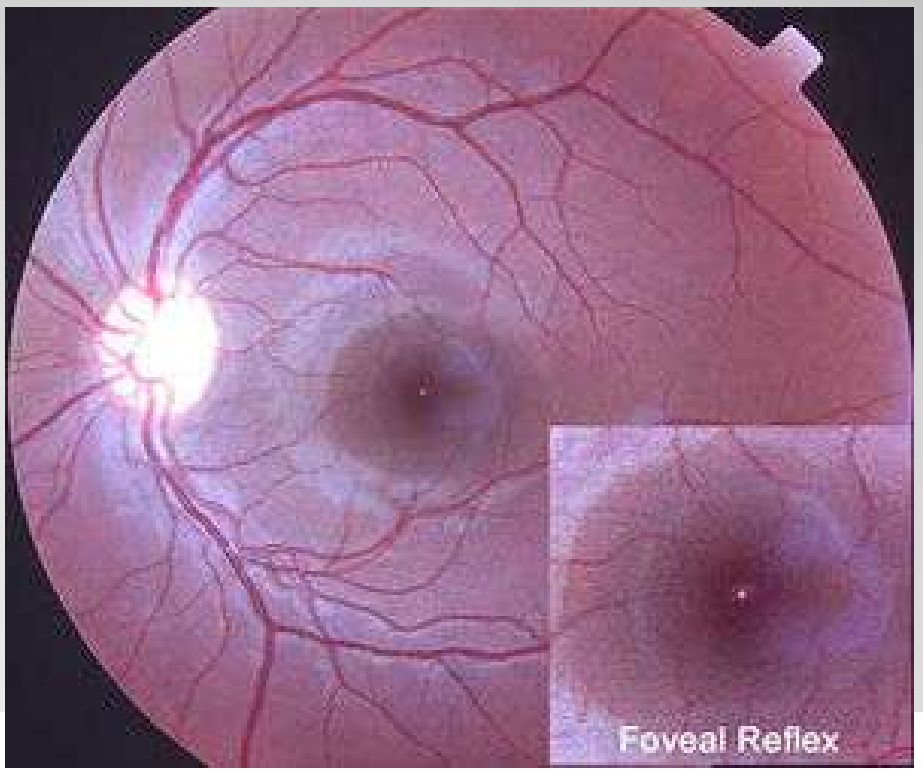
(3)ONL (which contains about 10 rows of cone nuclei),

(4)external limiting membrane,

(5)photoreceptor layers

(6)RPE

- Foveal reflex is caused by the parabolic shape formed by the clivus/umbo
- Loss of foveal reflux implies disruption of neural layers

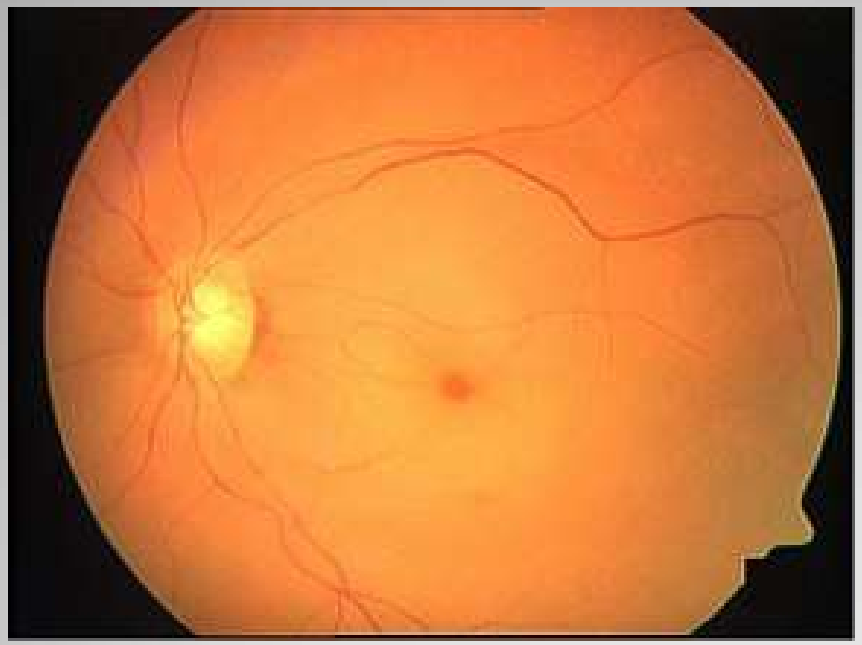


Foveola

- Diameter – 0.35 mm
- Thickness – 0.13mm
- represents the area of the highest visual acuity in the retina
- even though its span corresponds to only 1° of the visual field

- Sole presence of cone and partly avascular
- Lack of blood vessels and neural tissue in foveola allows light to pass unobstructed into the photoreceptor outer segment

- Appears deeper red – rich choroidal circulation of choriocapillaries which shines through it.
- Cherry red spot : when surrounding retinal cloudy after obstruction to retinal vasculature or metabolic diseases.



Cherry-red spot

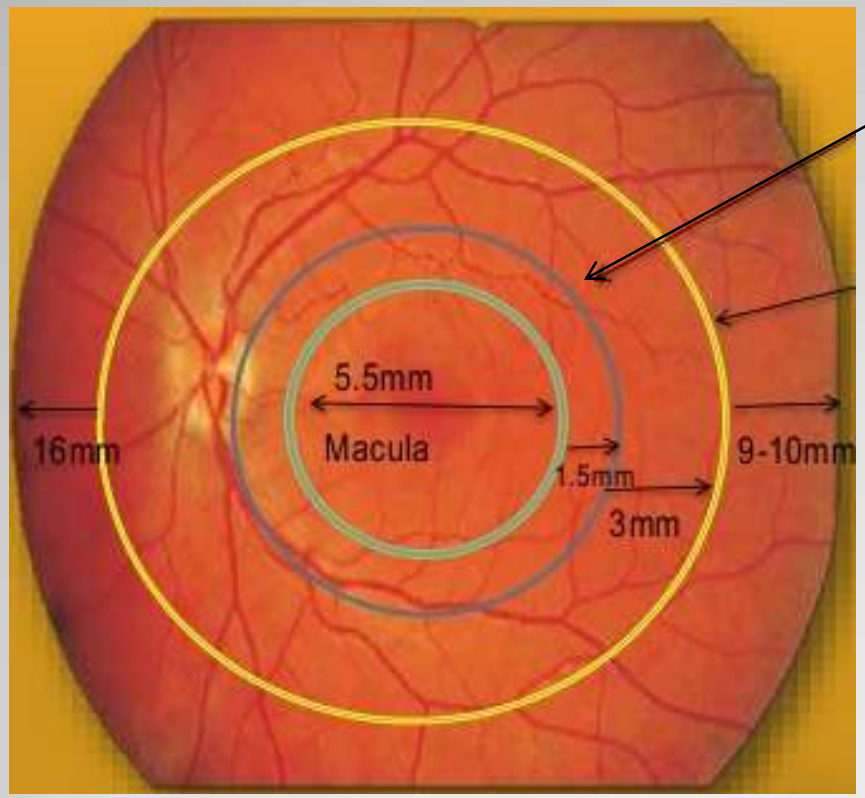
D/D of cherry red spots:

1. Metabolic Storage Diseases
2. Leber's congenital amaurosis
3. central retinal artery occlusion
4. Quinine toxicity & Dapsone toxicity
5. Poisoning like carbon monoxide and methanol

Peripheral Retina

4 Regions:

1. Near Periphery: Circumscribed region of about 1.5mm around the area centralis.
2. Mid periphery: Occupies 3mm wide zone around the near periphery
3. Far periphery: Extends from the optic disc 9-10mm on the temporal side and 16mm on the nasal side in the horizontal meridian.



Near periphery

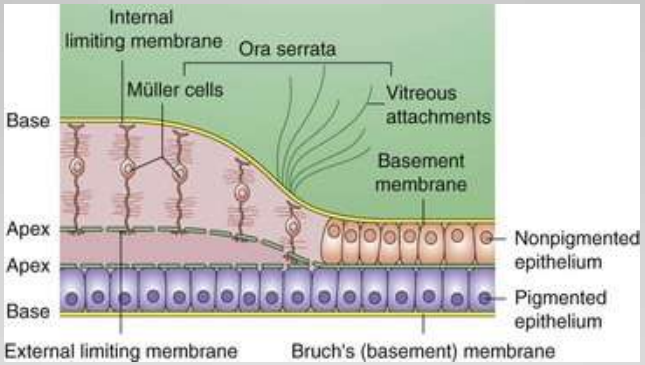
Mid Periphery

Far periphery

4. Ora serrata

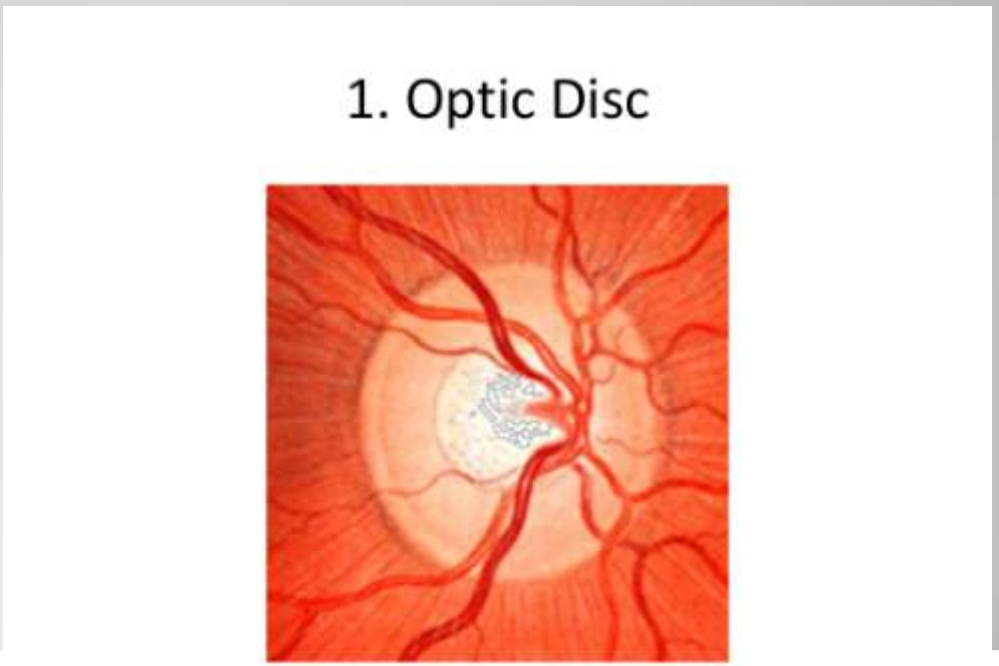
- Most anterior region of retina
- It is transition zone between retina and par plana
- Strong vitreous attachment
- Safe zone for retinal procedures

Description	Length
Width of ora serrata	2.1mm temporally 0.7-0.8mm nasallly
Location from limbus	6mm nasally 7mm temporally
From equator	6-8mm
From optic disc	25 mm nasally


Internal
limiting membrane
Ora serrata
Müller cells
Vitreous
attachments
Base
Basement
membrane
Apex
Nonpigmented
epithelium
Apex
Pigmented
epithelium
Base
External limiting membrane
Bruch's (basement) membrane

Optic disc

- It is a pale-pink, well-defined circular area of about 1.5 mm diameter.

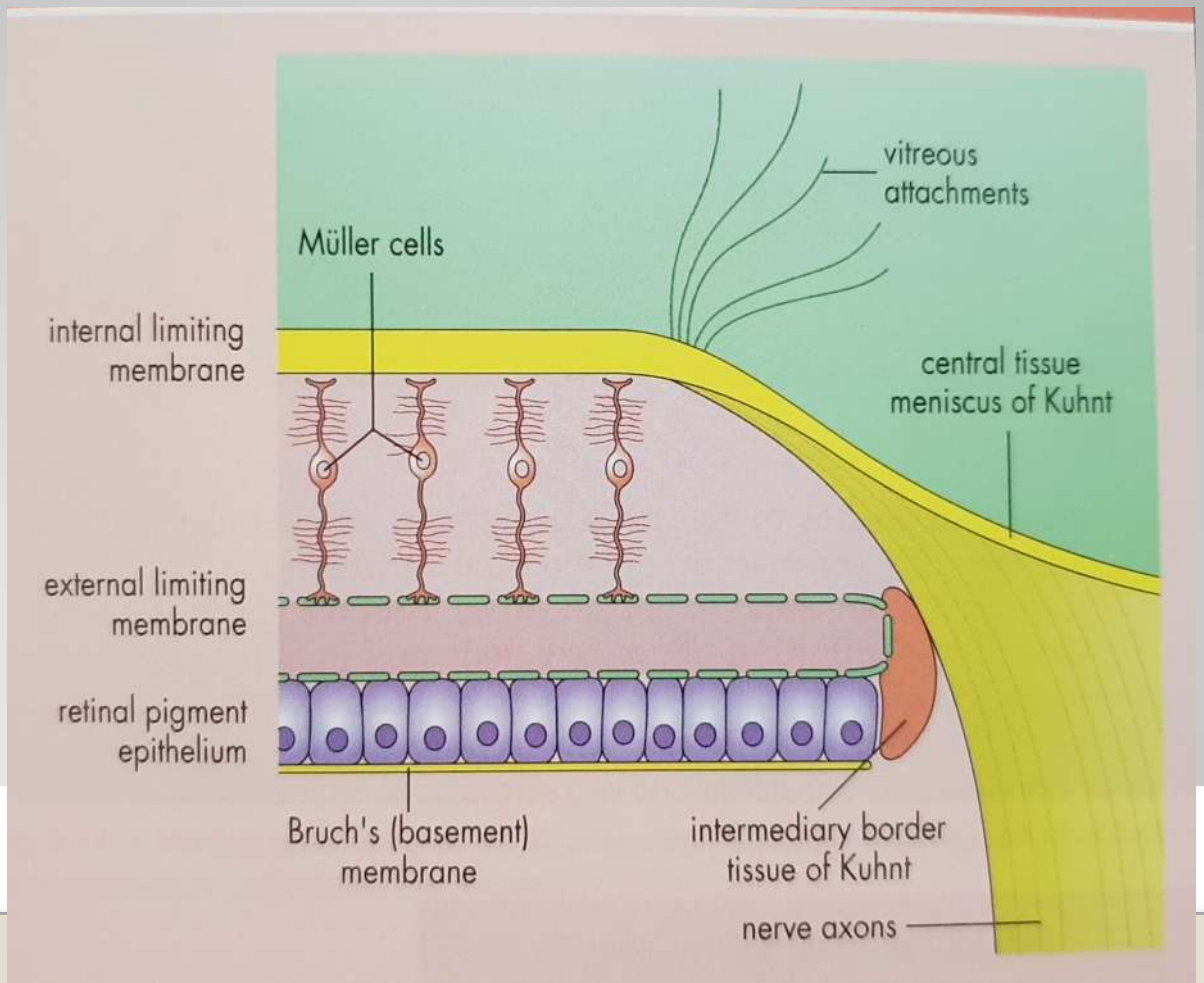


- There is a central depression, of variable size, called the optic cup. This depression can be a variety of shapes

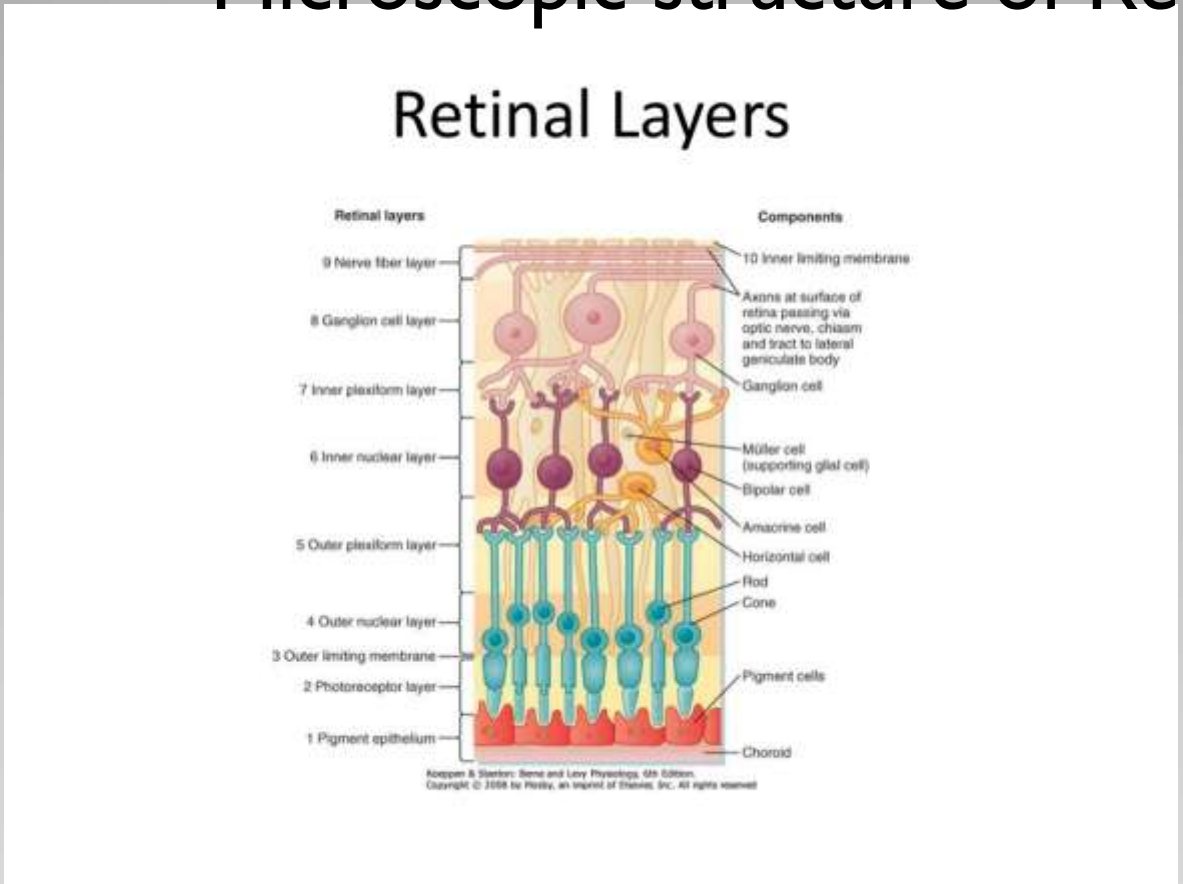
- there are no rods or cones overlying the optic disc, it corresponds to a small PHYSIOLOGICAL blind spot in each eye.

- Around the optic cup is neuroretinal rim:
  - Pink and sharp peripheral margin
  - Contain nerve axon
  - Broad inferior rim followed by superior> nasal>temporal (ISNT rule)

- At the optic disc, all the retinal layers terminate except the nerve fibres, which pass through the lamina cribrosa to run into the optic nerve

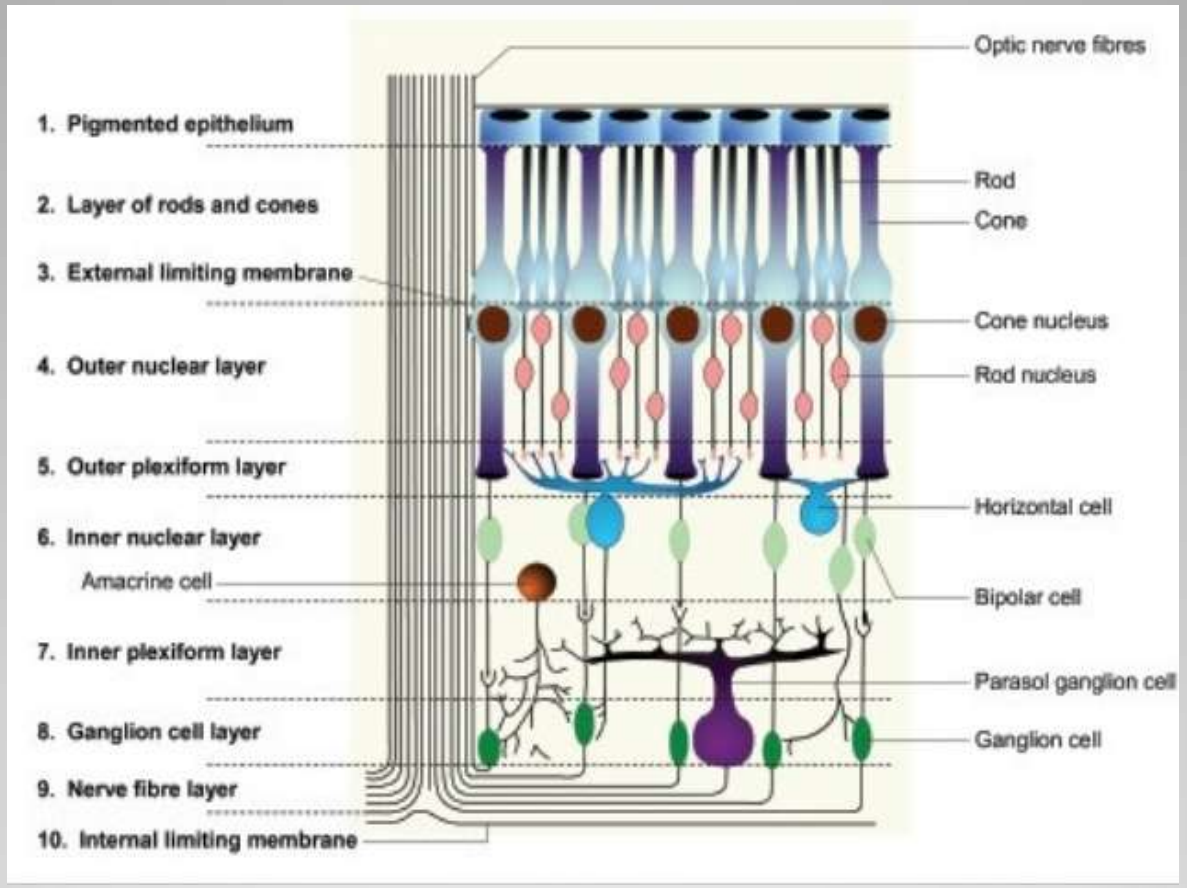


Microscopic structure of Retina

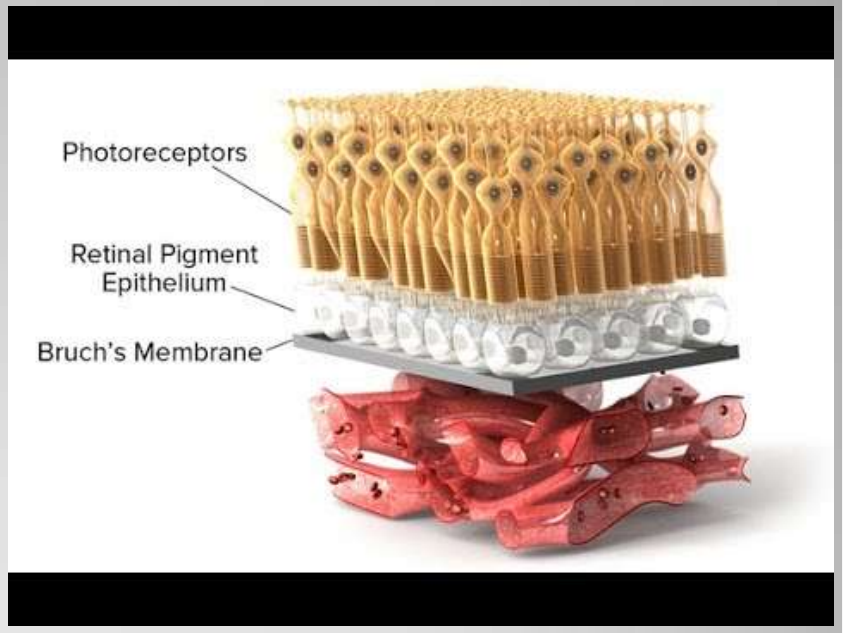


1. Pigment epithelium (RPE)
2. Photorececeptor Outer and Inner Segment Layers (OS & IS)
3. External Limiting Membrane (ELM)
4. Outer Nuclear Layer (ONL)
5. Outer Plexiform Layer (EPL)
6. Inner Nuclear Layer (INL)
7. Inner Plexiform Layer (IPL)
8. Ganglion Cell Layer (GCL)
9. Nerve Fibre Layer (NFL)
10. Internal Limiting Membrane (ILM)

Microscopic structure of Retina


1. Pigmented epithelium
2. Layer of rods and cones
3. External limiting membrane
4. Outer nuclear layer
5. Outer plexiform layer
6. Inner nuclear layer
Amacrine cell
7. Inner plexiform layer
8. Ganglion cell layer
9. Nerve fibre layer
10. Internal limiting membrane
Optic nerve fibres
Rod
Cone
Cone nucleus
Rod nucleus
Horizontal cell
Bipolar cell
Parasol ganglion cell
Ganglion cell

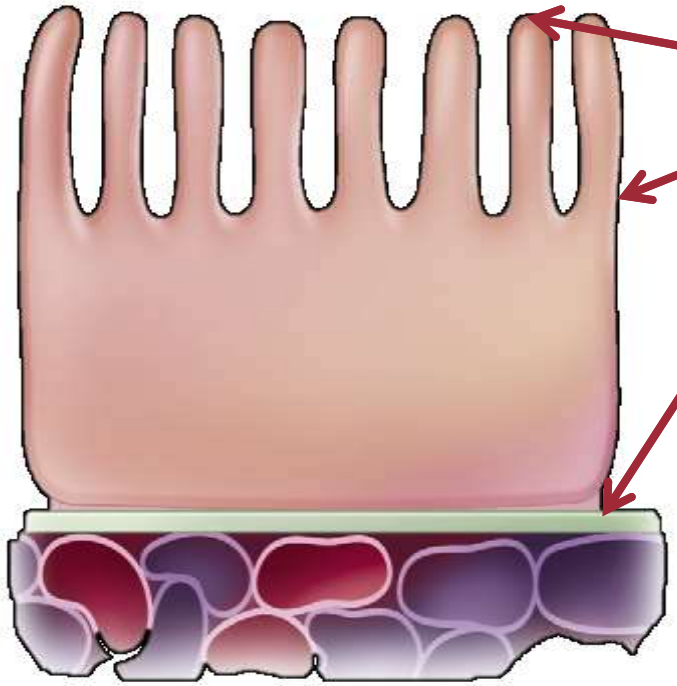
- Single layer of 4.2 – 6.1 million cells firmly attached to Bruch's membrane (basal lamina of choroid)
- Microfibrils originate here and extend to lamina elastica of bruch's membrane



1. Retinal pigmented epithelium

RPE- ULTRASTRUCTURE

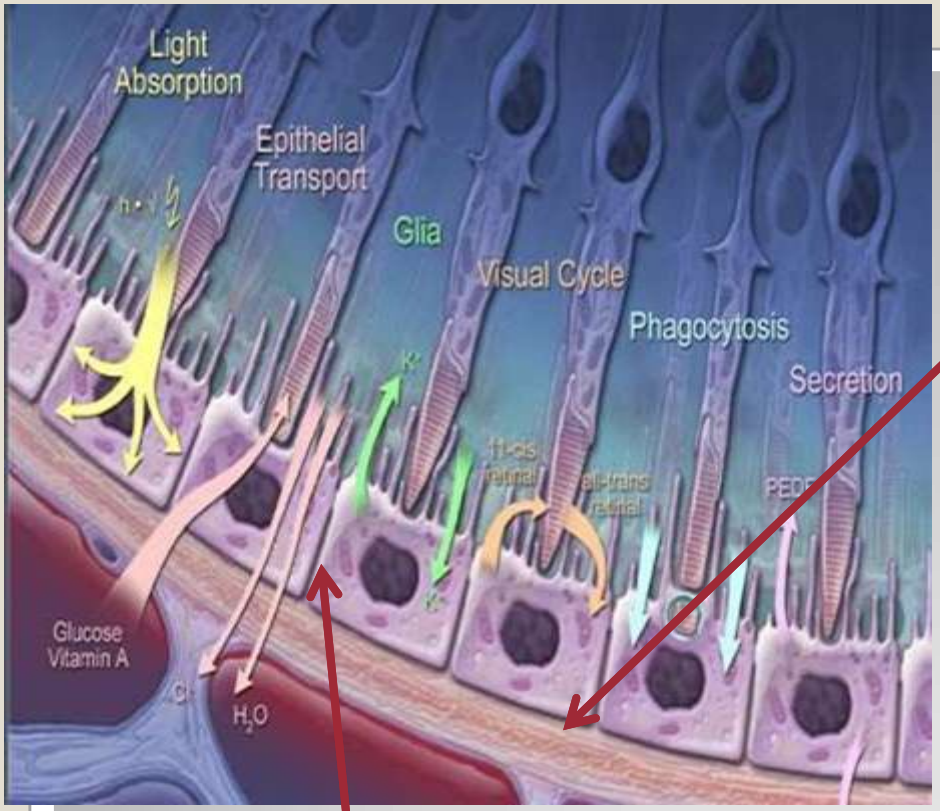
RPE are Cuboidal cells with three Cell Surfaces



1.Apical surface –inner **surface**
2.Paracellular surface- intercellular surfaces
3.Basal surface – outer surface

1. Apical surface

- Has microvillous processes- Increases Surface area
- Interdigitate with outer segments of photoreceptor cells
- Contains melanin granules – more in macular region

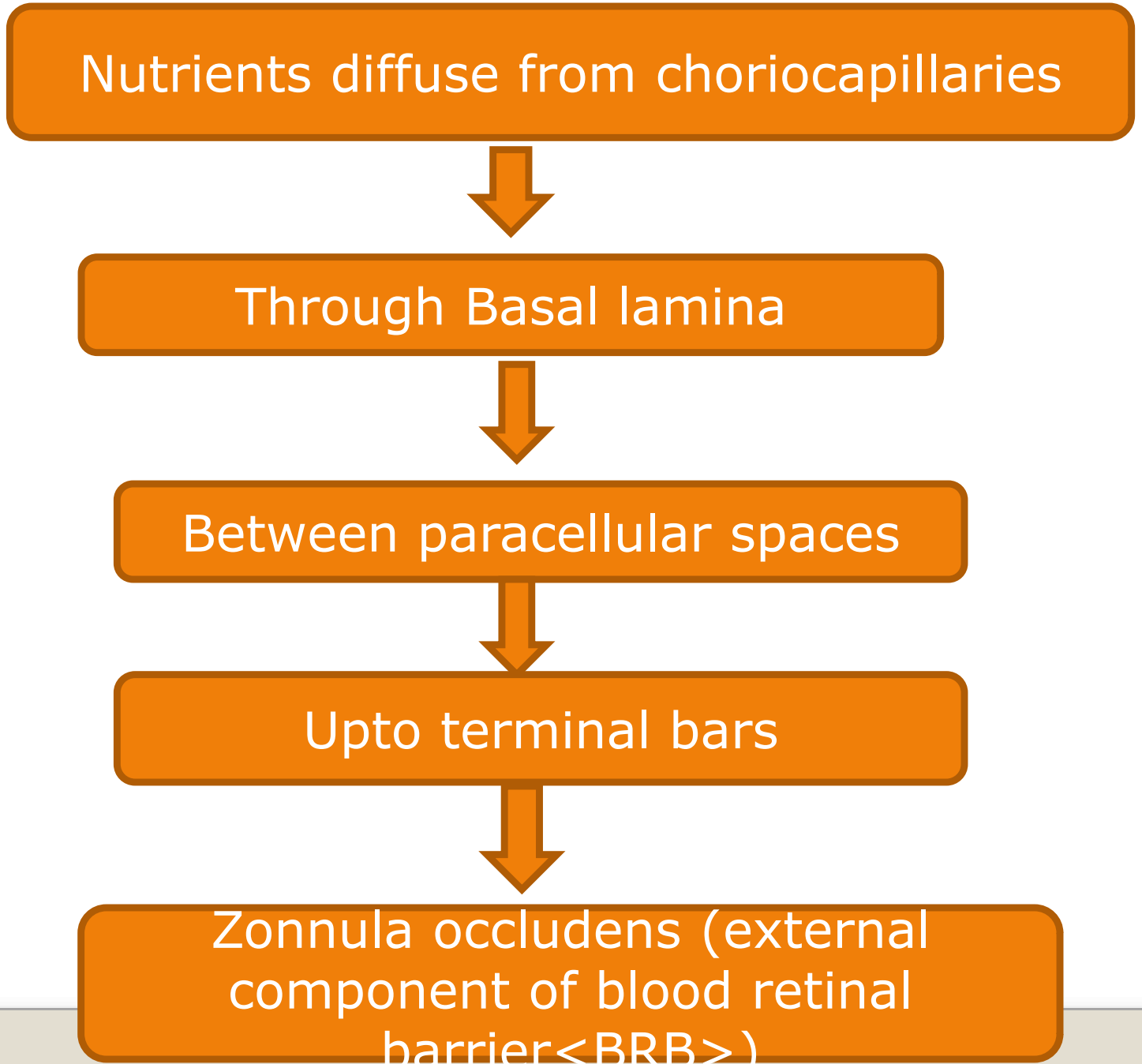


2. Basal surface;

- Attached to its basal lamina, the lamina vitrea of Bruch's membrane.
- Nutrients from choriocapillaries difusess to RPE through basal lamina

3. Paracellular surface;

- Contains tight junction(Zonula Occluden & adheran, gap junctions)
- Junctional complex form **blood-retinal barrier**
- Maintains retinal homeostasis and prevents from toxic damages


Nutrients diffuse from choriocapillaries
Through Basal lamina
Between paracellular spaces
Upto terminal bars
Zonnula occludens (external component of blood retinal barrier<BRB>)

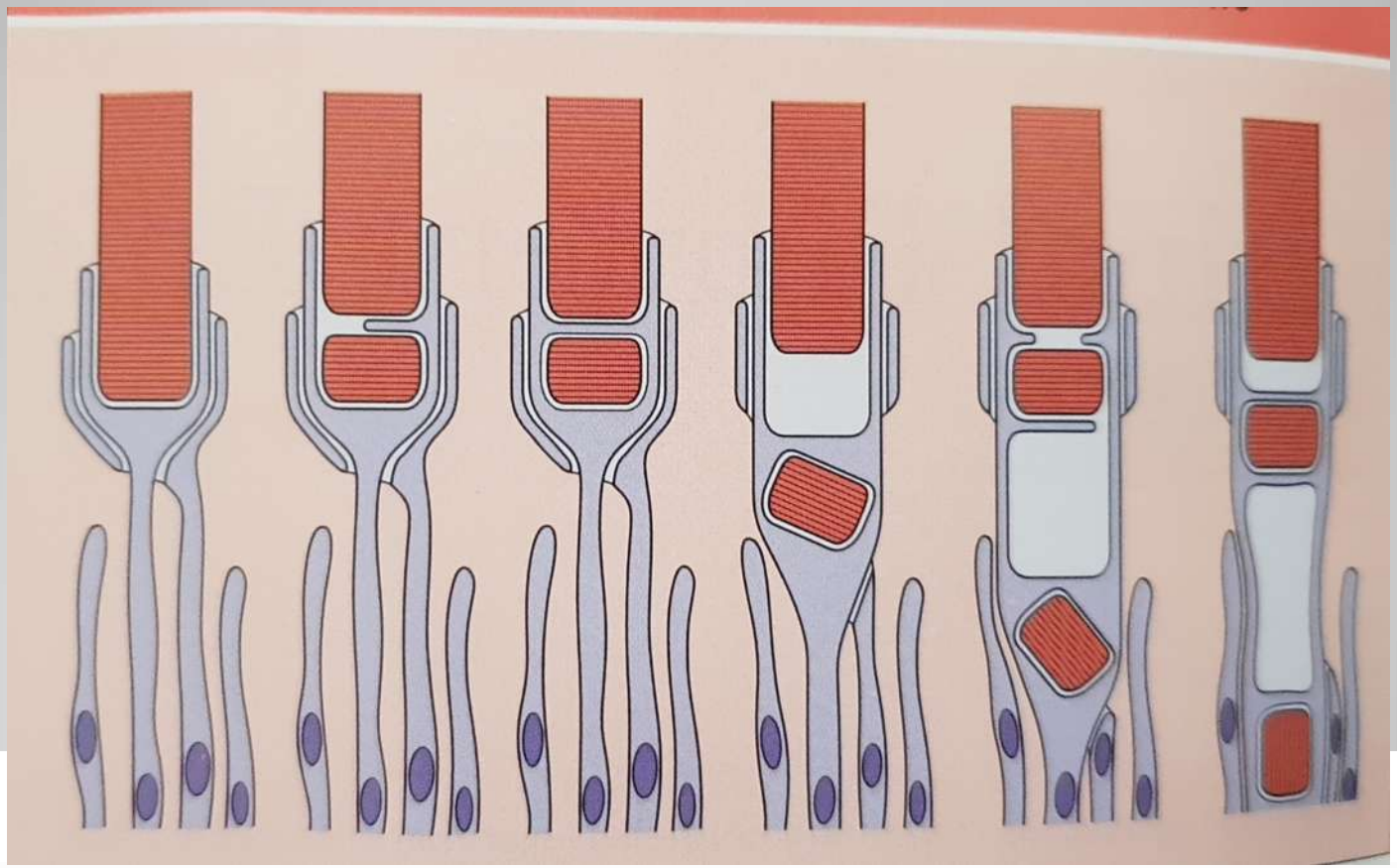
Size and shape of the RPE cells

- Cobblestone appearance
- In area centralis each cell 12-18um in width 10-14 um in length
- Peripherally flatter to 60um width

Functions

1. Plays an important role in photoreceptor renewal & recycling of vitamin A
2. RPE is involved with transport of nutrients & metabolites through the BRB & elaboration of extracellular matrix

3. RPE cells have phagocytic action by phagocytosis and digestion of photoreceptors

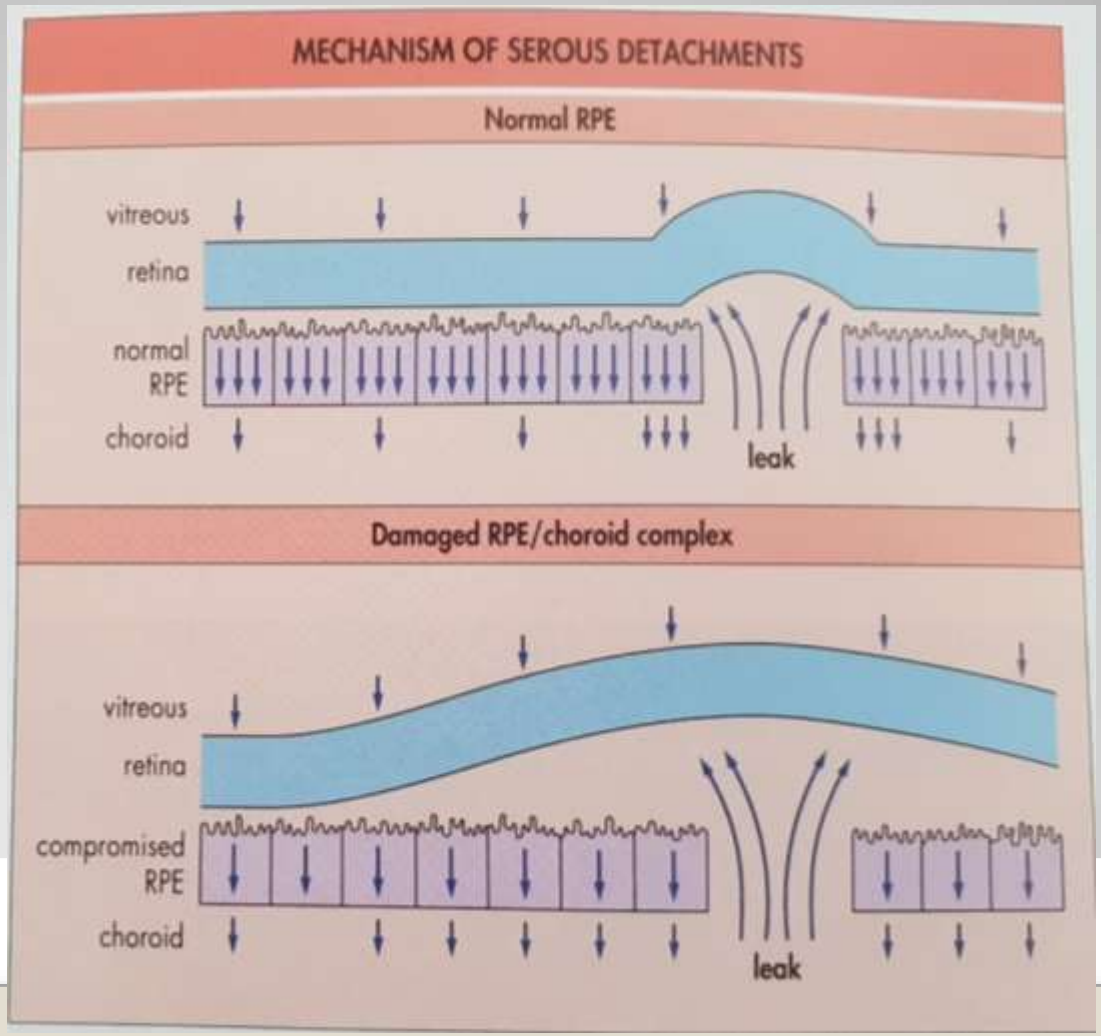


4. Regenerative and reparative function after injury and surgery.

5. Provides mechanical support to the processes of photoreceptors.

6. Manufacture the pigment called melanin which helps in the absorption of scattered light by and thus is optically functional.

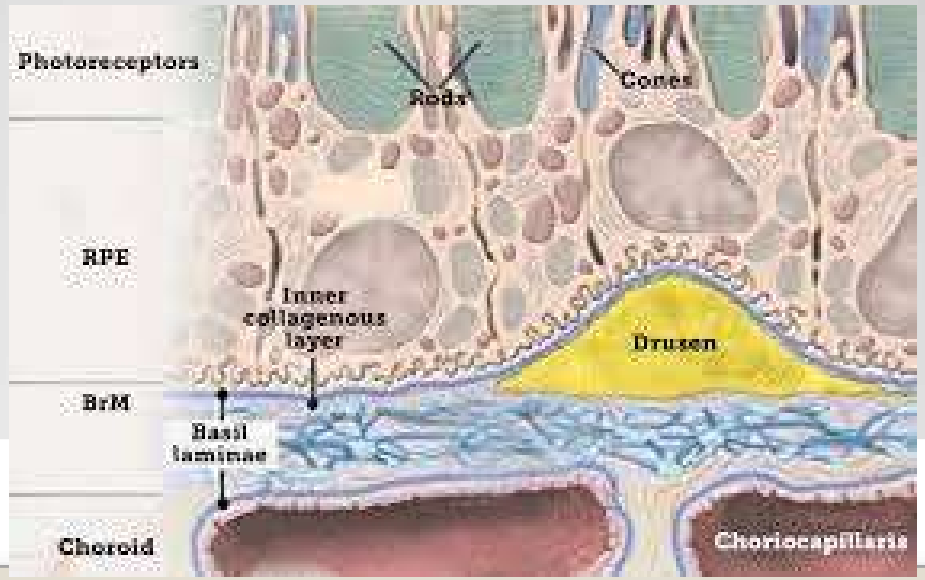
7. Maintains integrity of sub-retinal space by forming BRB and actively pumping out ions & water



- Clinical significance:

1. Failure of the RPE to process cellular debris associated with outer segment turnover cause deposition of Drusen in ARMD

2. Disruption of blood retinal barriers causes retinal edema eg. Macular edema



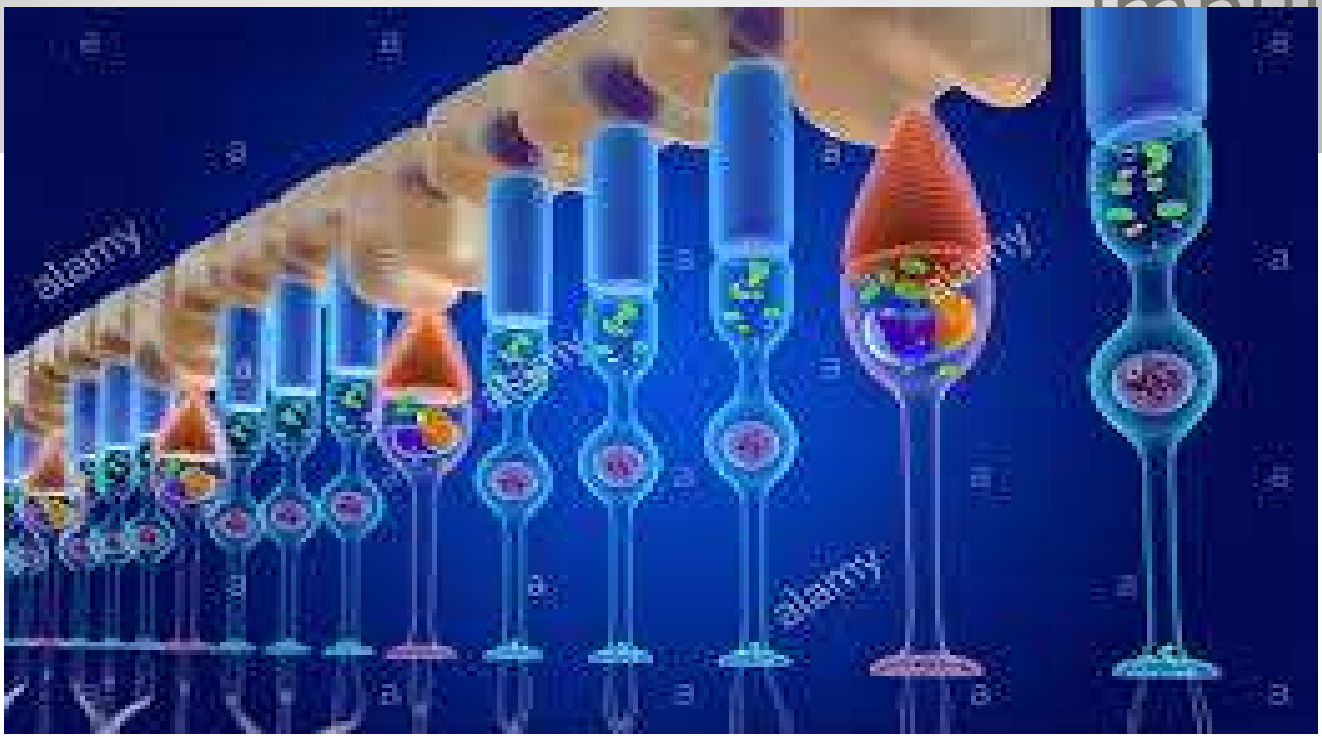
3. In the eyes of albinos, the cells of this layer contain no pigment.

4. Dysfunction of the RPE is found in age-related macular degeneration and retinitis pigmentosa

5. Gardner syndrome is characterized by: FAP (Familial Adenomatous Polyps), osseous and soft tissue tumors, retinal pigment epithelium hypertrophy and impacted teeth.

2. Layer of Rods & Cones

Photoreceptors are end organs that transform light into nerve impulses



- Cones are responsible for
  - Photopic (highly discriminatory central vision)
  - Color vision

- Rods contain photosensitive visual purple.
  - Peripheral vision and
  - Scotopic vision

Density and distribution of photoreceptors

Cones:

- 6.5 million
- density is maximum at fovea

(1,99,000 cones/mm2)

-minimum density- periphery

-light sensitive molecule- **Iodopsin**

(color vision-photopic vision)

❑3 types of iodopsin- trichromatic pigments

1. S wavelength cones- 440nm blue light)

2.M wavelenght cone- 540nm green

3.L wavelenght cone- 577nm red

Rodes:

-120 million

-maximum density in 20°(3mm) from the fovea

(160,000 rods/mm2)

-rod-free at the fovea ; 0.35 mm

-minimum density- periphery

-light sensitive molecule- **rhodopsin**

(night vision- scotopic vision)

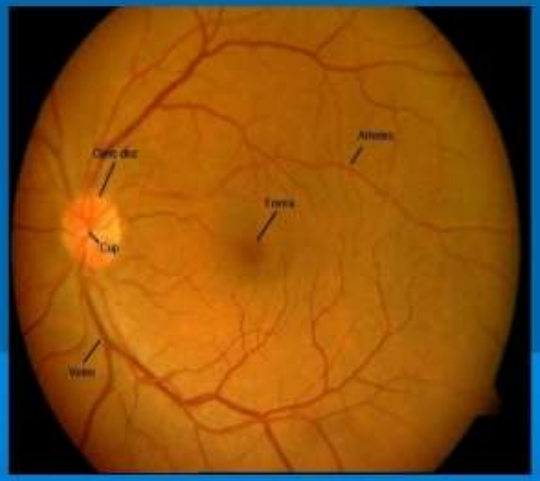
-rhodopsin is sensitive to blue-green light- 493nm

- **CLINICAL ASPECT**

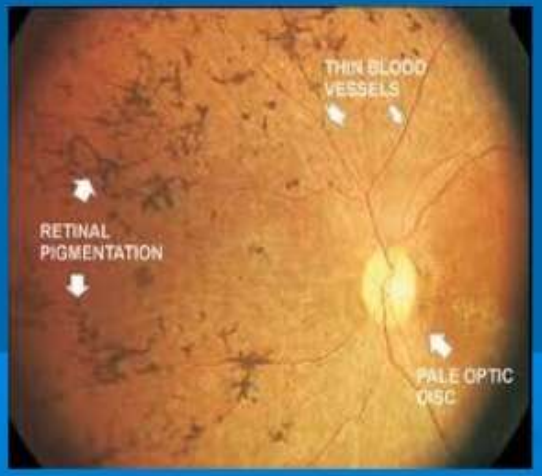
- Mutation of rhodopsin in retinitis pigmentosa causes maximum pigmentation 3mm around the fovea.

- With advanced of age there is progressive loss of photoreceptors (rods are affected more than cone)- poor night vision in elderly.

Fundus



NORMAL FUNDUS



RETINITIS PIGMENTOSA

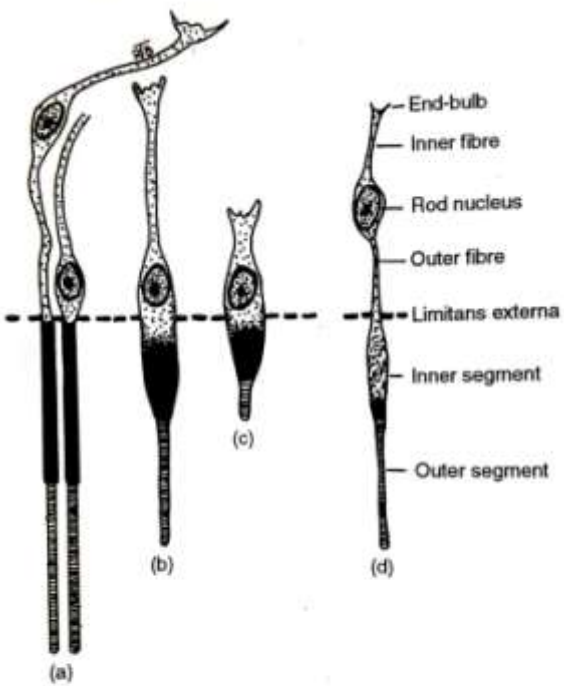
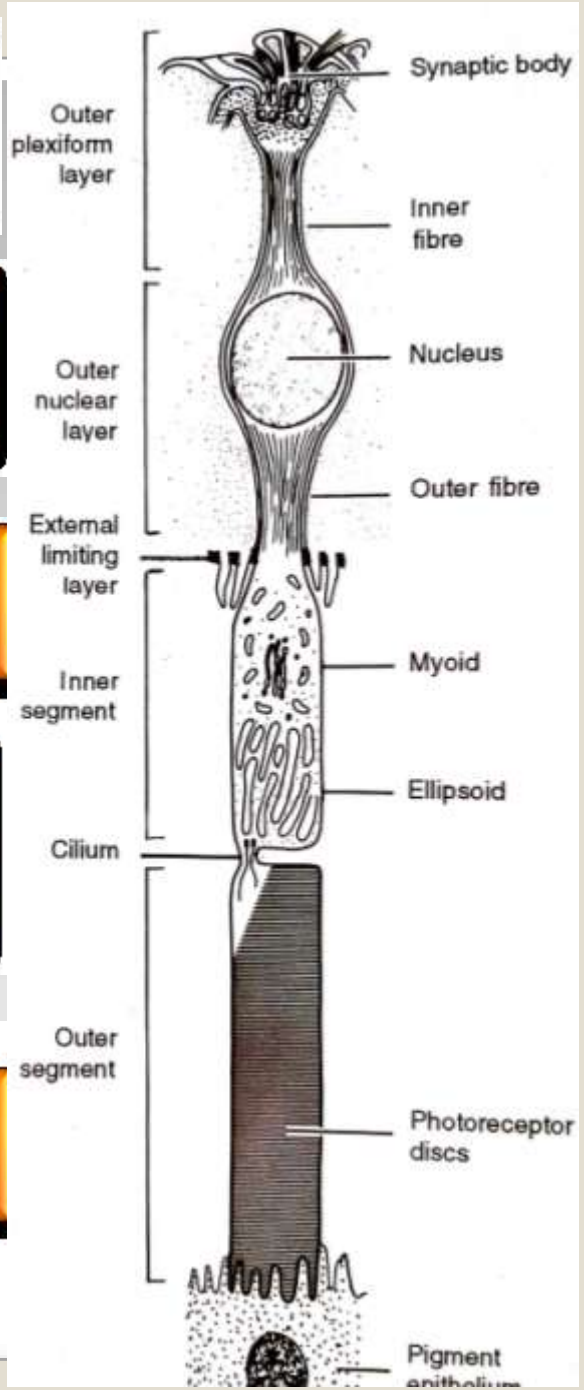
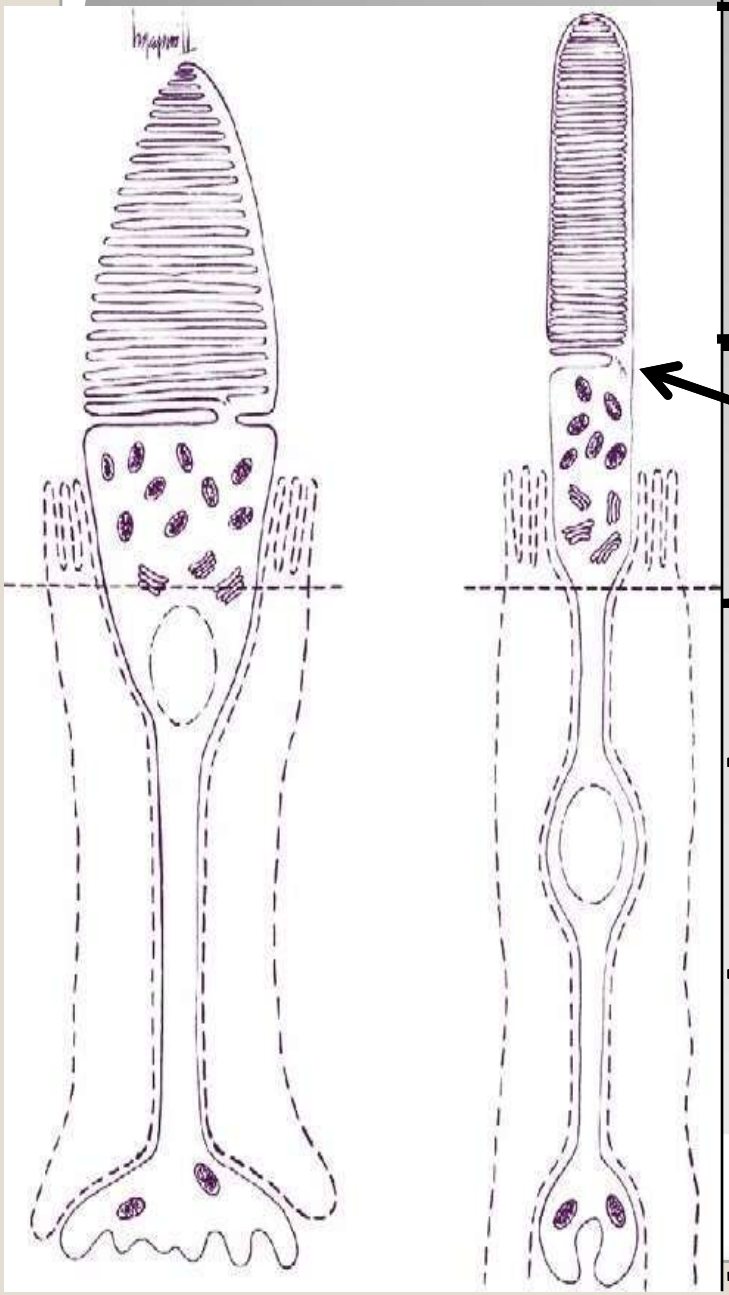


Fig. 14.22 Schematic representation of photoreceptors of human retina. (a) Cones from the foveola; (b) cones from midway between the ora serrata and the optic disc; (c) cone from near the ora serrata; (d) rod. (From Tripathi, R. C. and Tripathi, B. J. in Davson, H. (ed.) (1984) *The Eye*, published by Academic Press.)

Photoreceptor

- Cell body
- Nucleus
- Cell Process
- Inner Segment
- Outer Segment





Rods and cones are composed of several parts- six main parts.

1. The outer segment, containing the visual pigment molecules for the conversion of light into a neural signal;

2. A connecting stalk, the cilium(cytoplasmic isthmus)

3. The inner segment, containing the metabolic Apparatus.

4. The outer fiber;

5. The cell body- forms outer nucleated layers

6. The inner fiber, which ends in a synaptic terminal- outer plexiform layer

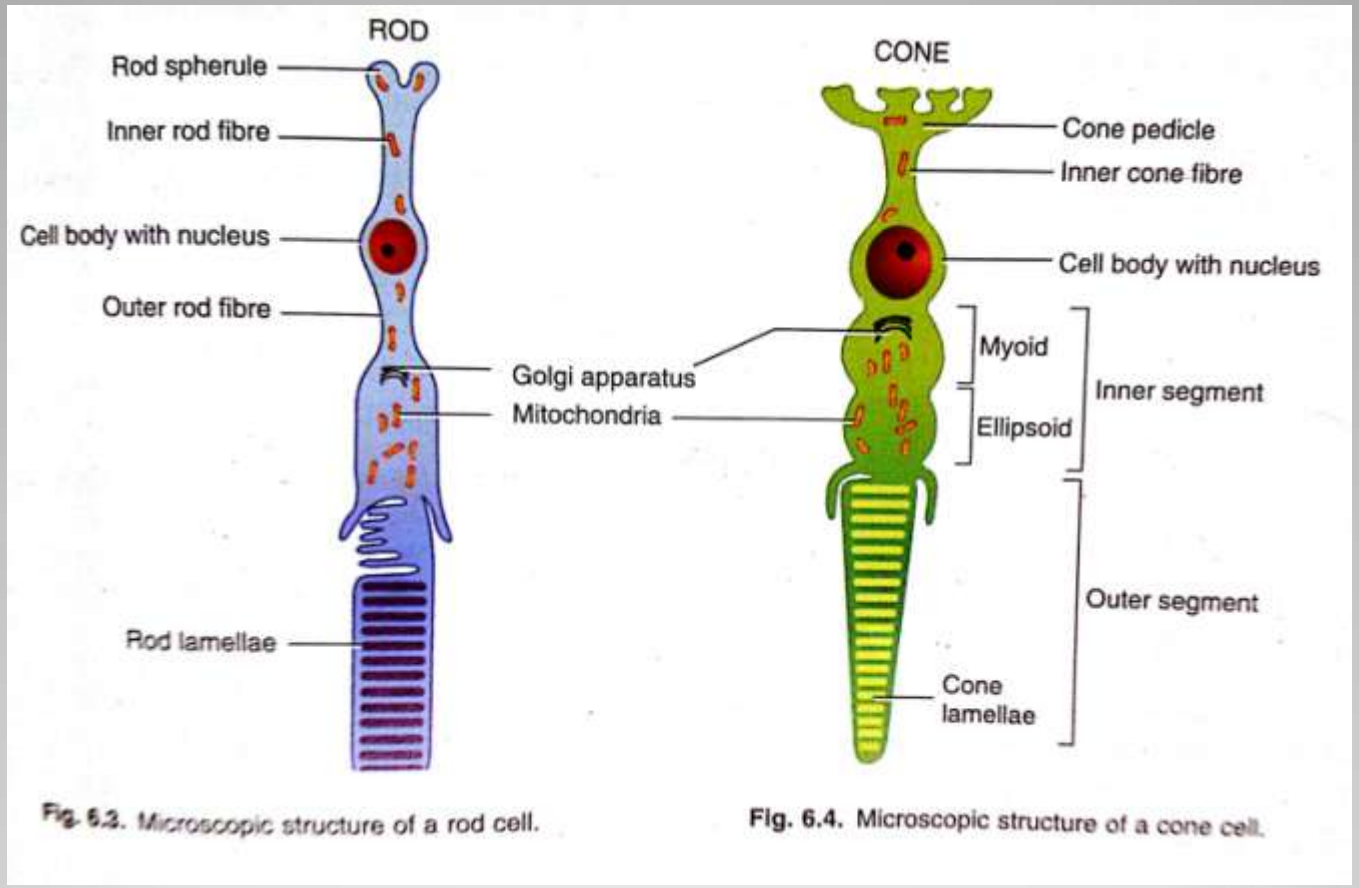


Fig. 6.3. Microscopic structure of a rod cell.

Fig. 6.4. Microscopic structure of a cone cell.

Rod cell

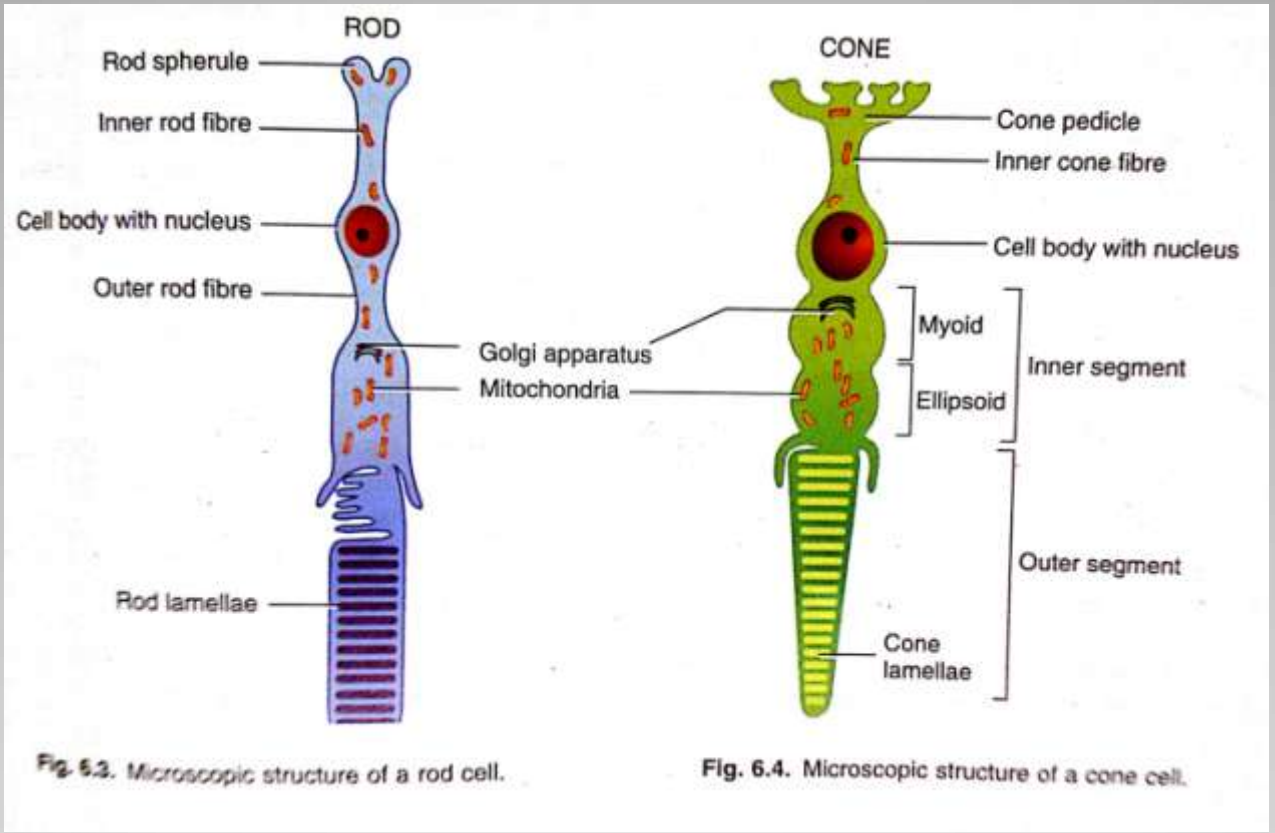


Fig. 6.3. Microscopic structure of a rod cell.

Fig. 6.4. Microscopic structure of a cone cell.

Cone Cell

- In low magnification appears as a fenestrated membrane extending from ora serrata to edge of optic disc
- Through this pass **processes of rods and cones**

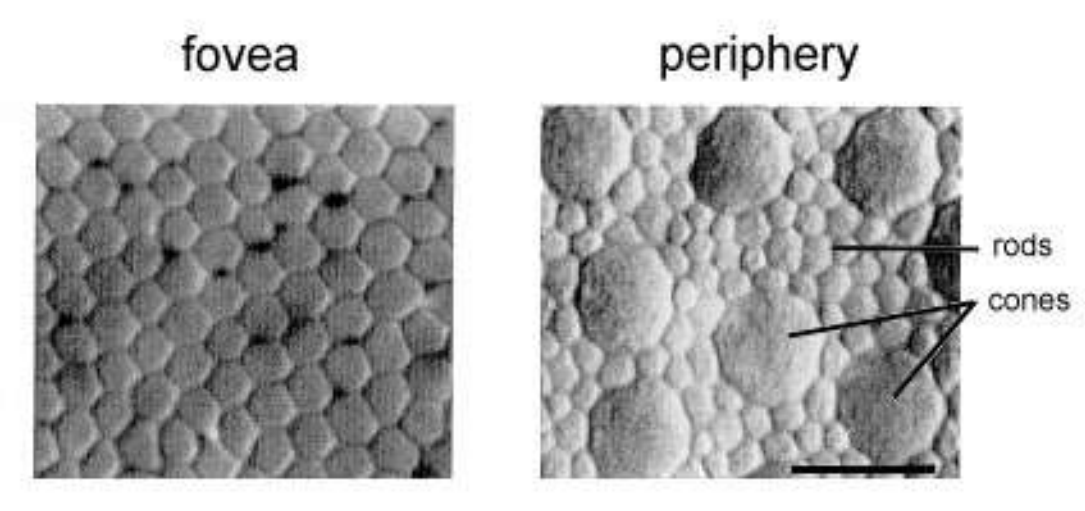
3.External limiting membrane

- EM shows it is formed by zonula adherentes (junctions) between cell membrane of photoreceptor cells and muller cells
- Thus is not a basement membrane

- Main function:
- Selective barrier for nutrients
- Stabilization of transducing portion of the photoreceptors

- Primarily formed by nuclei of rods and cones
- Cone nuclei 6-7 um are larger than rod nuclei 5um
- Rods form the bulk of the thickness in all except cone dominated foveal region

4. Outer Nuclear Layer



Complete absence of rods

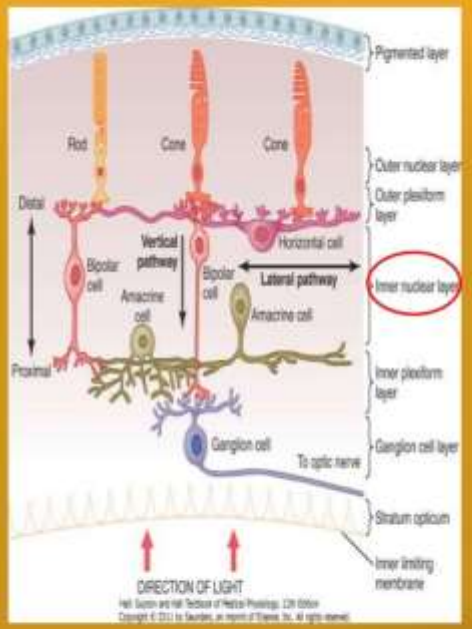
Thickess and number of layers

- Nasal to disc – 8 to 9 layers of nuclei – 45um thickness
- Temporal to disc – 4 layers of nuclei – 22um thickness
- **Foveal region – 10 layers of nuclei** – 50um thickness
- Rest of retina except ora – one row of cones 4 rows of rods with a thickness of 27 um

- Synapses between rod spherules and cone pedicles with dendrites of bipolar cells and horizontal cells
- Basically marks the junction of end organs of vision and first order neurons
- Thickest in macula (51um) consisting predominantly of oblique fibres that have deviated from fovea aka **Henle's layer**

5. Outer Plexiform Layer

INNER NUCLEATED LAYER



Located betweeen OPL and IPL

Consists of following 8-12 rows of cells:

- Bipolar cells- 9 types
- Horizontal- 3 types(H1,H11,H111)
- Amacrine
- Supportive Muller's cells

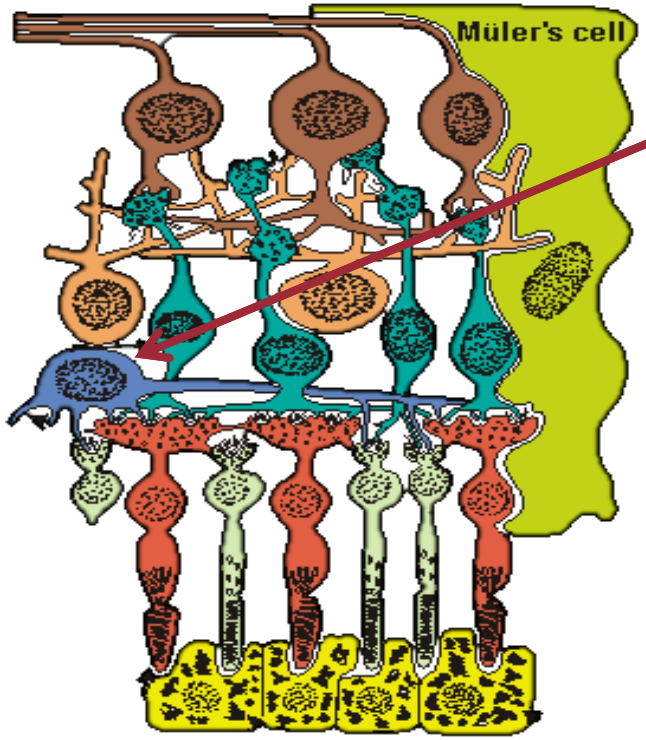
Four layers can be distinguished by light microscopy

1. Outermost layer -horizontal cell nuclei
2. Outer intermediate layer- bipolar cells
3. Inner intermediate layer -Muller cell
4. Innermost layer-amacrine and interplexiform cell nuclei.

Numerous cells and extensive cellular connection of INL is essential for transduction and amplification of light signals.

- Resembles the outer nuclear layer except it is very thin
- Disappeared at fovea otherwise contains
  - Bipolar Cells
  - Horizontal Cells
  - Amacrine Cells
  - The soma of the Muller’s cells
  - Capilliaries of the central retinal vessel

6. Inner Nuclear Layer

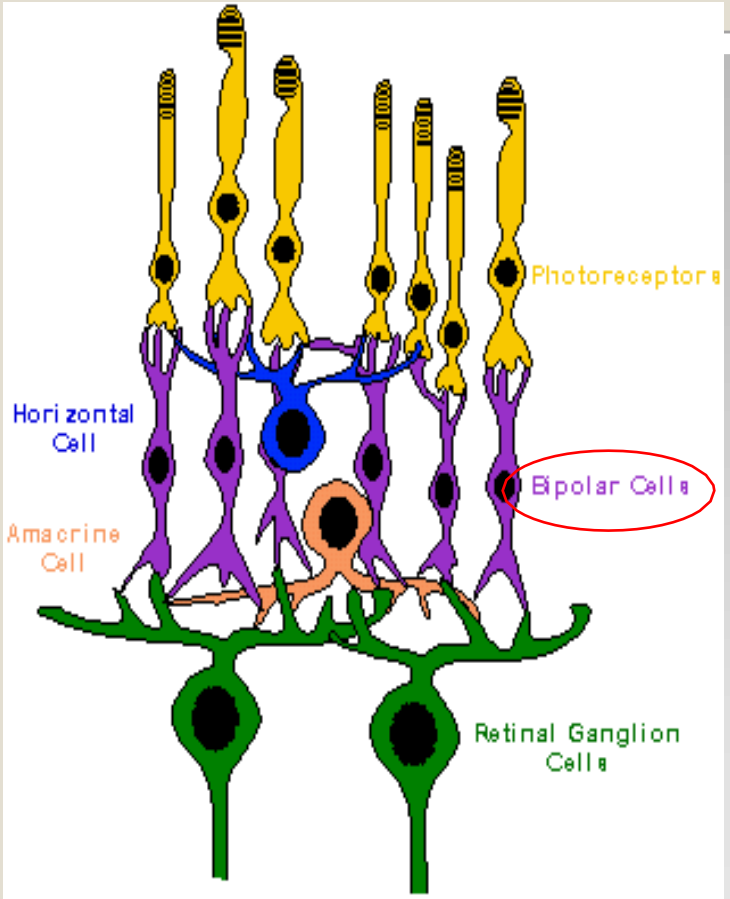


I. Horizontal cells

- Flat cells,
- Has numerous neuronal interconnections between photo receptor and bipolar cells in the outer plexiform layer.
- highest concentration in fovea
- Their processes branch extensively as one proceeds from the central retina towards the ora serrata.

Function:

Modulate and transform visual information received from the photoreceptors.



2. Bipolar cell

- Oriented radially in the retina
- 1st order neurons

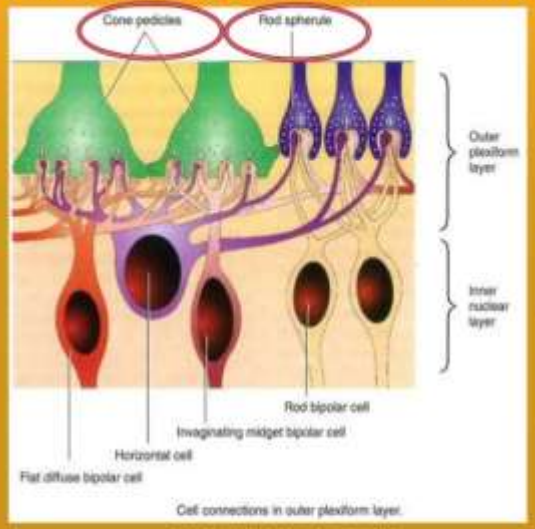
Located in the inner nuclear layers and their processes extend to the outer and inner plexiform layers

- Receive extensive synaptic feedback from amacrine cells

Function:

Bipolar cells relay information from photoreceptors to horizontal, amacrine, and ganglion cells

PHOTORECEPTOR SYNAPTIC TERMINAL



- Synaptic terminal are formed by the photoreceptor terminal and the dendritic processes of INL cells
- The rods has a round or oval cytoplasmic expansions called spherules with few synaptic terminals
- Cone have larger cytoplasmic expansions known as pedicles with multiple synaptic terminals

Two type of dendritic processes contact with spherules

1. One Deep horizontal cell axon
2. 1-4 Shallow bipolar cell axon

(this form total synaptic complex of 2-7 per spherules)

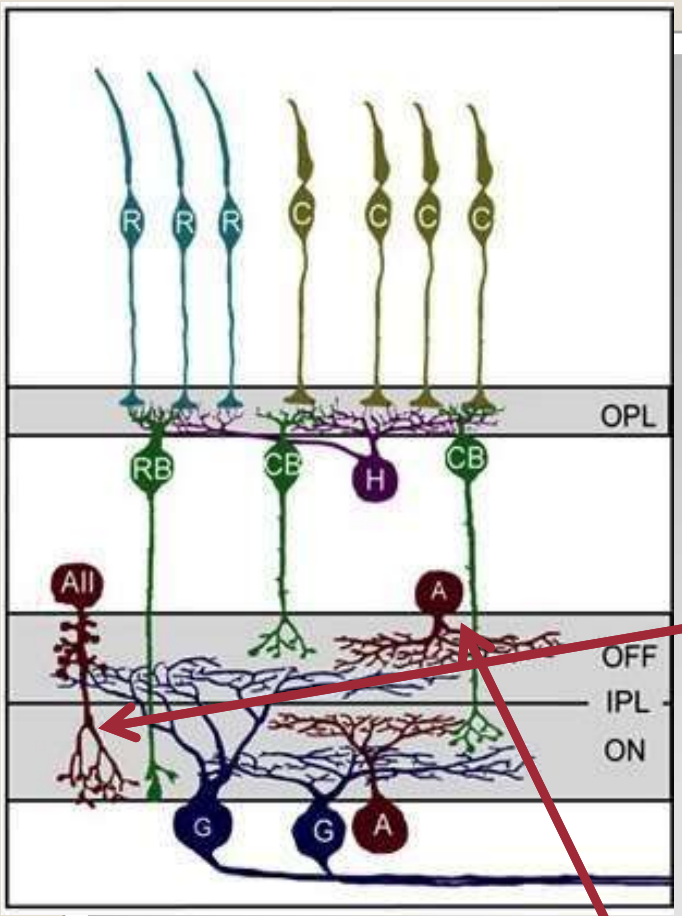
Cone pedicle are pyramidal in shape with three type of neuronal axon/processes (triad arrangement)

1. Central axons of midget bipolar cell that may contact the same cone at 10-25 different points.
2. Two dendrites on either side of the triad which originates from different horizontal cells

- Have total synaptic complex of 25 per pedicle which helps to spread light excitation over a large portion of the connections in the outer plexiform layer

❖ Clinical significance:

- The OFF bipolar depolarizes in dark and hyperpolarizes in light- activated by cones.
- The ON bipolar depolarizes in light and hyperpolarizes in dark- activated by rods.
- Bipolar cells transfer information to retinal ganglion cells, which are the first cells in the visual pathway to respond with an action potential



3. Amacrine cells

Amacrine cells are located in inner nucleated layer close to the inner plexiform layers

Upto 24 varieties has been described but two major types are based on their characteristics;

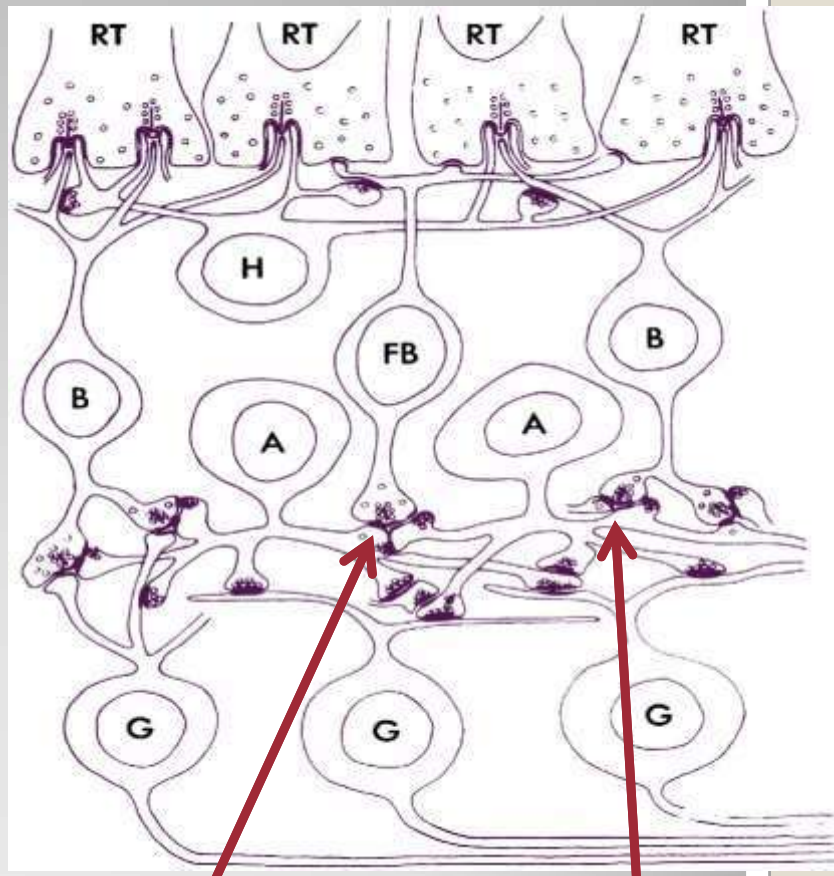
1. Diffuse Amacrine cells.
   - processes extend throughout the entire inner plexiform layer
   - Further subdivided into narrow, medium, or wide field types, depending on the width covered by their axonal fields
2. Stratified Amacrine cells.
   - fibers run in the outer half of the inner plexiform layer

- The remarkable feature of amacrine cells is the broad distribution of their axonal processes through all strata of the inner plexiform layer.

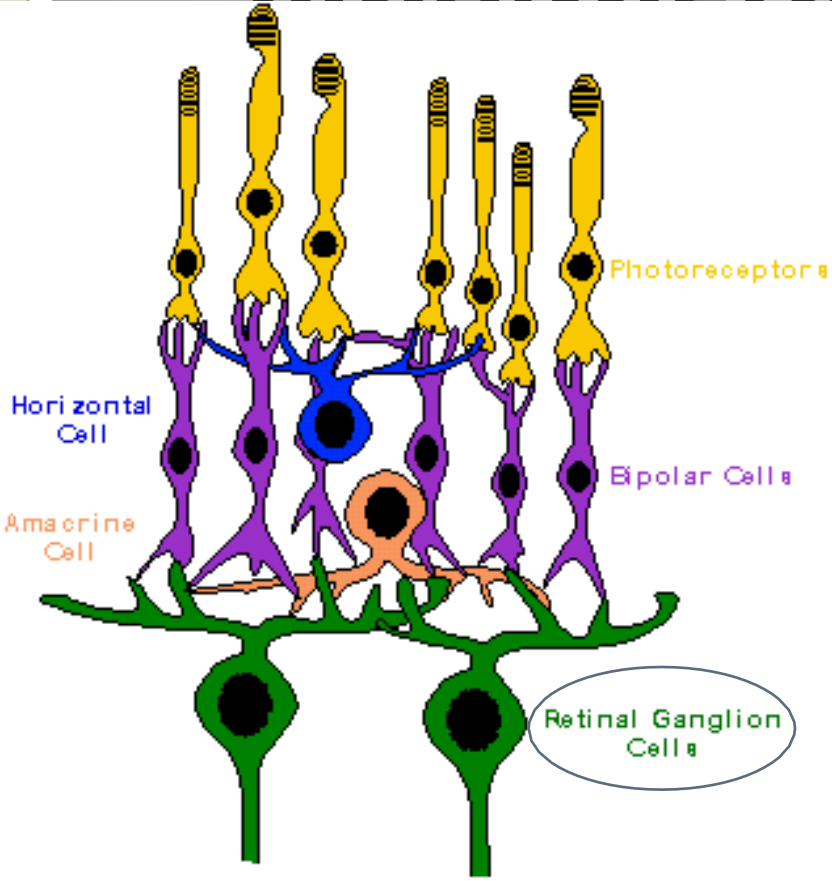
- Amacrine cell processes indicates that these cells play an important role in the modulation of electrical information reaching the ganglion cells.

7. INNER PLEXIFORM LAYER

- Consists of synapses bet. Axons of bipolar cells and dendrites of ganglion and amacrine cells.
- Two elements are present at synapse in an arrangement that is known as a 'dyad'



8.GANGLION CELL LAYER



- 2^{nd} order neurons
- Single row in Peripheral Retina.
- At the edge of foveola(macula) it is multilayer(6-8 layered) and on temporal side of disc it has two layers.
- It is absent in foveola and optic disc.

- Ganglion cells transmits signal from the bipolar cell to the lateral geniculate body
- 1.2 million ganglion cells are present in the retina each with a single axon.

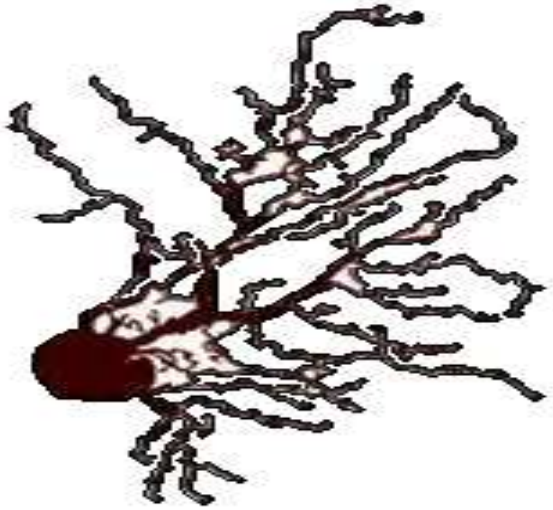
18 types of ganglion cells described- two main types are

1.P ganglion cells- The midget cells

•**Monosynaptic** ganglion cells, show dendrites that synapse exclusively with axon terminals of midget bipolar cells and amacrine cell processes.

•P cells are concentrated in central retina,

•Constitute **80%** of the ganglion cell population.



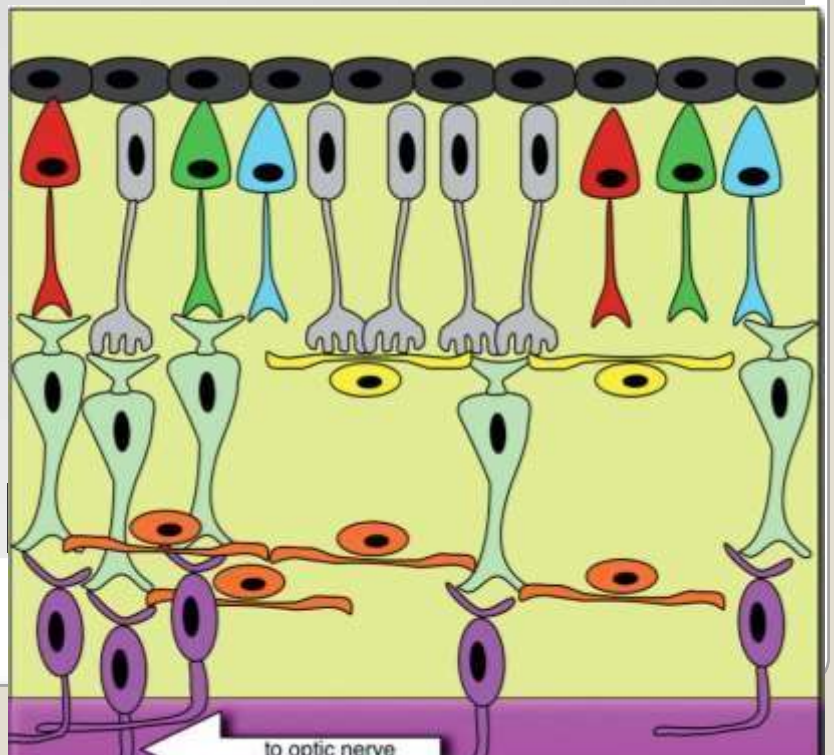
2.M ganglion -polysynaptic because they make synapses over a wide area.

•They synapse with all types of bipolar cells except the midget bipolar cells.

•M cells constitute 5% of the total ganglion cell population at the fovea and 20% at the periphery of the retina.

- Also known as stratum opticum
- It contains axons of ganglion cells which passes through lamina cribrosa to form the optic nerve

9. NERVE FIBER



- Innermost layer of retina
- Formed by the union of terminal expansions of muller’s fibres
- Basement membrane
- Separates retina from vitreous

10. Internal limiting membrane

Blood supply of retina

- Outer four layers : choroidal vessels
- Inner six layers : CRA

- CRA : Branch of OA, end artery, four branches
- Retinal veins : follows the arteries, drains into cavernous sinus / SOV

THANK YOU