

Retina

Sourav

Hod

Introduction

- Innermost tunic of the eye ball. Thin, delicate, transparent membrane. Its thickness at the posterior pole in the peripapillary region is aprox. 0.56 mm
- Equator 0.18 to 0.2 mm
- At the ora serrata 0.1 mm
- Appurtenance purplish-red due to visual purple rods. After death retina appears white opaque.

Gross anatomy

- Retina extends from the optic disc to ora serrata and surface area of about 266 mm²
- Ophthalmoscopically it can be divided into 3 distinct regions
 1. Optic disc
 2. Macula lutea
 3. Peripheral retina

(1)Optic disc

- It is pale pink, well define circular area of about 1.5 mm diameter.
- At the optic disc, all retinal layers terminate except the nerve fibers, which pass lamina cribrosa run into the optic nerve.
- Optic disc appears white due to lamina cribrosa and medulated nv.fibres behind it & absence of vascular choroid. Center nv. Fibres are thinnest. White lamina shine more brightly.

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- Physiological cup of the disc is a depression seen in it.
- Cup varies in size, shape, position and depth in different eyes.

(2) Macula lutea

- The macula lutea appears as a darkened region in the central retina and may seem to have a yellow hue because of the xanthophyll pigments, lutein, and zeaxanthin.
- These pigments are located throughout the retina, but the greatest concentration is in the macula.
- The pigments are primarily located in the photoreceptor inner fibers but are also found in the rod outer segments.

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- The newborn has little if any of these pigments, but they gradually accumulate from dietary sources.
- These pigments apparently act as filters, absorbing short wavelength visible light to reduce chromatic aberration but may also have an antioxidant effect,
- Suggesting a protective role against UVR damage.

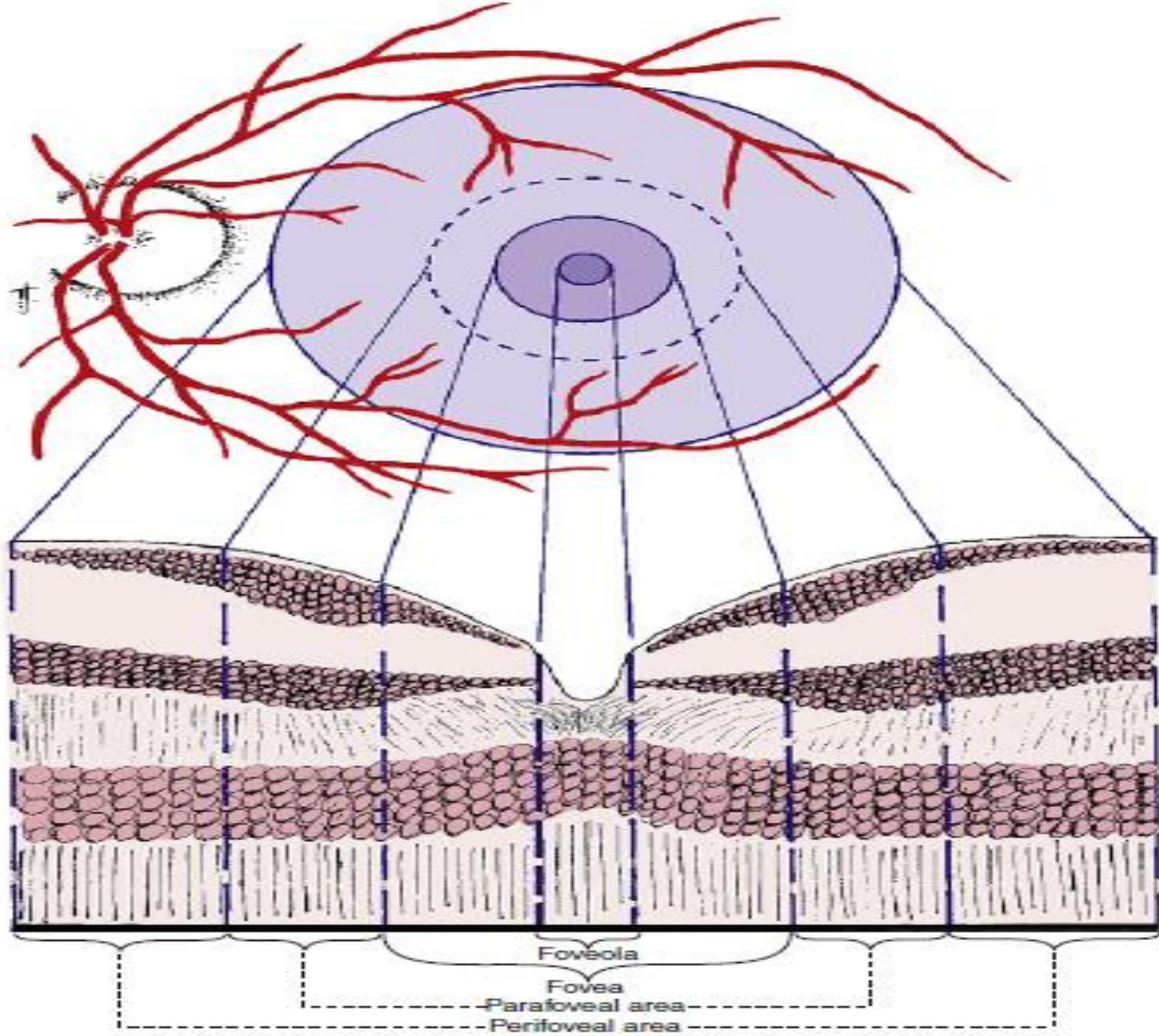
- The macula lutea is approximately 5.5 mm in diameter;
- its center is approximately 3.5 mm lateral to the *edge of* the disc and approximately 1 mm inferior to the *center* of the disc.
- The pigment epithelial cells are taller and contain more pigment than cells elsewhere in the retina, contributing to the darkness of this area.

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- The density of the pigment varies greatly from person to person.
- The choroidal capillary bed also is thicker in the macula lutea than elsewhere.
- Useful color vision occupies an area approximately 9 mm in diameter, the center of which is the macula lutea.

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- The entire macular region consists of the foveola, the fovea, and the parafoveal and perifoveal areas.



Fovea (Fovea Centralis)

- The shallow depression in the center of the macular region is the fovea, or central fovea of the retina (*fovea centralis retinae*)
- This depression is formed because the retinal neurons are displaced, leaving only photoreceptors in the center.
- The fovea has a horizontal diameter of approximately 1.5 mm.

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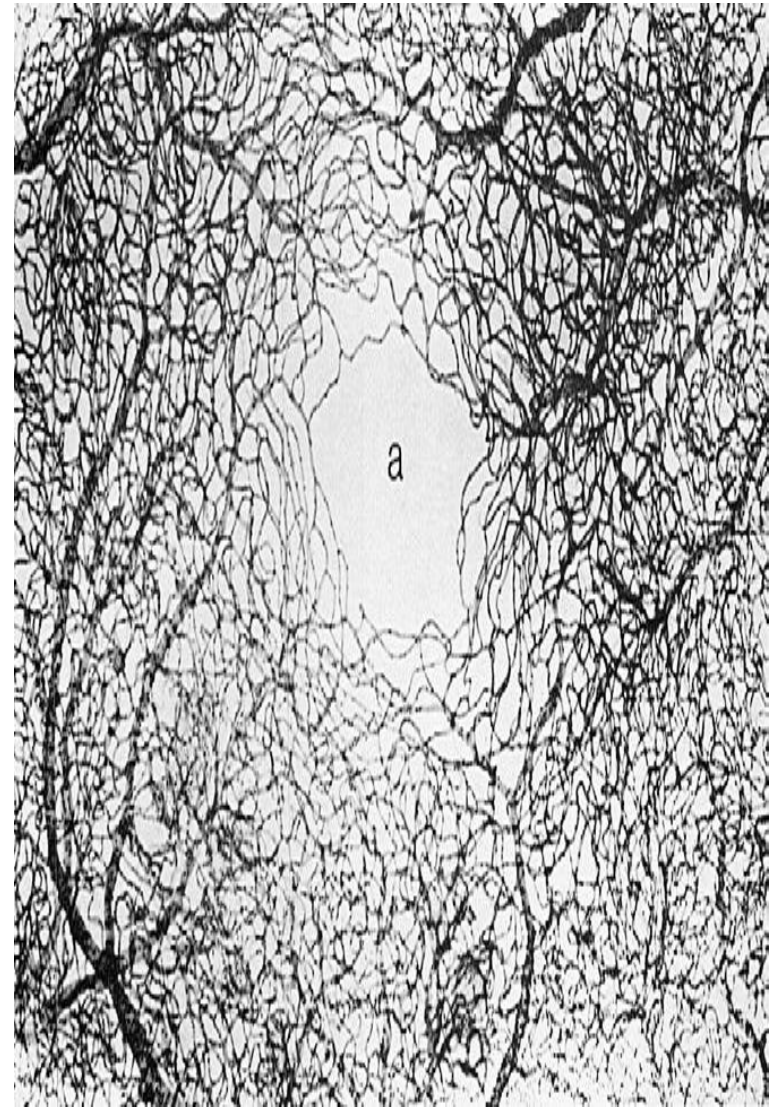
- The curved wall of the depression is known as the *clivus*, which gradually slopes to the floor, the *foveola*.
- *The fovea has the* highest concentration of cones in the retina; estimates vary from 199,000 to 300,000 cones per square millimeter.

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- In this area of the retina, specialized for discrimination of detail and color vision, the ratio between cone cells and ganglion cells approaches 1:1.
- In more peripheral areas of the retina, which are sensitive to light detection but have poor form discrimination, there is a high ratio of rods to ganglion cells.

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- Within the fovea is a *capillary-free zone 0.4 to 0.5 mm* in diameter.
- The lack of blood vessels in this region allows light to pass unobstructed into the photoreceptor outer segment. The only photoreceptors located in the center of the fovea are cones.



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- These are tightly packed, and the outer segments are elongated, appearing rod like in shape yet containing the visual pigments of the cone population.
- The external limiting membrane is displaced vitreally because of the lengthening of the outer segments.
- This *rod-free region* has a diameter of approximately 0.57 mm and represents approximately 1 degree of visual field.

Foveola

- The diameter of the foveola is approximately 0.35 mm.
- At the foveola, the retina is approximately 0.13 mm thick, compared with 0.18 mm at the equator and 0.11 mm at the ora serrata.
- The foveola contains the densest population of cones that have the smallest cross-sectional diameters of all the photoreceptors.

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- The layers present in the foveola are the
 - (1) RPE,
 - (2) photoreceptor layer,
 - (3) external limiting membrane,
 - (4) ONL (which contains about 10 rows of cone nuclei),
 - (5) Henle's fiber layer, and
 - (6) the internal limiting membrane.

Para foveal and Perifoveal Areas

- The annular zone surrounding the fovea can be divided into an inner parafoveal area and an outer perifoveal area.
- **The parafoveal area** :contains the largest accumulation of retinal bipolar and ganglion cells. The inner nuclear layer can be 12 cells thick and the ganglion cell layer 7 cells thick
- At the maximum density of ganglion cells there can be 40,000 cells/mm².

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- **The perifoveal area** :begins where the ganglion cell layer is four cells thick and ends where it is one cell thick.
- The width of the parafoveal area is 0.5 mm and of the perifoveal area, 1.5 mm.

(3) PERIPHERAL RETINA

- The peripheral retina can be divided into 4 regions
 1. **Near periphery:** refers to a bounded region of about 1.5 mm around the area centralis.
 2. **Mid periphery:** occupies a 3 mm wide zone around the near periphery.
 3. **Far periphery:** extend from the optic disc, 9-10 mm on the temporal side and 16 mm on the nasal side in the horizontal meridian.

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4. Ora serrata : dented process, consist of tooth like extensions of the retina on the pars plana separated by oral bays, are well marked on the nasal half of the retina.

- At the ora, retina is firmly attached both to the vitreous and RPE. Ora serrata is

Temporally wide 2.1 mm

Nasally wide 0.7-0.8 mm

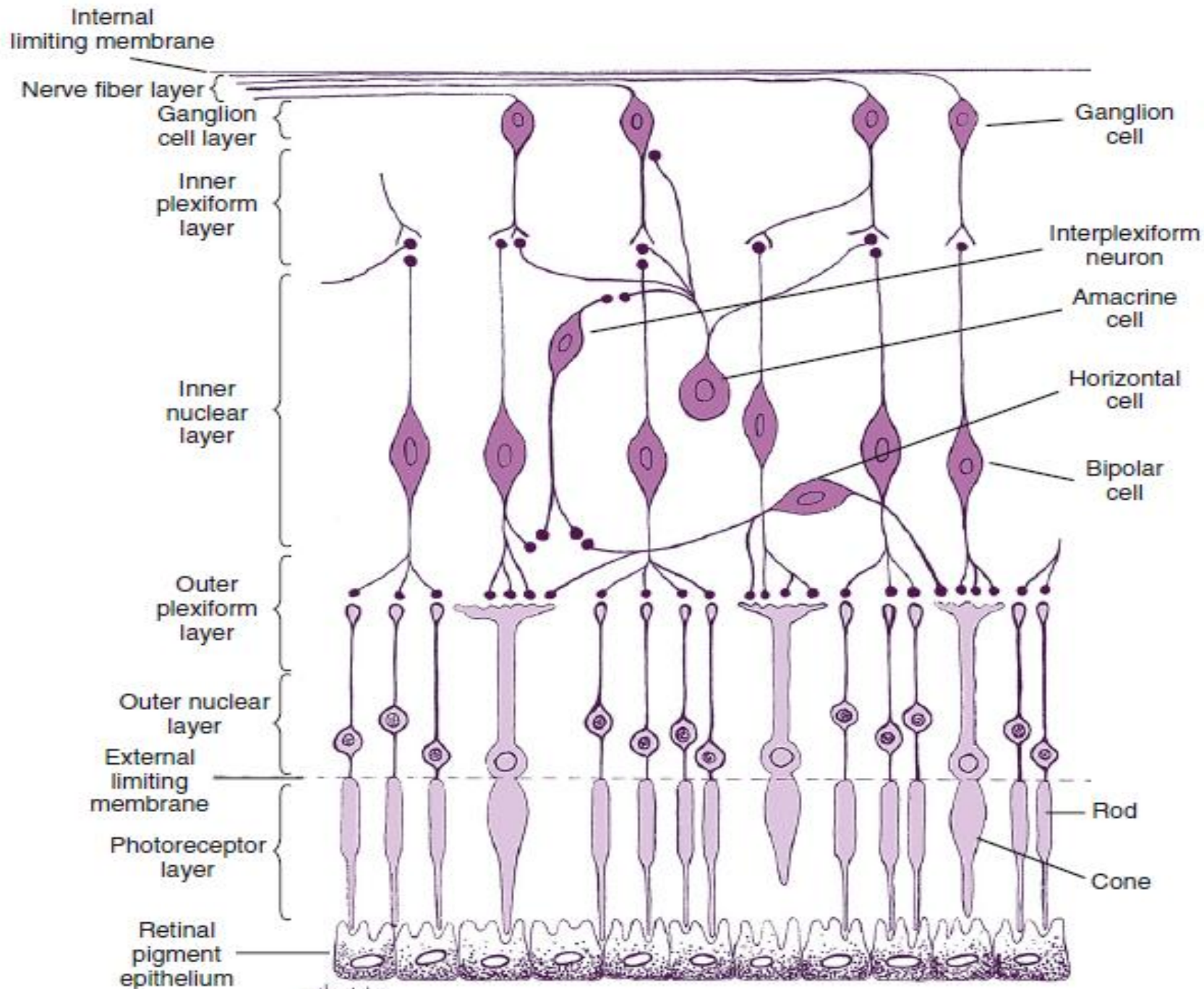
- Distance from limbus is 6.0 mm nasally & 7.0 mm temporally. It is located 6-8 mm away from the equator and 25 mm from the optic nerve on the nasal side.

Microscopic structure of the retina

- Retina consist of 3 types cells and there synapses arranged in the following layers.
 1. Retinal pigment epithelium
 2. Layers of Rods & Cones (Photoreceptor cell layer)
 3. External limiting membrane
 4. Outer nuclear layer
 5. Outer plexiform layer

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6. Inner nuclear layer
7. Inner plexiform layer
8. Ganglion cell layer
9. Nerve fiber layer
10. Internal limiting membrane



1. Retinal pigment epithelium (RPE)

- The retinal pigment epithelium (RPE), the outermost retinal layer, is a single cell thick and consists of pigmented hexagonal cells.
- These cells are columnar in the area of the posterior pole and are even longer, narrower, and more densely pigmented in the macular area.
- The cells become larger and more cuboidal as the layer nears the ora serrata,

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- The RPE cells contain numerous melanosomes, pigment granules, that extend from the apical area into the middle portion of the cell.
- In the retina, melanin is densest in the RPE cells located in the macula and at the equator.
- Other pigmented bodies, lipofuscin granules, contain degradation products of phagocytosis, which increase in number with age.

Continue...

- **Function of RPE:**

1. Plays important role in photoreceptor renewal and cycling of Vitamin A.
2. Maintains integrity of subretinal space by forming outer blood-retinal barrier and actively pumping ions and water out of this space.
3. RPE involved with transport of nutrients and metabolites through the blood-retinal barrier.

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4. RPE cells have phagocytic action.
5. Provide mechanical support to the proccess of photoreceptors.
6. they manufacture pigment which presumably has an optical function in absorbing lights.

(2) Layers of Rods & Cones

- Rods and cones are the end organs of vision which transform light energy into visual impulse.
- Rods contain a photosensitive substance visual purple and sub serve the peripheral vision and vision of low illumination (scotopic vision)
- Cones also contains a photosensitive substance and primarily responsible for highly discriminatory central vision and color vision.

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- There are about 120 million rods and 6.5 million cones.
- Highest density of cones is at fovea with an average of 199000 cones/mm². the number of cones falls off rapidly outside the fovea, begins only 6000 cones /mm² away from the fovea and about 4000 cones/mm² 10 mm away.
- Cone density is 40-45% > on nasal side than temporal. Slightly lower in superior than inferior.

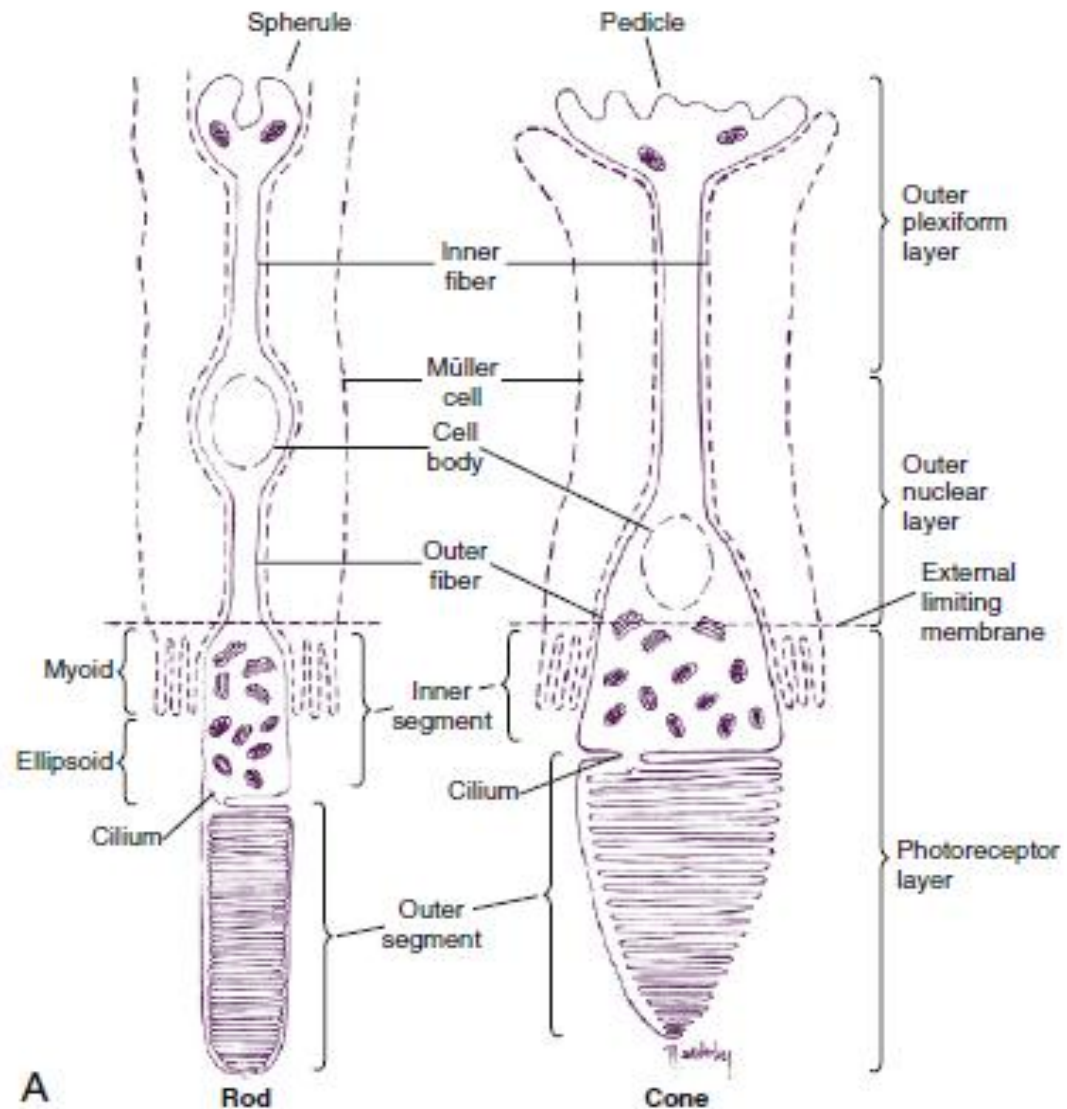
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- Rods are absent at the fovea in an area of 0.35mm which correspond to 1.25° of the visual field
- Presents in a ring shaped zone 5-6 mm from the fovea. Maximum below the optic disc and number reduce towards the periphery.

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- Structure of the photoreceptor:

Each photoreceptor consist of a cell body ad nucleus, a cell process that extend into outer plexiform layer and inner and outer segments.

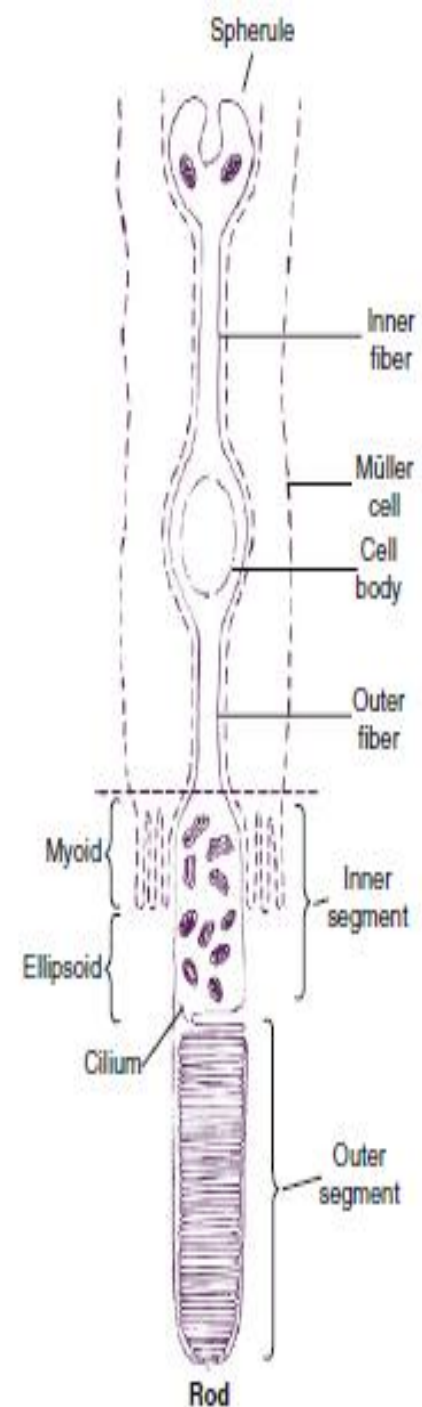


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- **The rod cells:** each rod is about 40-60 μ m long
- Outer segments of the rod is cylindrical, high retractile, transversely striated and contains visual purple. It composed of numerous lipid proteins lamellar disc staked one on top of the other and surrounded by a cell membrane.
- The number of the discs varies between 600-1000 /rod and each disc is 22.5-24.5 nm in thickness.

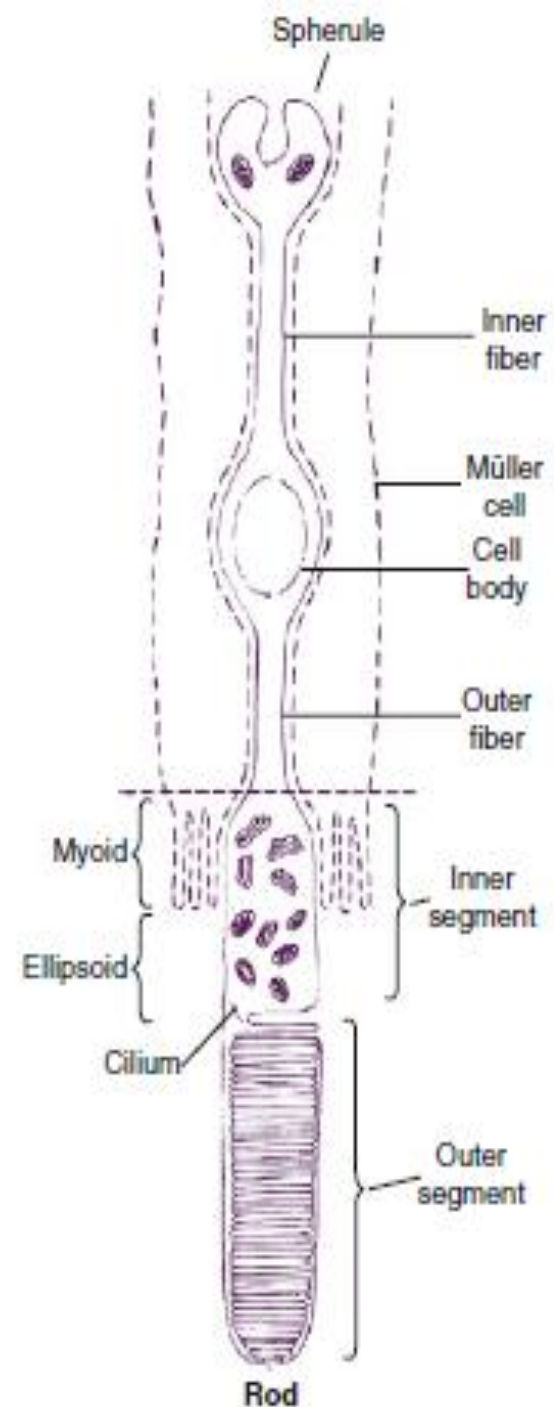
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- The inner segments of the rod is thicker than outer segments. Consist of two regions: ellipsoid and myoid.
- **Ellipsoid**: is adjacent to outer segments and contain abundant number of mitochondria.
- **Myoid**: contains glycogen as well as the usual organelles.



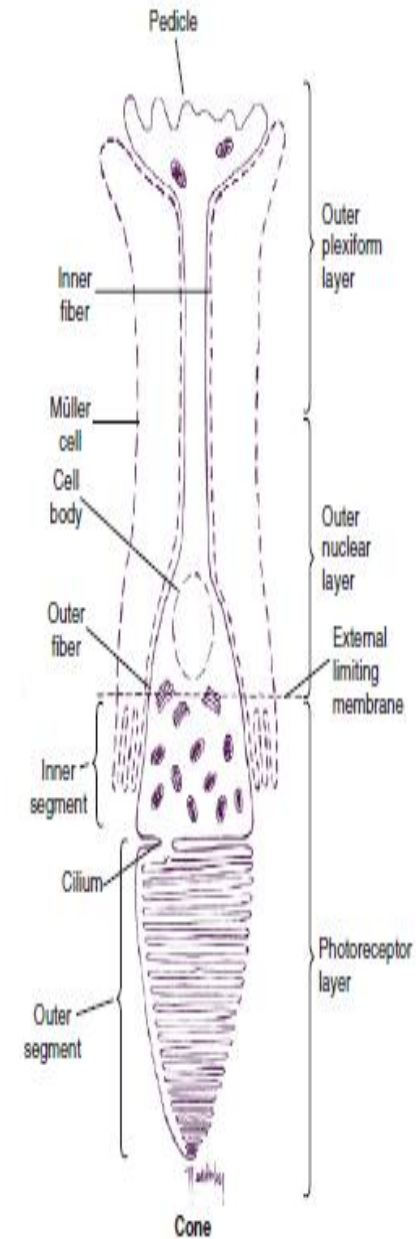
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- Outer rod fiber arises from the inner end of rod . Which passes through the external limiting membrane and terminates as inner rod fiber which at its end has an bulb called the rod spherule.



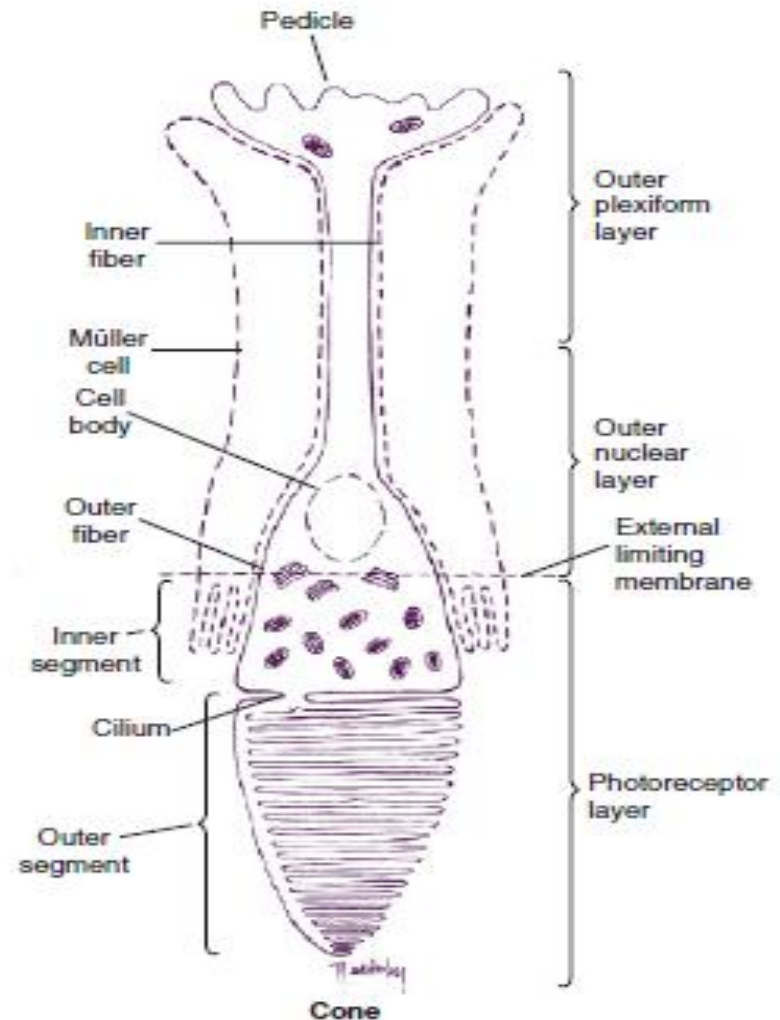
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- **The cone cell:** each cone cell is 40 - 80 μm long. It largest at the fovea and shortest at the periphery.
- Cone outer segments is conical in shape, much shorter than that of the rod and consist of iodopsin. The lamellar disc which are narrower than those of the rod. Maintain continuity with the surface plasma membrane. There are about 1000-1200 discs/ cone.



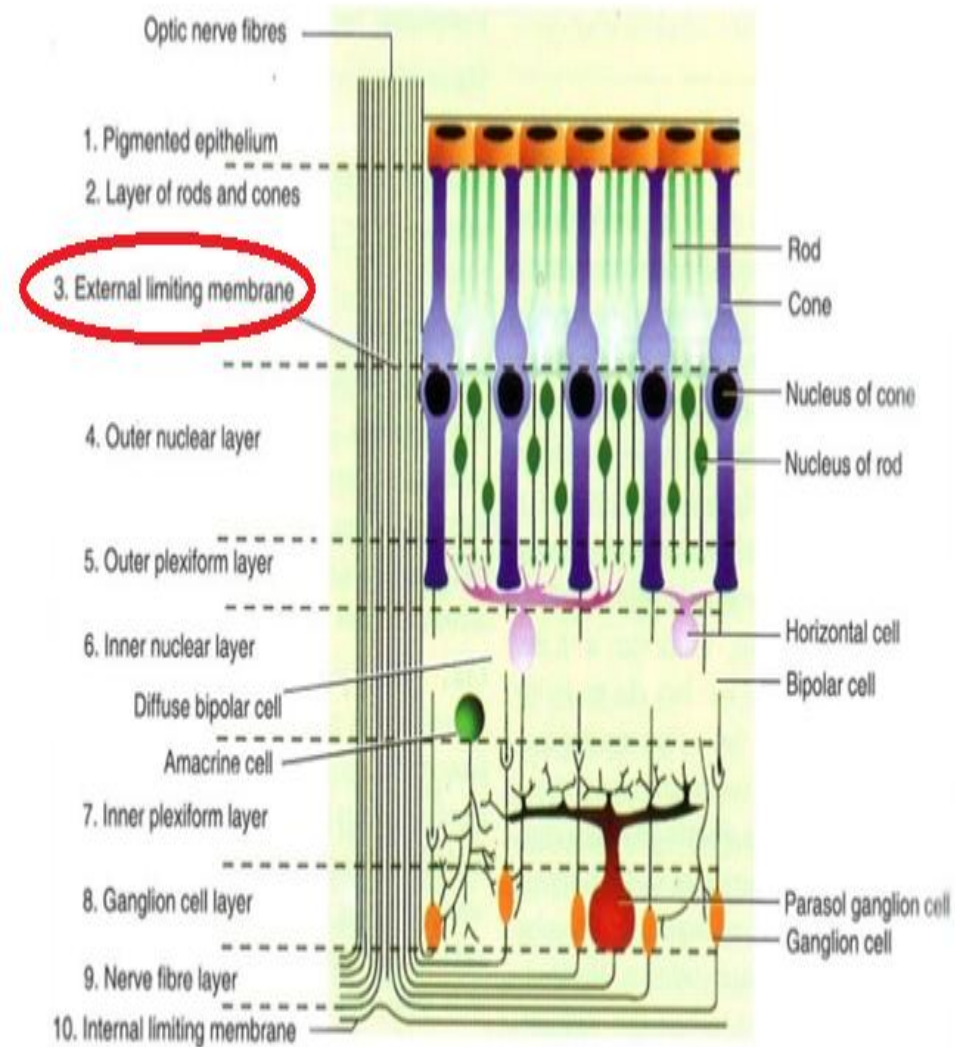
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- The cone inner segments and cilium are similar to the rod structures; cone ellipsoid is very plump and contain large number of mitochondria.
- Intersegments of the cone become directly continuous with nucleus and lies in outer nuclear layer



(3) External limiting membrane

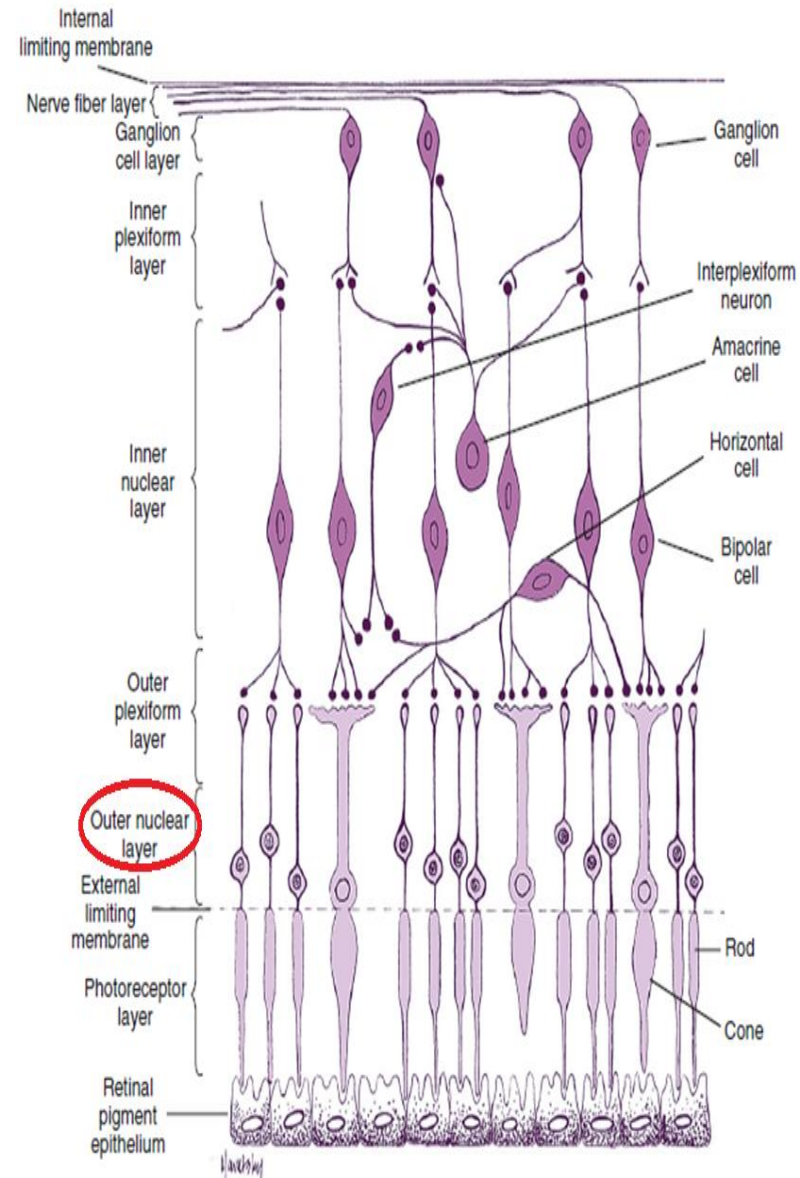
- It appears as a fenestrated membrane extending from ora serrata to the edge of the optic disc. (in low magnification)
- Formed by the junctions between the cell membrane of photoreceptors and muller's cells



Microscopic structure of the retina.

(4) Outer nuclear layer

- Layer is formed by the nuclei of rods and cones, cone nuclei are larger ($6-7\mu\text{m}$) than the nuclei ($5.5\mu\text{m}$) and lie in a single layer next to the ELM.
- Rod nuclei form the bulk of this multilayered outer nuclear layer except the cone dominated foveal region.
- Number of rows of nuclei and thickness of this layer varies from region to region.

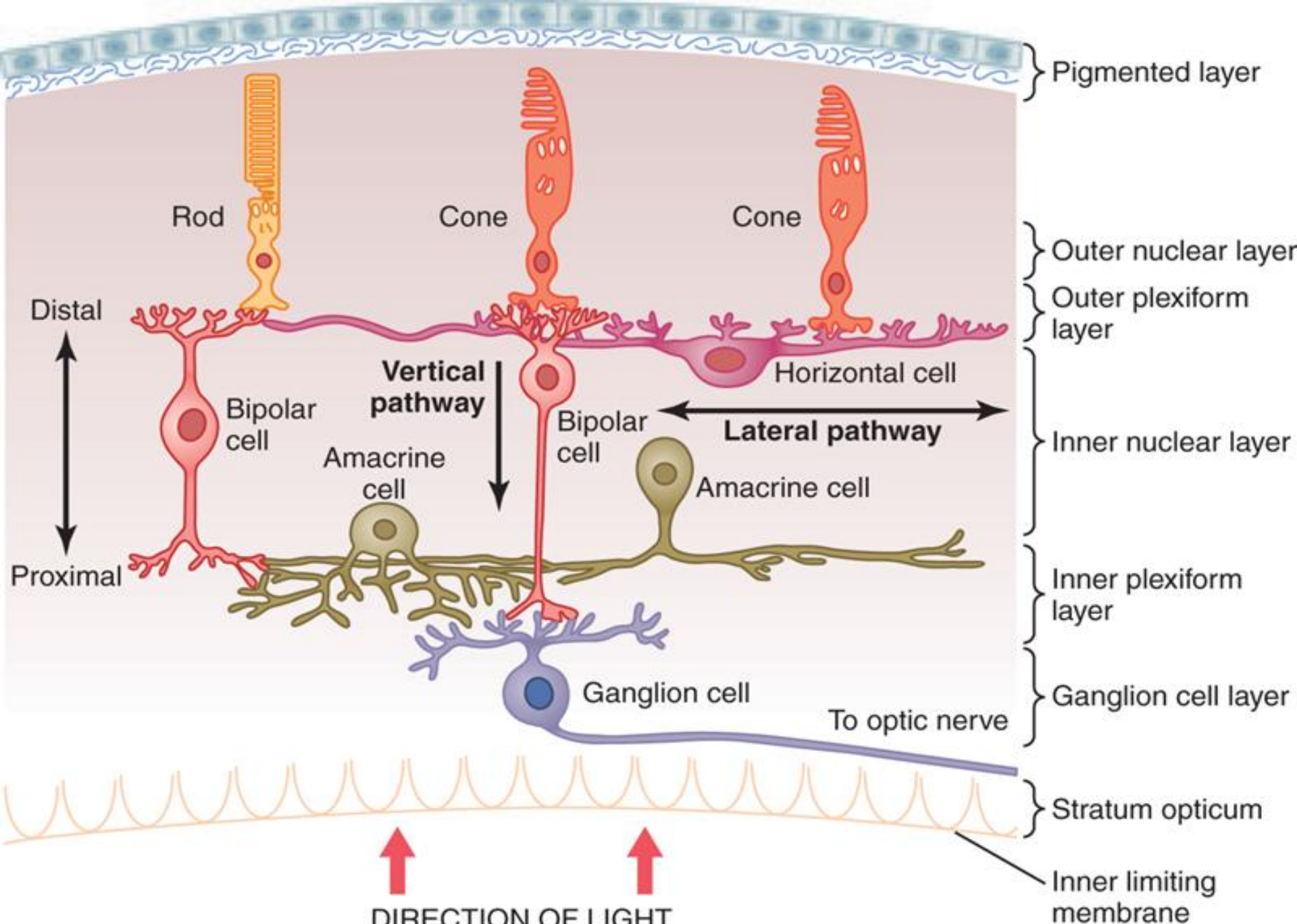


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- Nasal to disc – 8 to 9 layers of nuclei and 45 μm thickness.
- Temporal to disc – 4 rows of nuclei and 22 μm thickness.
- Foveal region – 10 rows of nuclei and 50 μm thickness.
- Rest of the retina except ora serrata – 1 row of cone nuclei and 4 rows of rod nuclei with a thickness of 22 μm .

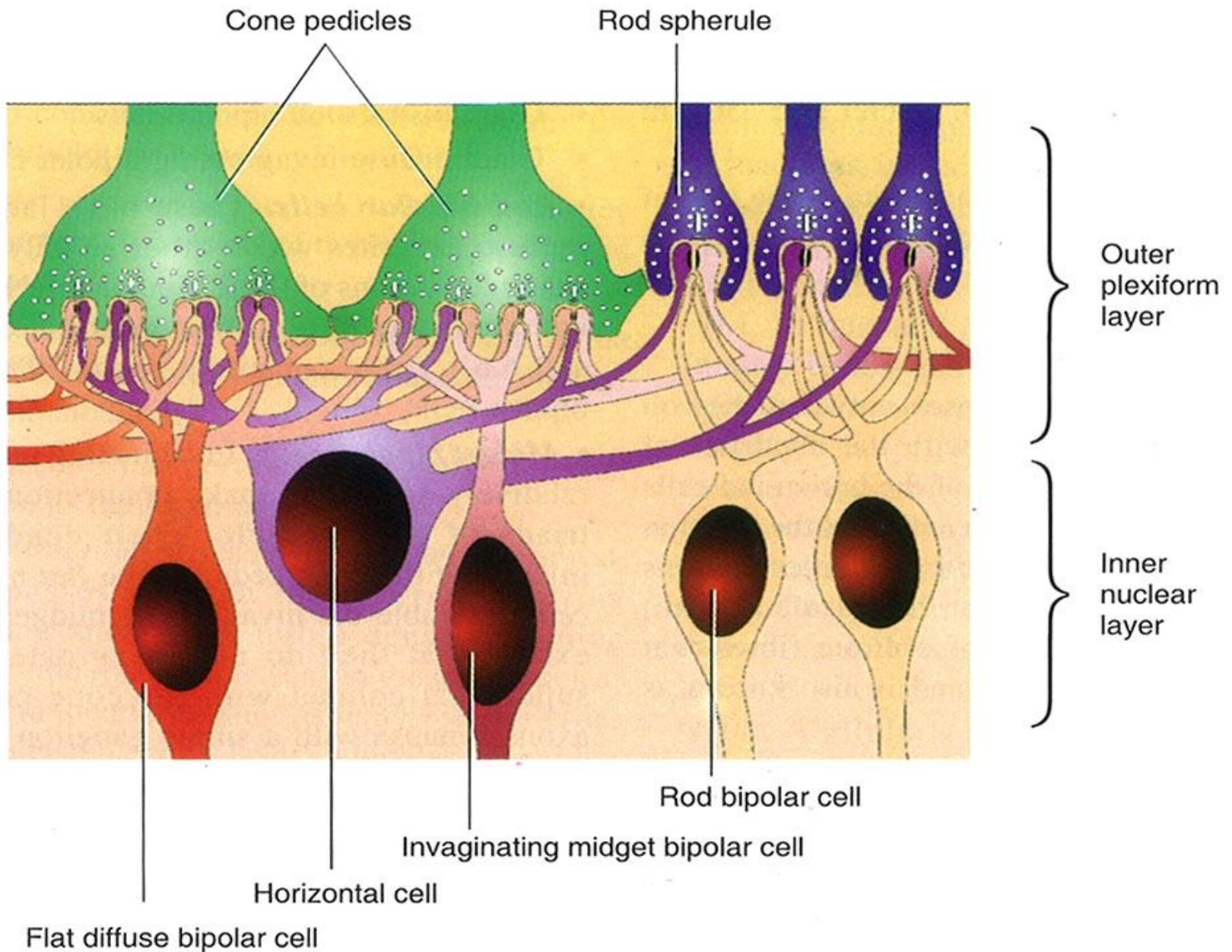
(5) Outer plexiform layer

- This layer contains the synapses bet. rod spherules and cone pedicles with the dendrites of the bipolar cells and processes of the horizontal cells. It marks the junction of the end organs of vision and first order neurons in retina.
- Its thickness at macula 51 μm and consists predominantly of oblique fibers that have divided from the fovea and is also known as Henle's layer



(6) Inner nuclear layer

- Under microscope, this layer resembles the outer nuclear layer except that it is thin. Layer disappears at fovea and rest of the retina consists of the following:
 - Bipolar cells
 - Horizontal
 - Amacrine
 - The soma of the Müller's
 - Capillaries of the central retinal vessels



Cell connections in outer plexiform layer.

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BIPOLAR CELLS:

- Neurons of first order of vision.
- Body of the bipolar cells consists entirely of nucleus, which lies in the inner nuclear layers. Their dendrites arborize with the rod spherules and cone pedicles in outer plexiform layer.
- Nine types of bipolar cells are seen under light microscopy

3. Under light microscopy nine types
 - a. Rod bipolar cells
 - b. Invaginating midget bipolar
 - c. Flat midget bipolar
 - d. Invaginating diffuse bipolar
 - e. Flat diffuse bipolar
 - f. On-centre blue cone bipolar
 - g. Off-centre blue cone bipolar
 - h. Giant bistratified bipolar
 - i. Giant diffuse invaginating bipolar

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- **HORIZONTAL NEURONS:**
- Consists of following cells:
- Flat cells having neumerous horizontal associative and neuronal interconnections between photo receptor and bipolar cells in the outer plexiform layer.
- **Type A** horizontal cells have seven groups of dendrites which have contact with triad of 7 cone pedicles and their single axon has contact with distant cone triad.

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- **Type B** horizontal cells dendrites have contact with rod receptors only and their axones with distant rod cells.

AMACRINE CELLS:

- Present in the inner most of this layer. They have a piriform body and single process which passes inwards in the inner plexiform layer.
- Forms connections with the axons of the ganglion cells.

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MULLERS CELLS:

- Nucleus and cell bodies are within the inner nuclear layer. They provide structural support and contribute to metabolism of sensory retina.
- Their role in various layers is as follows:
 - 1) In outer nuclear layer, mullers cells provide reticulum around the cells scotoma.

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- 2) In OPL, the major processes of Muller's cells produce cells produce side branches which form the horizontal extending reticulam.
- 3) In layer of ganglion cells , provide reticulum around cell somata.
- 4) In nerve fiber layer, their processes interweave with axons of ganglion cells.
- 5) Internal limiting membrane, the inner fiber of the Muller's cells take part in the formation of this membrane.

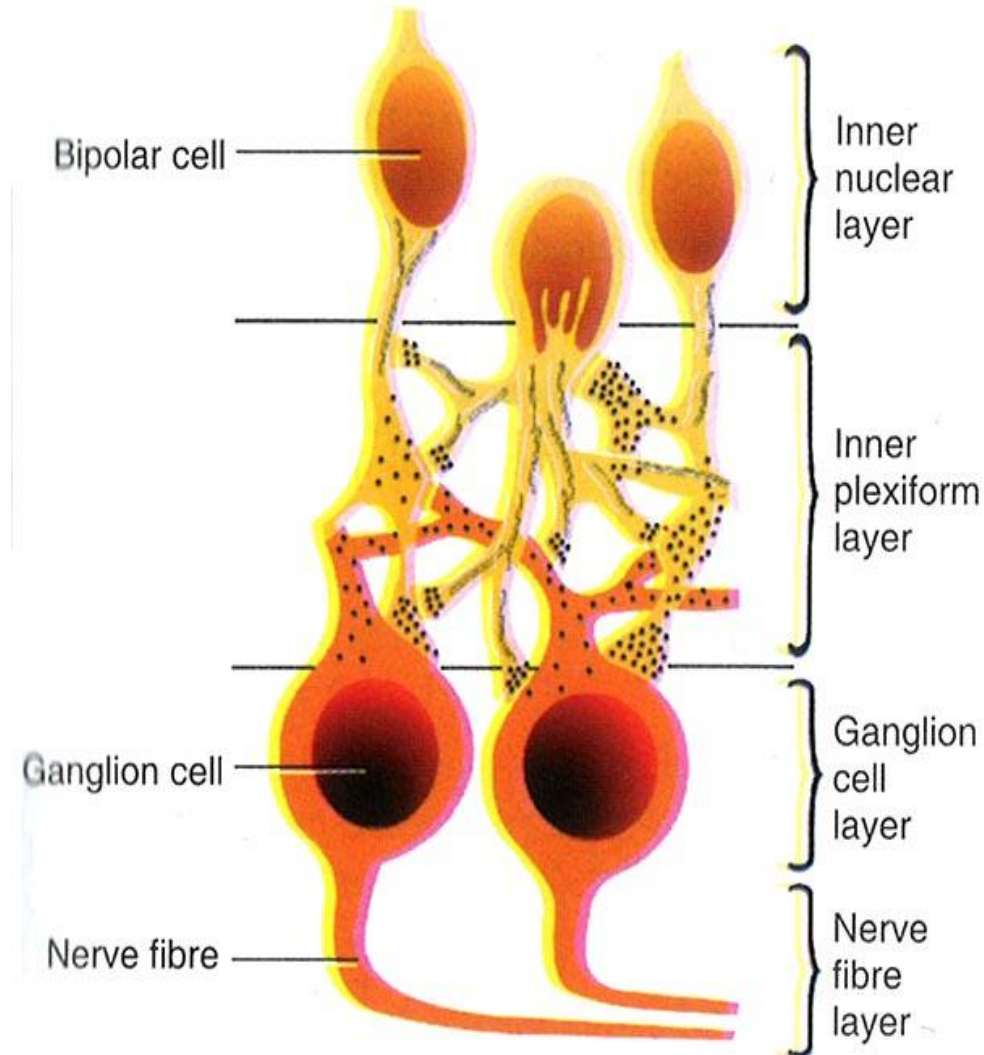
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Other glial cells

- Retina contains other glial cells like astrocytes, microglial and oligodendrocytes.

(7) INNER PLEXIFORM LAYER

- Consists of synapses bet. Axons of bipolar cells and dendrites of ganglion cells and the process of integrative amacrine cells.
- This layer is absent at the foveola.



Cell connections in inner plexiform layer.

(8) GANGLION CELL LAYER

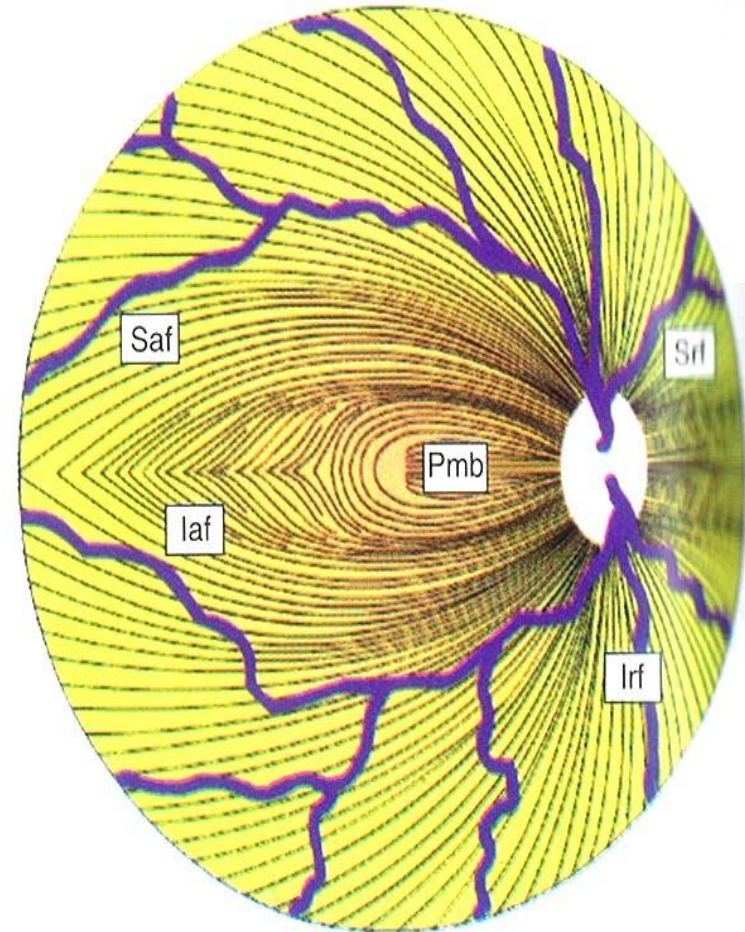
- Cell bodies and nuclei of ganglion cells lie in this layer.
- This layer is composed of single row of cells except in macula where it is multi layer and on temporal side of disc it has two layers.
- It is absent in foveola
- Classification of ganglion cells:
 - a. w, x, y ganglion cells
 - b. P & M ganglion cells
 - c. Off centre & on centre
 - d. Mono & Polysynaptic

(9) NERVE FIBRE LAYER

- Consists of unmyelinated axons of the ganglion cells which converge at the optic nerve head. Pass through the lamina cribrosa and become ensheathed by myelin posterior to the lamina.
- Thickness where is from 0.5 to 2 μ m.

• ARRANGEMENT OF NERVE FIBRES IN THE RETINA:

1. Fibres from the nasal half of the retina come directly to the optic disc as superior and inferior radiating fibres (srf and irf).
2. Fibres from the macular region pass straight in the temporal part of the disk as papillomacular bundle (pmb).
3. Fibres from the temporal retina arch above and below the macular and papillomacular bundle as superior and inferior arcuate fibres (saf and iaf) with a horizontal raphe in between.



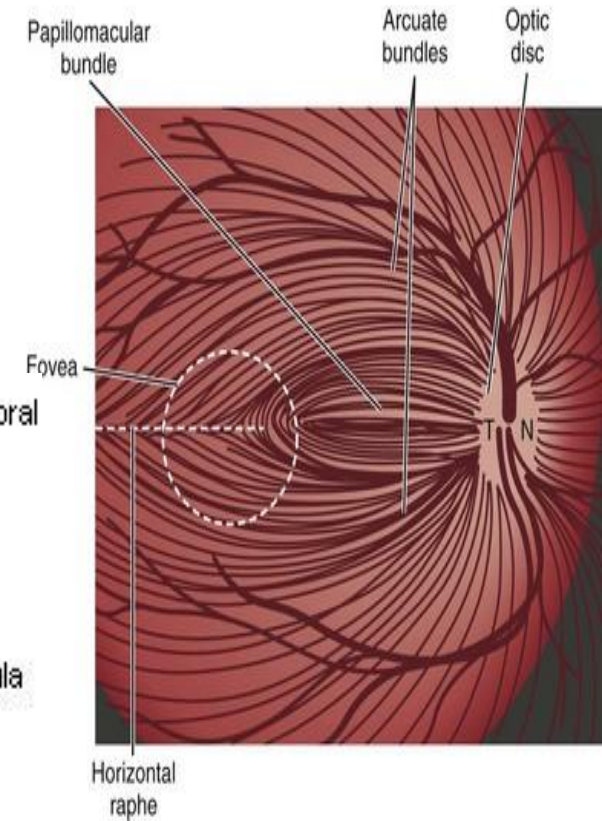
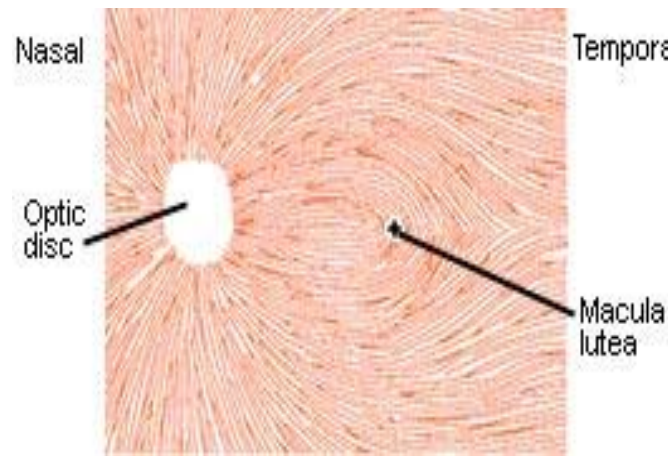
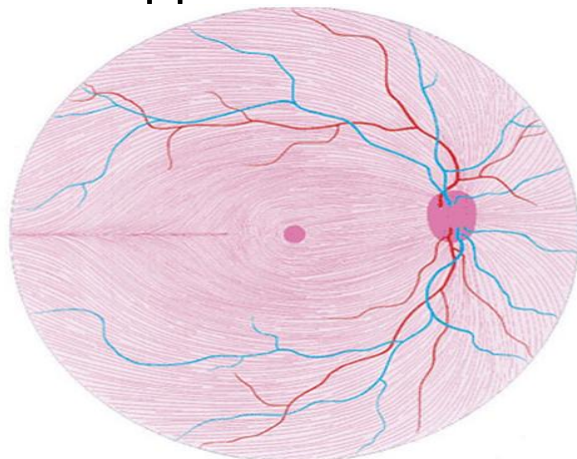
Arrangement of nerve fibres in the retina.

- **ARRANGEMENT OF NERVE FIBRES OF THE OPTIC NERVE HEAD:**

- Fibres from the peripheral part of the retina lie deep in the retina but occupy the most peripheral (superficial) part of the optic disc. While the fibres originating closer to the optic nerve head lie superficially in the retina and occupy a more central (deep) portion of the disc.

- **THICKNESS OF NERVE FIBRE LAYER AT THE DISC:**

- Thickness of the nerve fibre layer around the different quadrants of the optic disc margin progressively increases in the following order:
 - Most lateral quadrant (thinnest)
 - Upper temporal and lower temporal quadrant
 - Most medial quadrant
 - Upper nasal and lower nasal quadrant (thickest)

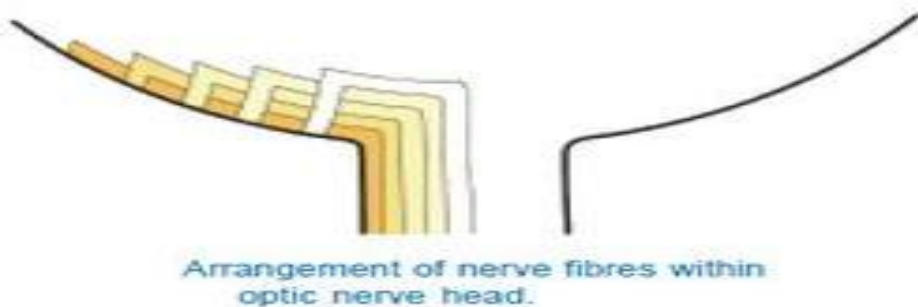


ARRANGEMENT OF NERVE FIBRES OF THE OPTIC NERVE HEAD:

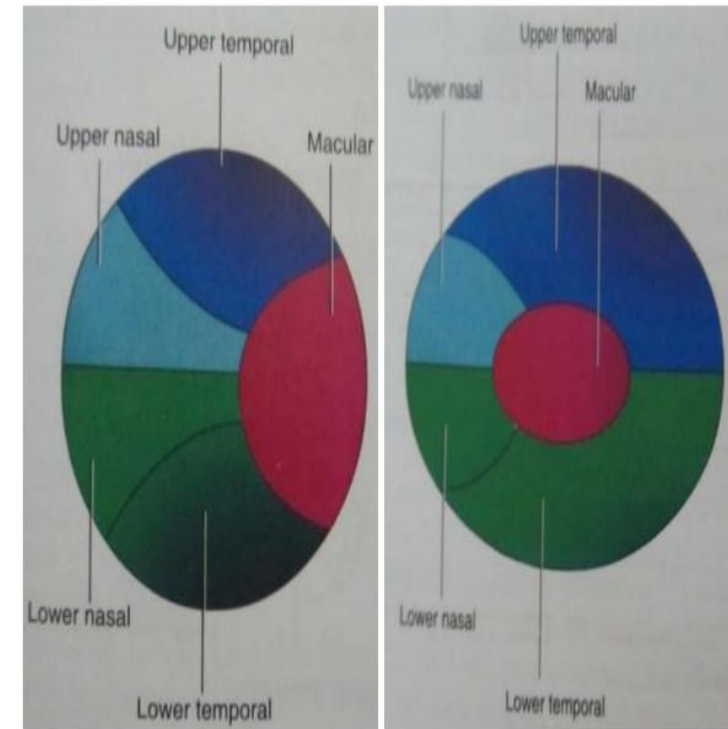
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Arrangement Of Fibres In Optic Nerve



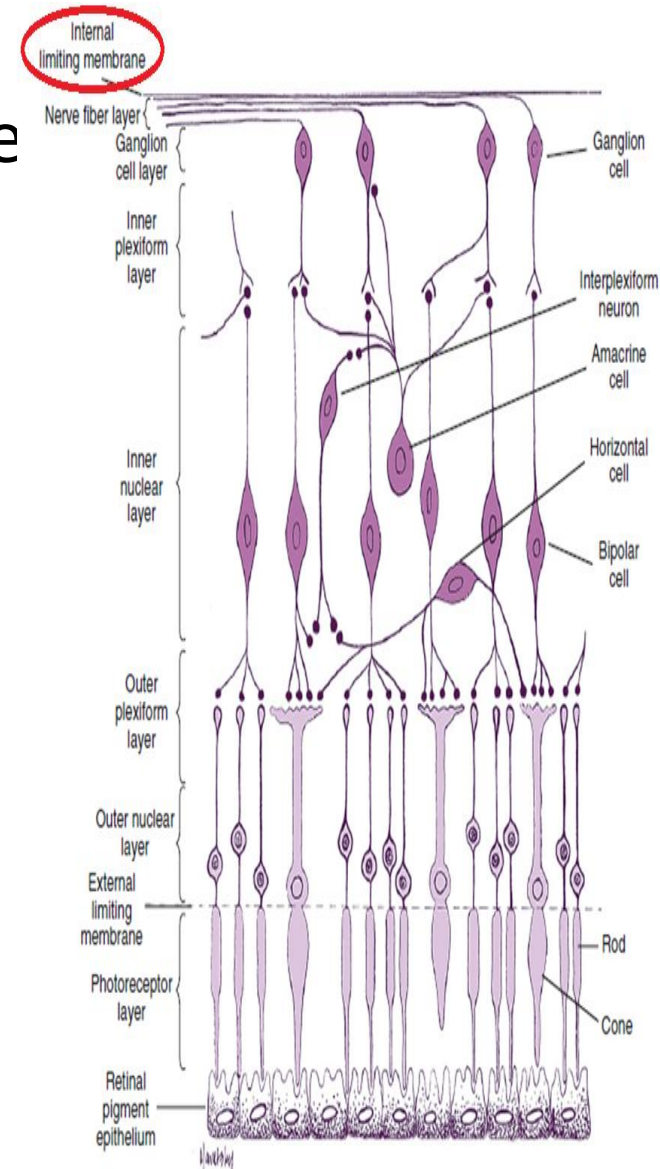
Arrangement of fibres in ON head & distal region

Arrangement of fibres in proximal region of ON

- **CLINICAL SIGNIFICANCE OF DISTRIBUTION AND THICKNESS OF NERVE FIBRES AT THE OPTIC DISC MARGIN:**
 1. Papilloedema appears first of all in the thickest quadrant (upper nasal and lower nasal) and last of all in the thinnest quadrant (most lateral).
 2. Arcuate nerve fibres which occupy the superior temporal and inferior temporal quadrants of optic nerve head are most sensitive to glaucomatous damage, accounting for an early loss in corresponding regions of visual field.
 3. Macular fibres occupying the lateral quadrant are most resistant to glaucomatous damage and explain the retention of the central vision till end.

(10) INTERNAL LIMITING MEMBRANE

- Consists of PAS positive true basement membrane that forms the interface between retina and vitreous. The fibrils of the vitreous merge with the internal lamellae of this membrane. It consists of
 1. Collagen fibrils,
 2. Proteoglycans,
 3. Basement Membrane,
 4. Plasma Membrane of the Muller cells
 5. possibly other glial cells of the retina.



• **BLOOD SUPPLY OF THE RETINA:**

- Outer 4 layers of retina is supplied by (till outer nuclear layer) choriocapillaries.
- The inner six layers gets its supply from central retinal artery which is a branch of ophthalmic artery.
- The outer plexiform layer gets partly by both the above arteries.
- The fovea is avascular and is mainly supplied by choriocapillaries.
- The inner portion of the retina is perfused by branches of the central retinal artery.
- In 30% of eyes ,a cilioretinal artery,branching from the ciliary circulation ,supplies part of inner retina mainly The Macula Region.
- The retinal blood vessels maintain the inner blood-retinal barrier.This physiological barrier is due to single layer of non-fenestrated endothelial cells,whose tight junctions are impervious to tracer substances such as fluorescein.

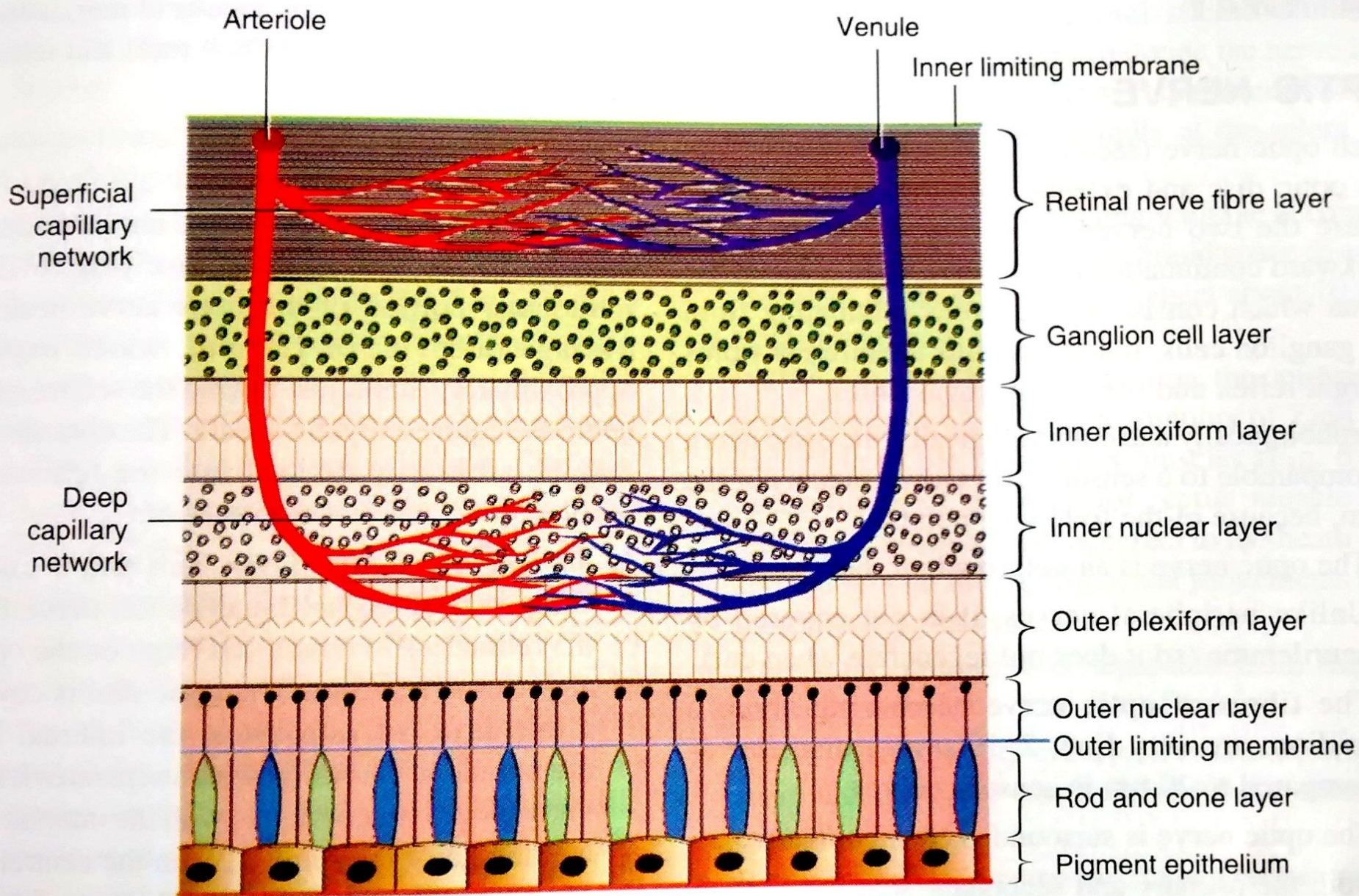
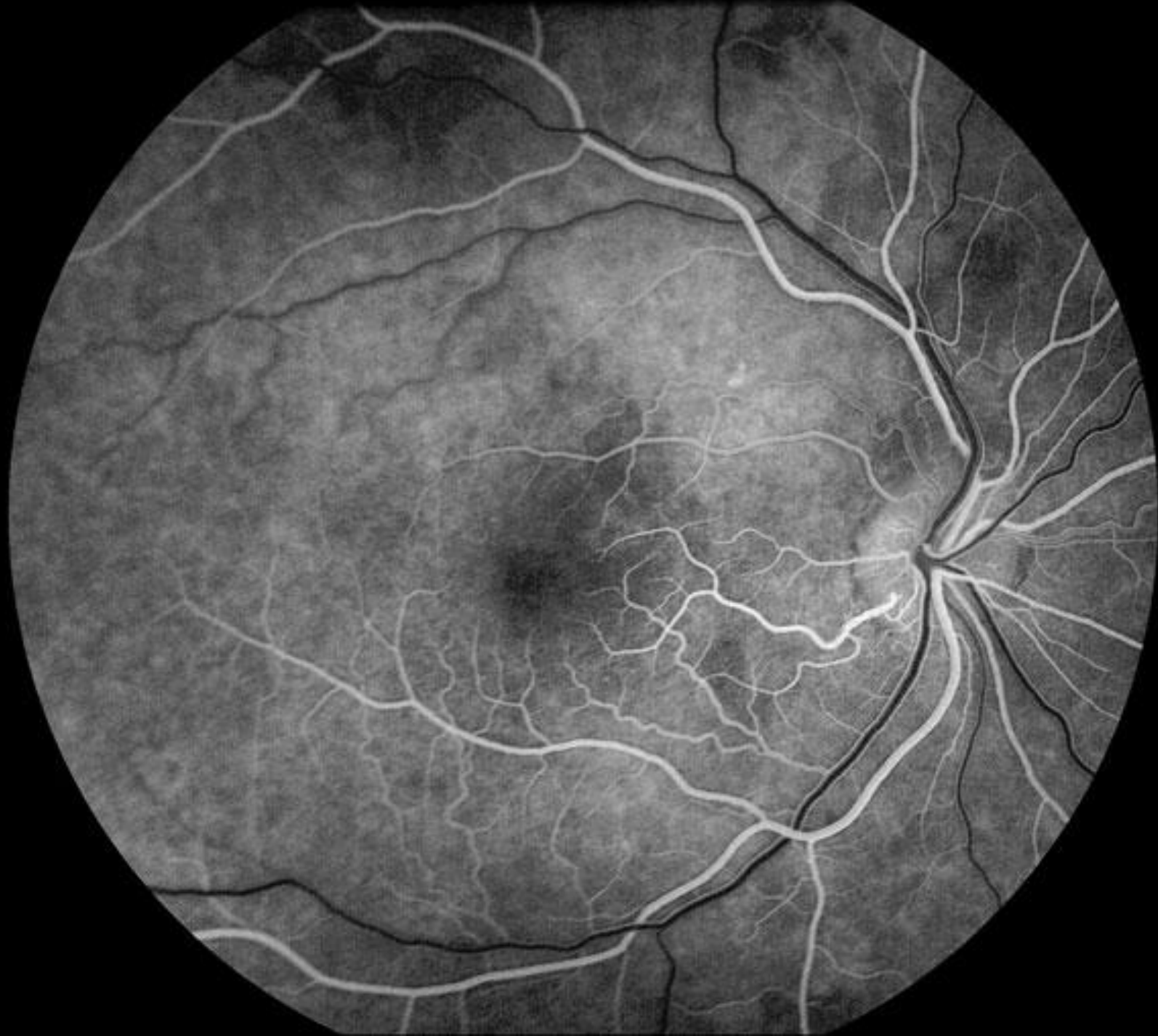


Fig. 6.11. Arrangement of retinal capillaries.

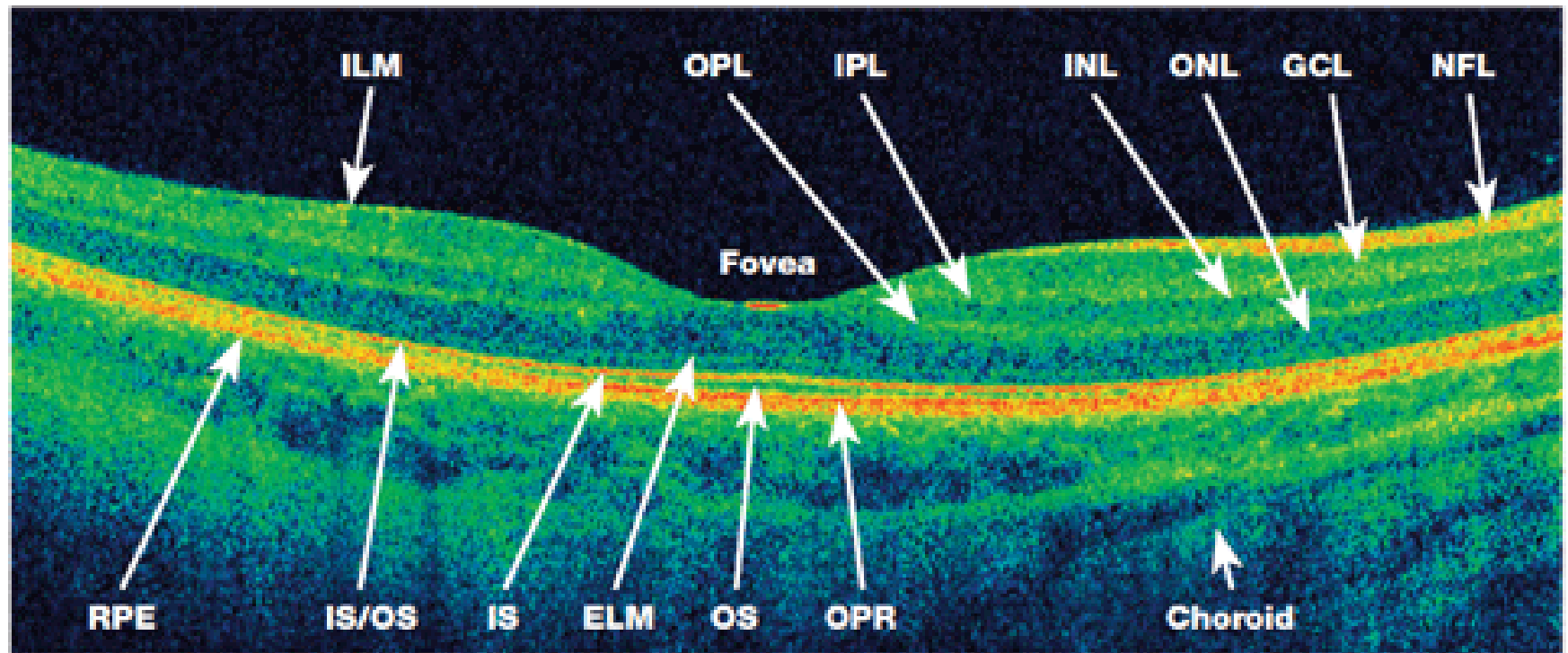
- Retinal blood vessels lack an internal elastic lamina & a continuous layer of smooth muscle cells.
- The retinal arteries are end arteries & have no anastomoses. The only place where the retinal system anastomoses is in the neighbourhood of lamina cribrosa.
- The veins of the retina unite to form Central retinal vein at the disc, which follows the corresponding artery.
- The terminal fundus arterioles bend sharply and dip almost vertically into the retina.
- In most of the Extramacular fundus- two retinal capillary networks- a superficial and a deep.
- In parafoveal zone it is well developed and in 3 layers.
- A capillary free zone of 500micrometre diameter in foveal zone- FAZ.

Blood Retinal Barrier

- Formed by the endothelial cells that are closely bound together about the lumen by intercellular junctions of zonula occludens type.
- These junctions normally prevent the free flow of fluids and solutes.
- The endothelial cells are encircled by basement membrane and which is surrounded by layer of pericytes- which is further surrounded by basement membrane.
- 1:1 ratio of pericytes and basement membrane cells is normal.



An HD-OCT scan of a healthy eye



NFL: Nerve fiber layer

ILM: Inner limiting membrane

GCL: Ganglion cell layer

IPL: Inner plexiform layer

INL: Inner nuclear layer

OPL: Outer plexiform layer

ONL: Outer nuclear layer

ELM: External limiting membrane

IS: Photoreceptor inner segment

OS: Photoreceptor outer segment

IS/OS: Interface between IS and OS

RPE: Retinal pigment epithelium

OPR: Outer photoreceptor/
RPE complex