

# EYE

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THE SENSORY ORGANS RECEIVE INFORMATION ABOUT THE STATE OF THE EXTERNAL ENVIRONMENT AND THE ACTIVITY OF THE SYSTEMS OF THE ORGANISM ITSELF.

**THE EYEBALL IS THE PERIPHERAL PART OF THE VISUAL ANALYZER!**

**THE CENTRAL PART IS LOCATED IN THE OCCIPITAL LOBE OF THE BRAIN!**

**BOTH SECTIONS OF THE OPTIC ANALYZER ARE CONNECTED BY THE OPTIC NERVE!**

**Eyeball (eye)** - is the peripheral part of the visual analyzer.

Through the organ of vision a person receives 80-85% of information about the world around him. Vision is the most important physiological process with the help of which an idea is created about the size, shape and color of objects, about their mutual location and distance. This information allows a person to navigate the world around him.

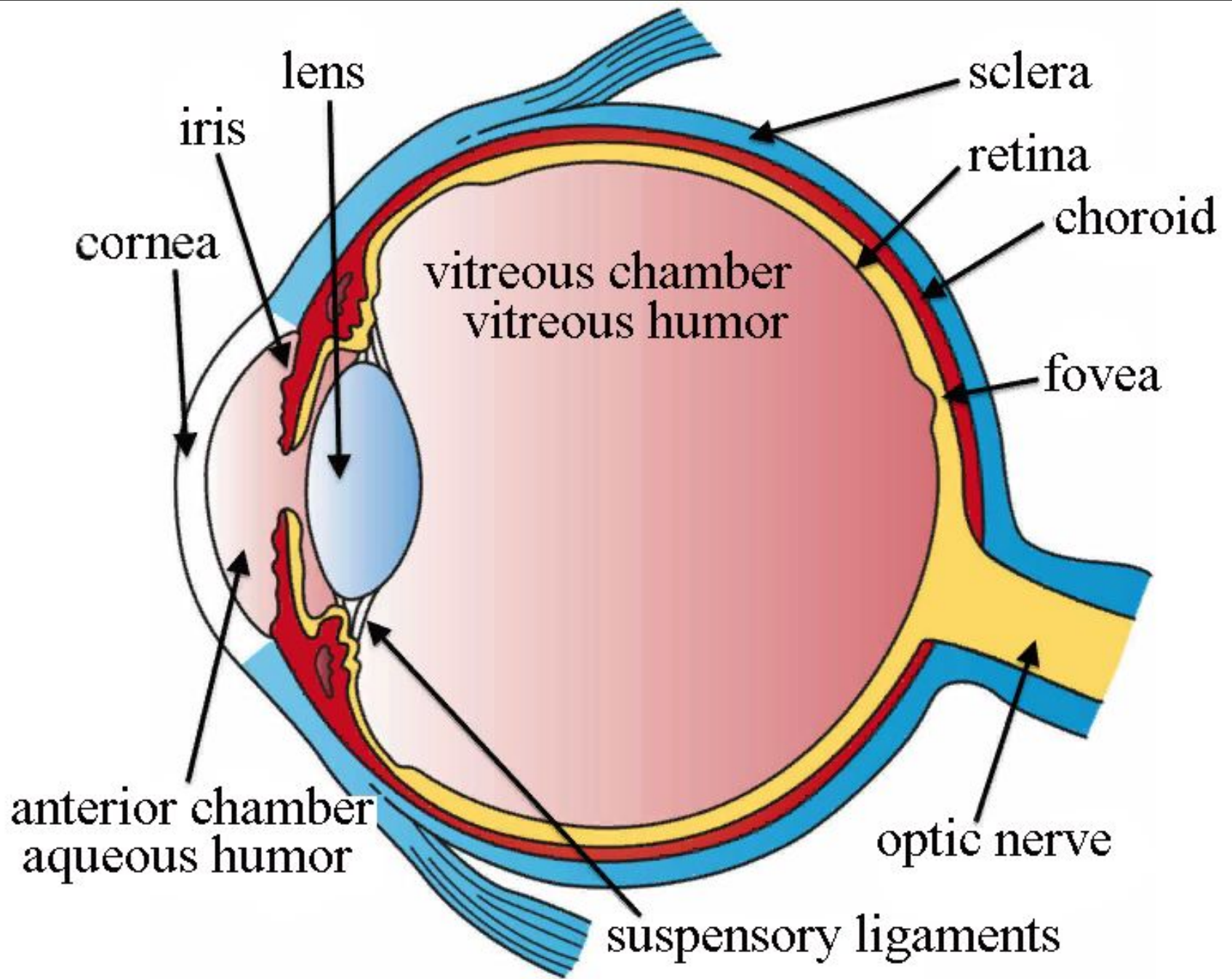
Three tunics are distinguished in the eyeball:

**Outer fibrous** (sclera and its transparent part - the cornea)

**Middle - choroid** with its derivatives - **ciliary body** and **iris**;

**Inner is the retina** (sensitive or receptor part).

In addition, the eyeball has a lens, a vitreous body, anterior and posterior camera with fluid



**Functionally several apparatuses are distinguished:**

- receptor (retina),**
- dioptric or light-refracting (cornea, crystalline lens, vitreous body, fluid of the anterior and posterior chambers of the eye)**
- accommodative (iris, ciliary body)**
- Auxiliary (eyelids, lacrimal glands, oculomotor**

# THE ORGAN OF VISION DEVELOPS FROM 3 EMBRYONIC SOURCES: ECTODERM, NEURAL TUBE AND MESENCHYME

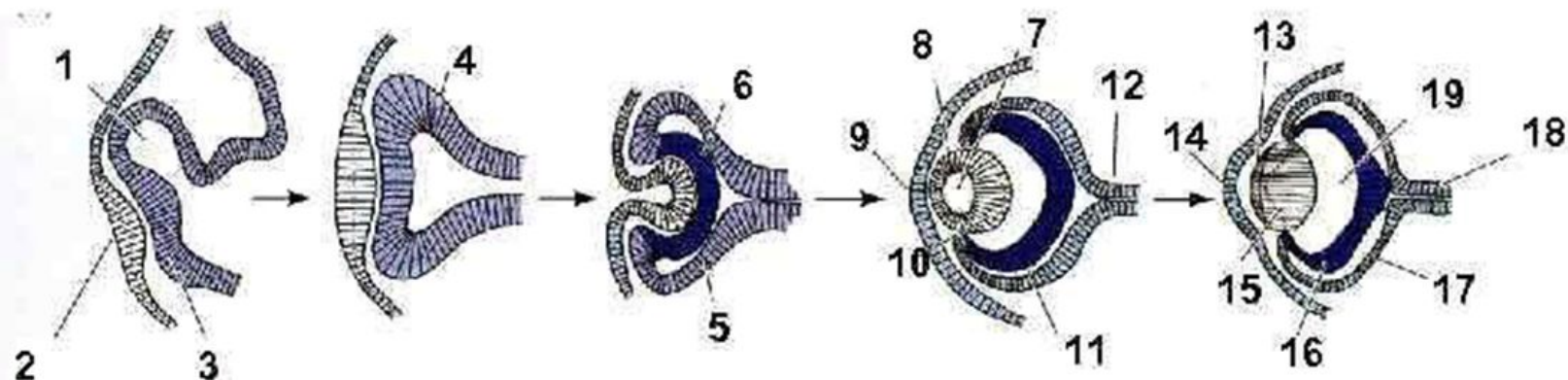
- DEVELOPMENT begins at the beginning of the 3rd week of embryonic development in the form of eye fossae in the wall that is still not closed in the neural tube, later 2 eye vesicles protrude from the wall of the diencephalon from the zone of this fossa. The eye vesicles are connected to the diencephalon using the eye stalk. The anterior wall of the vesicles is pushed and the vesicles turn into double-walled eye cups.

# DEVELOPMENT OF EYE

- At the same time, the ectoderm opposite the eye vesicles, while puffing, forms lens vesicles. Epithelial cells of the posterior hemisphere of the lens vesicle lengthen and turn into long transparent structures - lens fibers. A crystalline protein is synthesized in the lens fibers. Subsequently, in the lens-fiber cells organoids disappear, the nuclei shrink and disappear. Thus, the lens forms - a kind of elastic lens. From the ectoderm in front of the lens, the anterior epithelium of the cornea is formed.
- The inner layer of the 2-wall ocular cup differentiates into the retina, takes part in the formation of the vitreous body, and the outer layer forms the pigment layer of the retina.
- The material of the edge of the eye cup along with the mesenchyme is involved in the formation of the iris. From the surrounding mesenchyme, the choroid and sclera, the ciliary muscle, its own substance and the posterior corneal epithelium are formed. Mesenchyme is also involved in the formation of the vitreous, iris.

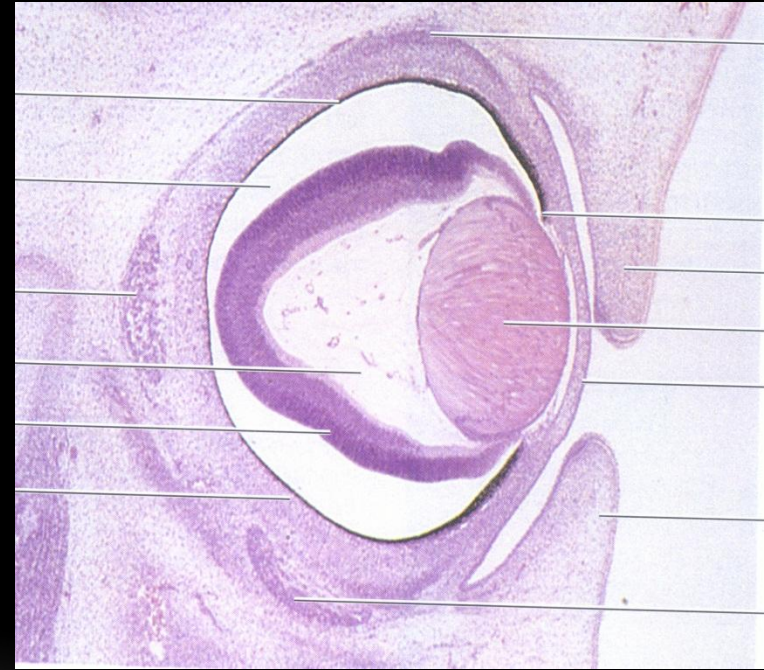


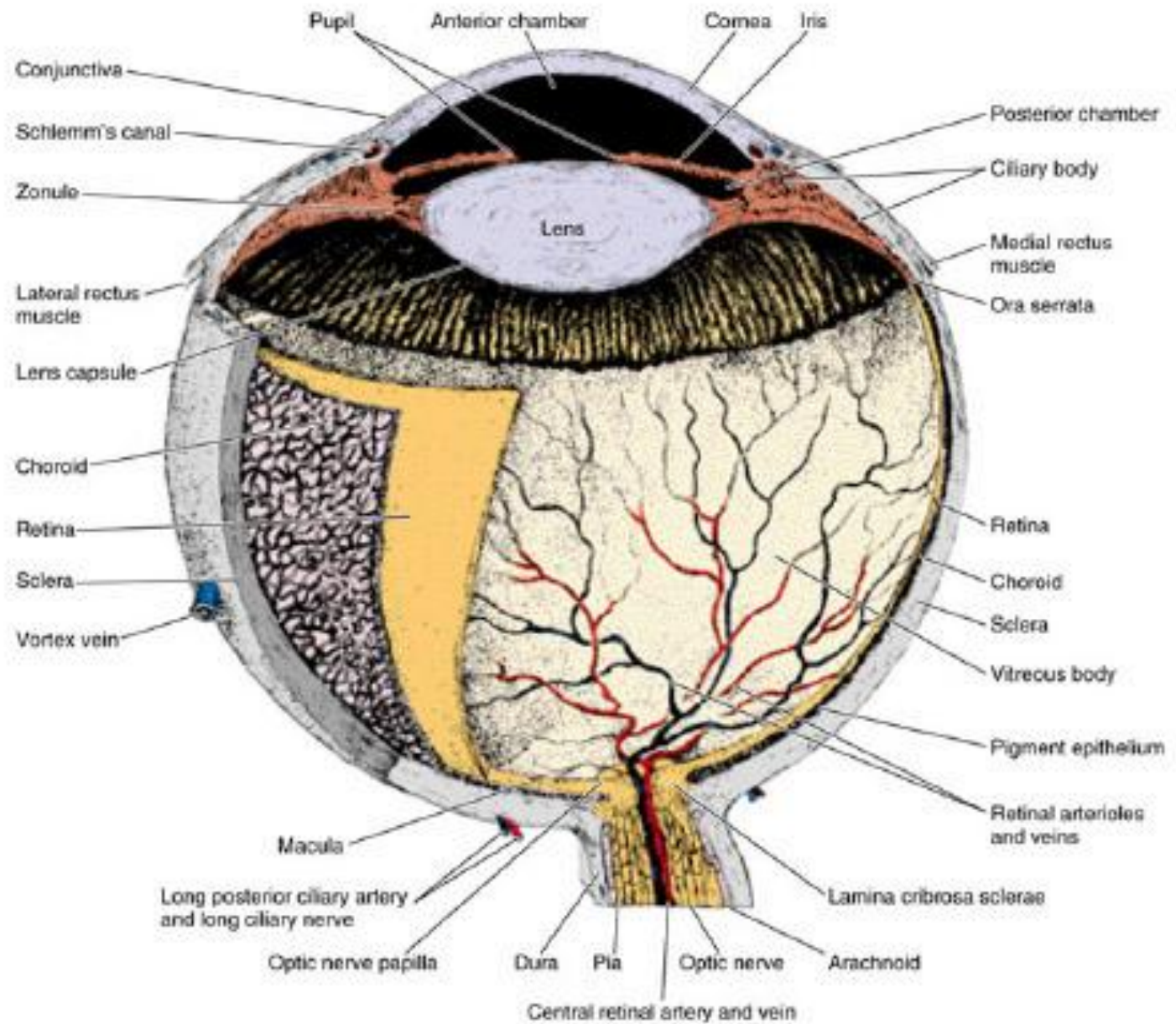
# СХЕМА РАЗВИТИЯ ГЛАЗА



1 – ГЛАЗНОЙ ПУЗЫРЬ; 2 – ХРУСТАЛИКОВАЯ ПЛАКОДА; 3 – НЕЙРАЛЬНАЯ ЭКТОДЕРМА; 4 – РАННЯЯ ГЛАЗНАЯ ЧАША; 5 – НАРУЖНЫЙ СЛОЙ (БУДУЩИЙ ПИГМЕНТНЫЙ ЭПИТЕЛИЙ); 6 – ВНУТРЕННИЙ СЛОЙ (БУДУЩАЯ СЕТЧАТКА); 7 – ХРУСТАЛИКОВЫЙ ПУЗЫРЕК; 8 – ХРУСТАЛИКОВАЯ КАПСУЛА; 9 – БУДУЩАЯ РОГОВИЦА; 10 – ПЕРВИЧНЫЕ ВОЛОКНА; 11 – ПРОСТРАНСТВО МЕЖДУ СЛОЯМИ; 12 – ГЛАЗНОЙ СТЕБЕЛЕК; 13 – ЭПИТЕЛИЙ ХРУСТАЛИКА; 14 – РОГОВИЦА; 15 – ВОЛОКНА ХРУСТАЛИКА; 16 – НЕЙРАЛЬНЫЙ СЛОЙ СЕТЧАТКИ; 17 – ПИГМЕНТНЫЙ СЛОЙ СЕТЧАТКИ; 18 – ГЛАЗНОЙ НЕРВ; 19 – СТЕКЛОВИДНОЕ ТЕЛО

# STAGES OF EYE DEVELOPMENT





# TUNICA FIBROSA

- Consists of **sclera** - a dense opaque membrane and **cornea** - a transparent front
    - The sclera is formed by a dense fibrous connective tissue, consisting of collagen fibers bundles running parallel to the surface of the organ and the fibroblasts and elastic fibers lying between them.
    - Contains blood vessels!
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## LIMBUS

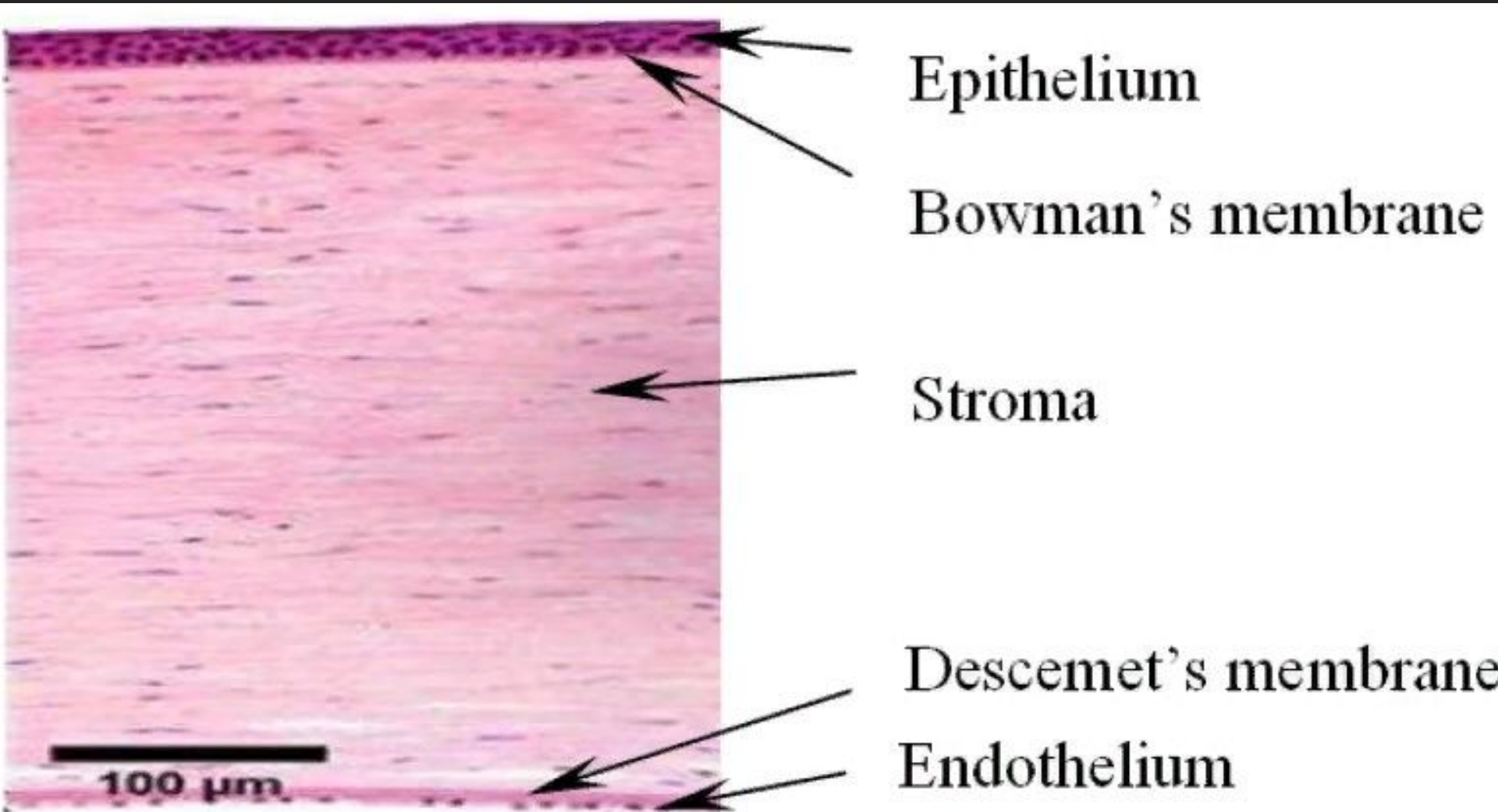
- The sclera passes into the cornea in the limb region, on the inner surface of which there is a system of channels lined with the endothelium leading to the venous sinus (Schlemm canal) - the path of the outflow of aqueous humor from the anterior chamber of the eye

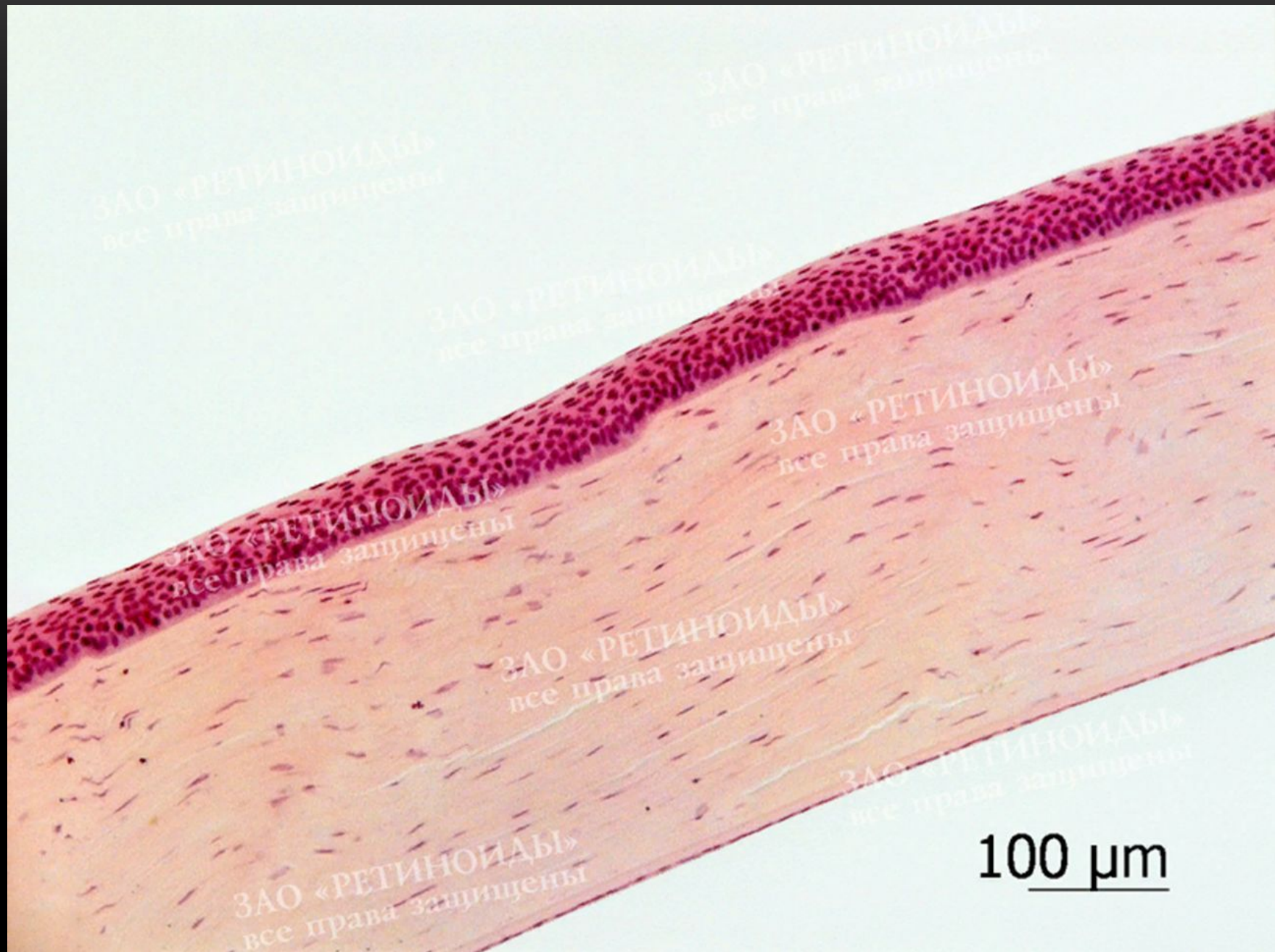
# CORNEA - HAS NO BLOOD VESSELS, IS WELL INNERVATED

## Includes 5 layers:

- **1. anterior epithelium** - stratified squamous non-keratinized
- **2. anterior limiting membrane** (Bowman's membrane) - consists of a network of collagen fibrils
- **3. substantia propiria or stroma** - occupies 90% of the thickness of the cornea and consists of connective tissue plates (there are collagen fibrils, fibroblasts and the main substance, glycoproteins (chondroitin and keratan sulfates) which ensure the transparency of the cornea
- **4. posterior limiting membrane** (Descemet's membrane)
- **5. posterior epithelium** (endothelium) - single layer flat cells

# CORNEA- TRANSPARENT PART OF TUNICA FIBROSA





100  $\mu\text{m}$



# HOROID

Includes:

choroid

ciliary body

iris

Actually, the choroid consists of Loose irregular connective tissue and includes 4 layers:

- subvascular (at the border with the sclera),

- vascular (contains arteries and veins),

- choriocapillary (contains a network of capillaries)

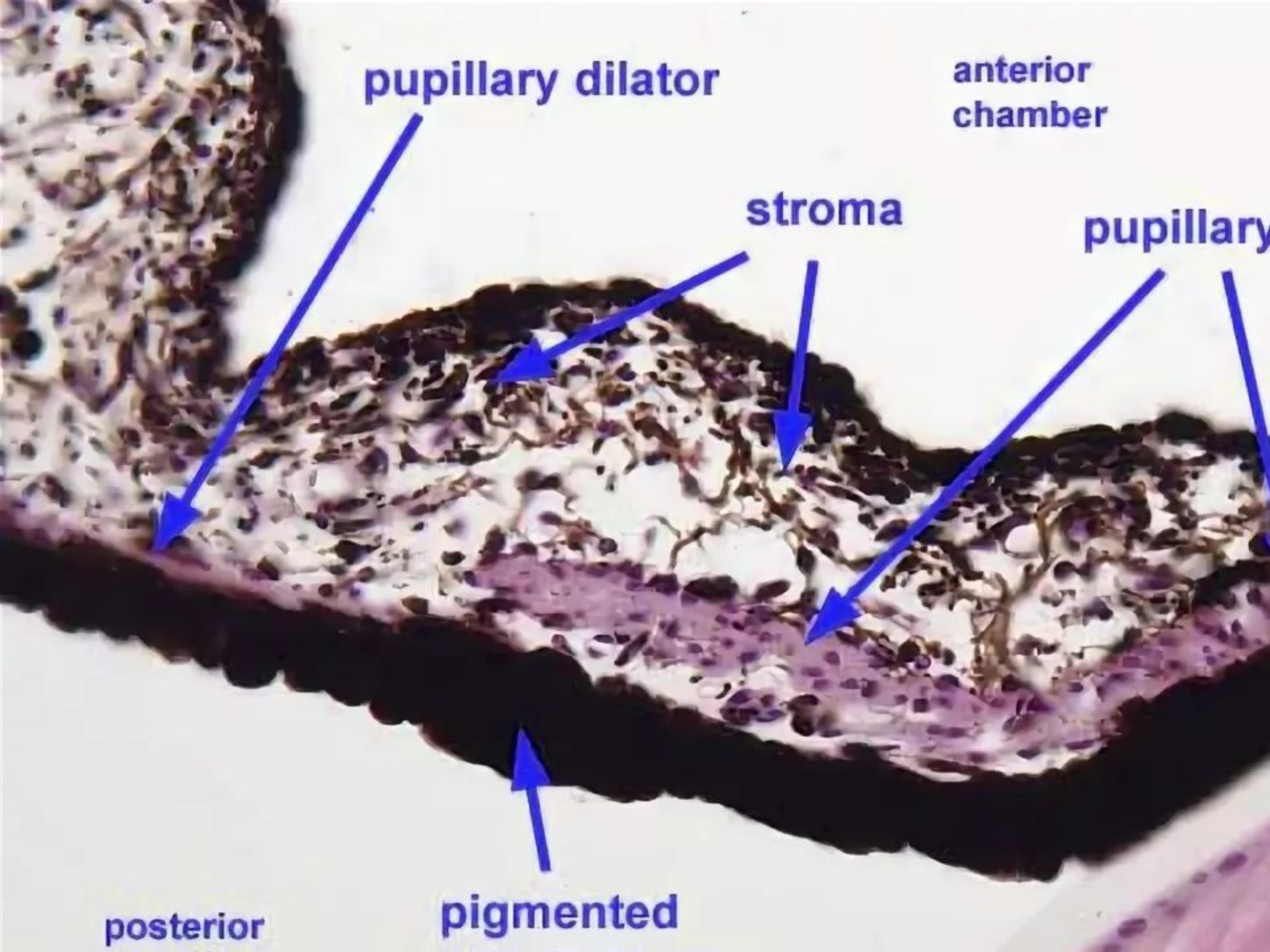
- basal (includes the basal membrane of capillaries, the basement membrane of the retinal pigment epithelium and the network of collagen and elastic fibers)

# CILIARY BODY

- It is formed by the ciliary muscle (smooth muscle) and ciliary processes that fix the lens
  - It takes part in the accommodation of the eye, changing the curvature of the lens
  - Covered with a bilayer cubic ciliary epithelium that produces watery moisture
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# IRIS

- the anterior part of the choroid, separates the anterior and posterior chambers of the eye, contains a hole of varying diameter (pupil). It is formed by rcbc with blood vessels and pigment cells.
  - Consists of 5 layers:
    - Anterior epithelium (single layer of squamose cells)
    - Outer limiting membrane
    - Vascular
    - Inner limiting membrane
    - Pigment epithelium - bilayered cubic pigment epithelium
- The iris contains 2 muscles of neural origin: m. sphinter pupillae, m. dilatator pupillae.



pupillary dilator

anterior chamber

stroma

pupillary

posterior

pigmented

# THE LENS - DOES NOT HAVE BLOOD VESSELS

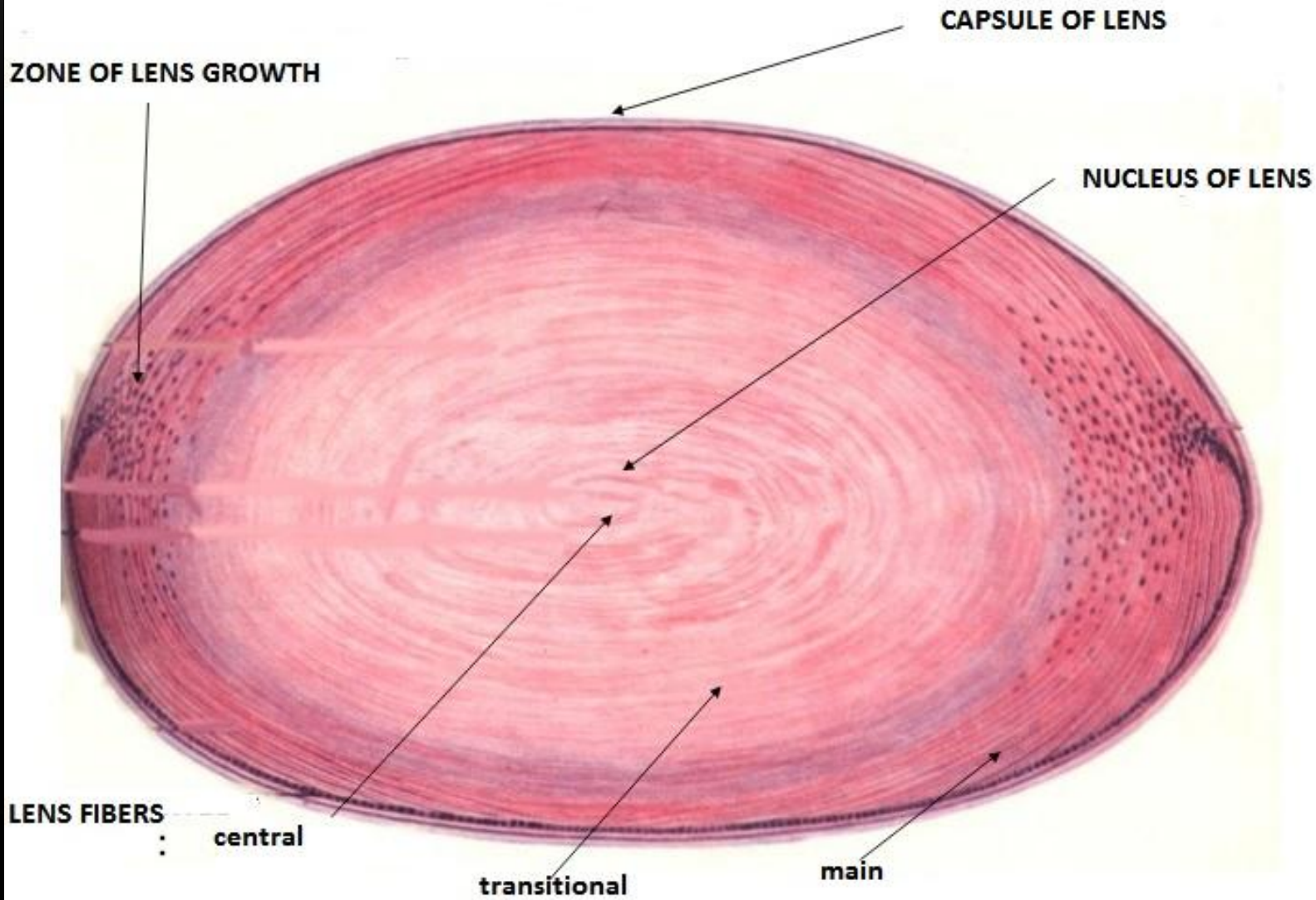
Consists of:

1. **Capsule** - a thin transparent layer covering the lens from the outside - is the basement membrane of its epithelium.
2. **Lens epithelium** - a layer of cuboidal cells lying under the capsule on its anterior surface (they are a growth zone), in the equatorial region the cells divide by mitosis, lengthen and gradually turn into lens fibers

# LENS FIBERS

- Elongated hexagonal epithelial cells lying parallel to the lens surface in concentric layers and forming its matrix, which consists of the cortex and nucleus. Contain transparent protein - crystallin!  
Lens fibers of the cortex contain nuclei, the nucleus of the lens consists of lens fibers without nuclei!
- With age, the elasticity of the lens decreases, which makes it difficult to study closely located objects (presbyopia).
- In some older people, the lens loses its transparency (cataract)







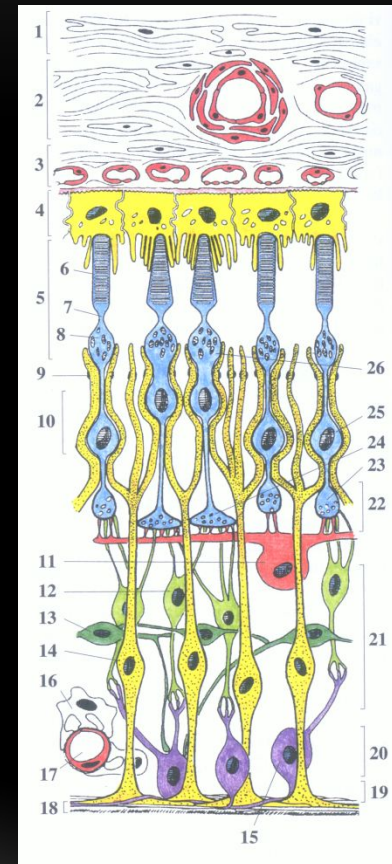
# VITREOUS BODY

- A transparent jelly-like mass filling the space between the lens and the retina.
- It consists of cells - hyalocytes, macrophages, lymphocytes and intercellular substance, consisting of 99.9% water, collagen fibrils and hyaluronic acid and a transparent protein **vitrein!**
- Provides the passage of light rays, maintaining the position of the lens, participates in the metabolism of the retina, presses the inner layers of the retina to the pigment epithelium

# RETINA

- Photosensitive tunica of the eye.
  - It is divided into the visual part, lining the inside of the back most of the eyeball and the front, the blind part, covering the ciliary body and the back surface of the iris.
  - There is a blind spot on the posterior surface of the retina (does not contain photoreceptor cells) - the exit site of the optic nerve and the central fossa is located more laterally along the axis of the eye - the yellow spot is the concentration site of the photoreceptor cells (best vision area)
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- **The retina consists of nerve tissue + pigment epithelium.**
- Nerve tissue includes neurons and neuroglia



# NEURONS

They form a three-membered chain of radially located neurons connected to each other by synapses:

- Photoreceptor
- Bipolar (associative)
- Ganglionic (multipolar)
- In addition, horizontal and amacrine neurons are located in the retina.

# PHOTORECEPTORS

- are bipolar neurons - rods and cones.

They consist of three parts: perikarion + modified dendrite + axon

Axons form synapses with bipolar and horizontal neurons

Modified dendrites consist of the **outer** and **inner segments**  
connected by a **cilia (connecting stalk)**

The outer segments are surrounded by processes of the pigment epithelium.

# ROD

- - With narrow elongated outer segments
  - The outer segment of the process has a cylindrical shape and contains a stack of 1000-1500 completed (closed) membrane disks (flattened sacs).
  - In the disc membranes is the visual pigment rhodopsin, which includes protein and aldehyde vitamin A.
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# RODOPSIN

- Rodopsin decomposes under the influence of light with the appearance of an electrical signal, and regenerates in the dark.
- Disks are constantly updated due to their formation in the proximal areas and displacement to the distal, where they are phagocytosed by pigment epithelium.
- Vitamin A is necessary for the regeneration of discs, in its absence they are destroyed (night blindness)

# INNER SEGMENT

- It contains mitochondria, centriole, rER, sER, Golgi complex and provides the outer segment with energy and substances necessary for photoreception. The core is small, round.
- The axon ends with a spherical thickening (spherule) and forms a synapse with a bipolar cell
- The sticks are located in the peripheral parts of the retina, are responsible for black and white vision



# CONES

The structure is similar to rods

**But**

The outer segments of them are conical in shape, contain open membrane disks (half-disk or semi-disks), formed by folds of plasmolemma, in which the visual pigment iodopsin is located, which decomposes under the action of red, green or blue light

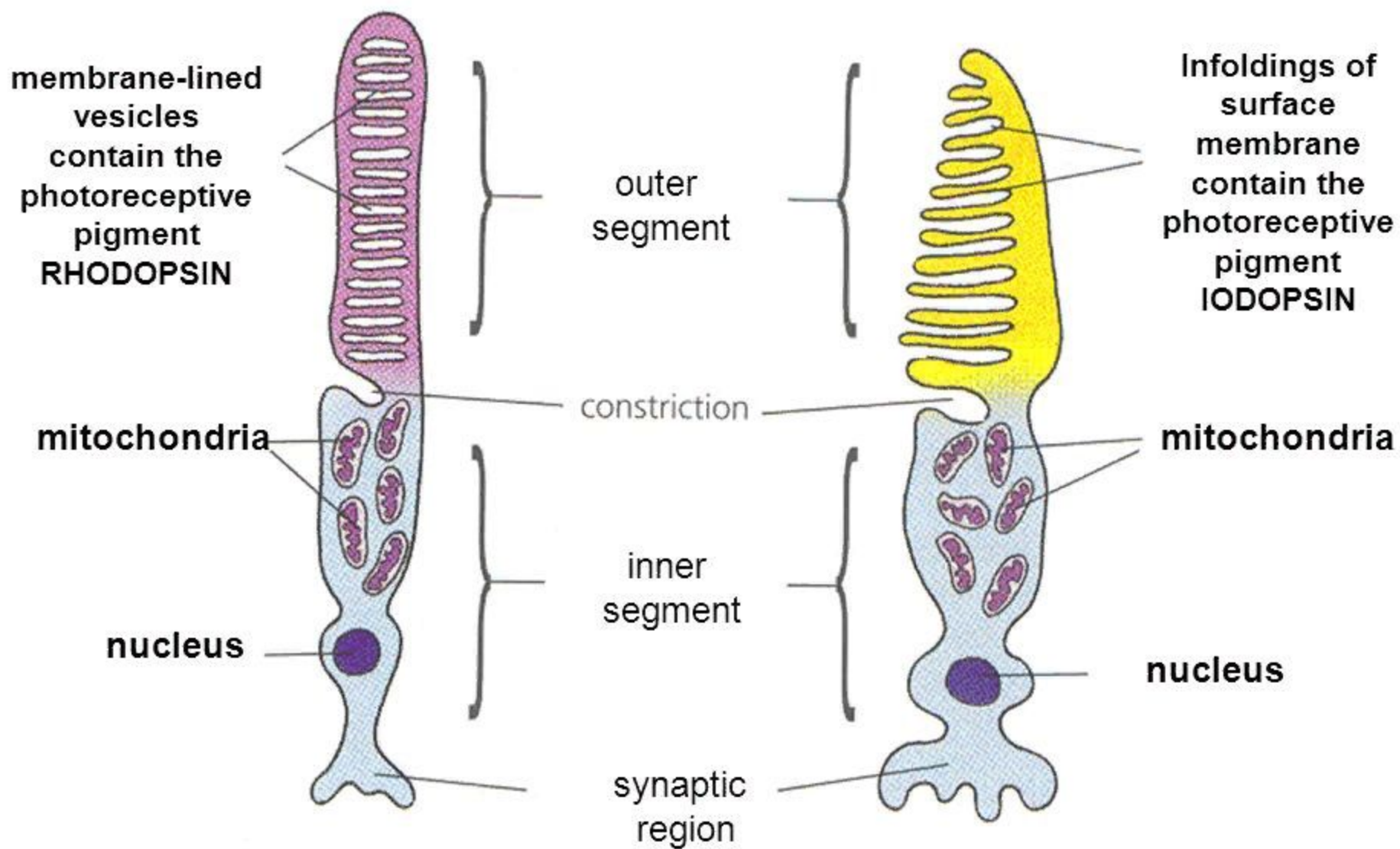
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# CONS

- The inner segment has a drop of fat inside, surrounded by mitochondria (ellipsoid)
- Contains larger and lighter nuclei in the perikarion!
- Axon ends with an extension (leg) of a triangular shape
- Cones are located in the central parts of the retina. Provide day and color vision.
- The absence of any type of cones causes color blindness (color blindness)

# rod cell

# cone cell



# Photoreceptors: Rods and Cones

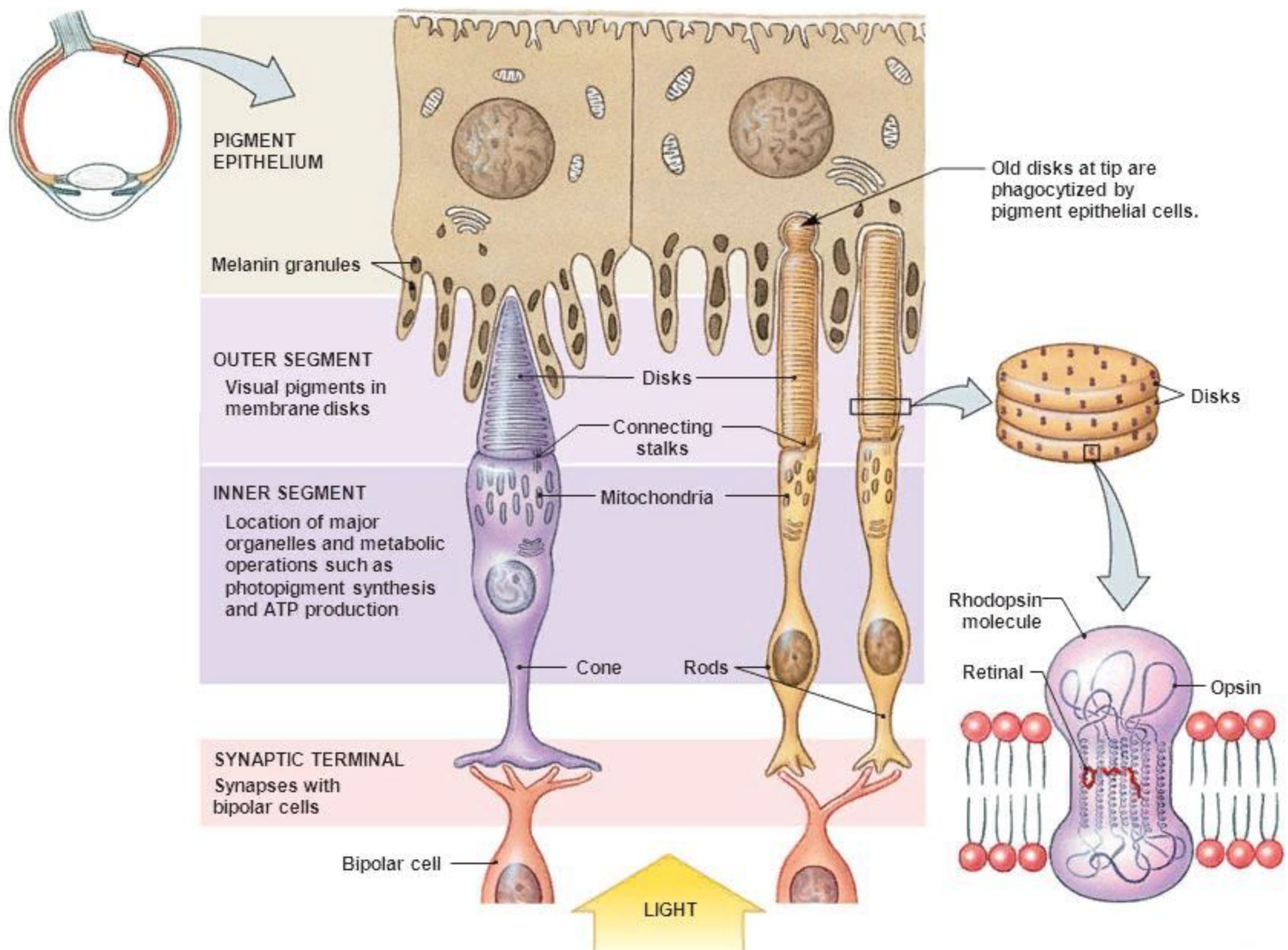


Figure 10-39

# BIPOLAR NEURONS

- Dendrites are associated with axons of photoreceptor cells, and their axons transmit impulses to the dendrites of ganglion and amacrine cells.

# MULTIPOLAR (GANGLIONIC) NEURON

- Large multipolar cells with an eccentrically located nucleus. Contain well-developed organelles. Their dendrites form bonds with the axons of bipolar cells, and the axons, when they are about to form the optic nerve.

# HORIZONTAL NEURON

- Associative multipolar neurons, their dendrites and axon are synaptically connected with the axons of the rods and cones, as well as with dendrites of bipolar neurons

# AMACRINE NEURONS

- Unipolar associative neurons whose dendrites form bonds with axons of bipolar cells and ganglionic dendrites.



## PIGMENT EPITHELIUM

- The outer layer of the retina is firmly connected with the choroid and is loosely connected with the adjacent layers of the retina.
- This makes it possible to detach the retina during pathological processes and leads to the death of the photosensory layer.

# FUNCTIONS OF THE PIGMENT EPITHELIUM

- Accumulation and transport of vitamin A to photoreceptors
  - Phagocytosis and digestion of discs
  - Providing nutrition to the outer layers of the retina
  - Light absorption and prevention of excessive exposure to photoreceptors
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# NEUROGLIA OF RETINA

- It is represented by radial gliocytes (Muller cells), astrocytes and microglia
  - Astrocytes are located in the inner layers of the retina and pull off capillaries with their processes - they form a blood-retinal barrier
  - Microglia are located in all layers of the retina and perform a phagocytic function.
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# MULLER CELLS

- Large star shaped cells stretch across the entire thickness of the retina perpendicular to its layers. They occupy the space between neurons and their processes.
  - With their bases, they form the inner glial border membrane, delimiting the retina from the vitreous, and the apical processes form the outer glial border membrane.
  - Lateral processes braid the bodies of neurons, perform supportive and trophic functions
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# LAYERS OF RETINA

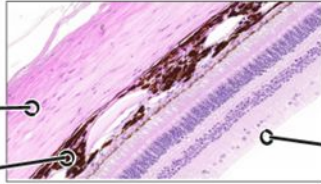
- 8 layers without limiting membranes
  - Pigment epithelium
  - A layer of rods and cones
  - Outer nuclear layer
  - Outer plexiform layer
  - Inner nuclear layer
  - Inner plexiform layer
  - A layer of ganglionic cells;
  - A layer of nerve fibers.
-

# LAYERS OF RETINA 10 LAYERS

- 1. pigment epithelium
- 2. layer of rods and cones - represented by photoreceptor dendrites
- 3. outer glial limiting membrane - formed by Muller cells
- 4. outer nuclear layer - contains photoreceptor perikarions
- 5. outer plexiform layer - the region of synapses between the processes of photoreceptors and bipolar neurons
- 6. the inner nuclear layer - contains the bodies of bipolar, amacrine, horizontal and muller cells
- 7. inner plexiform layer - the region of synapses between bipolar, ganglionic and amacrine cells
- 8. ganglion layer - contains the bodies of ganglionic cells
- 9. layer of nerve fibers - consists of axons of ganglionic cells
- 10. the internal glial limiting membrane is formed by Muller cells



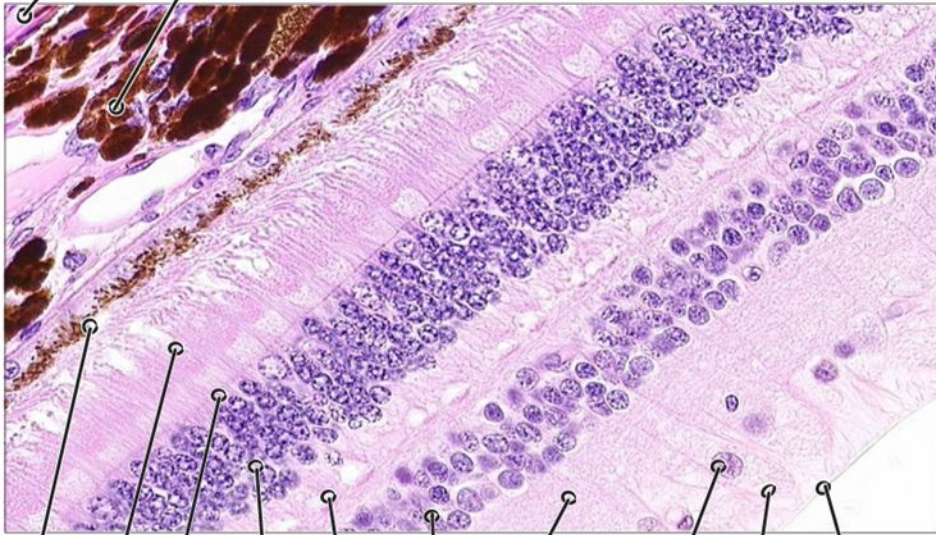
# RETINA: HISTOLOGY



Sclera

Choroid

Inner limiting membrane



Pigmented layer  
 External limiting membrane  
 Outer plexiform layer  
 Inner nuclear layer  
 Inner plexiform layer  
 Ganglion cell layer  
 Nerve fiber layer  
 Inner limiting membrane

Photoreceptor layer of rods and cones  
 Outer nuclear layer  
 Inner nuclear layer  
 Ganglion cell layer  
 Nerve fiber layer

