

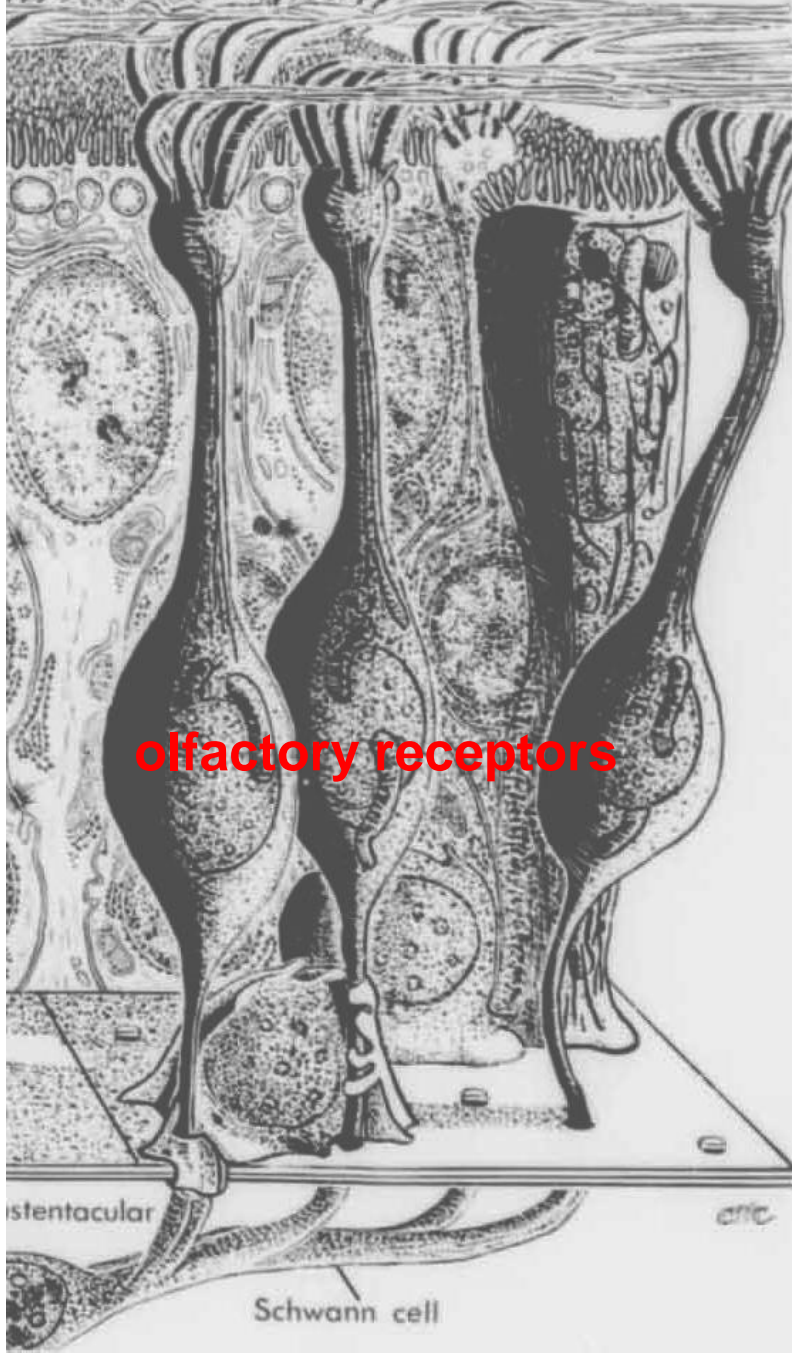
Classification of receptors of sensory organs

Receptors of sensory organs

morphological classification

- 1/ primary receptor cells – modified neurons
- 2/ secondary receptor cells – modified epithelial cells
- 3/ peripheral endings of afferent neurons
 - a) encapsulated
 - b) free

1/ primary receptor cells

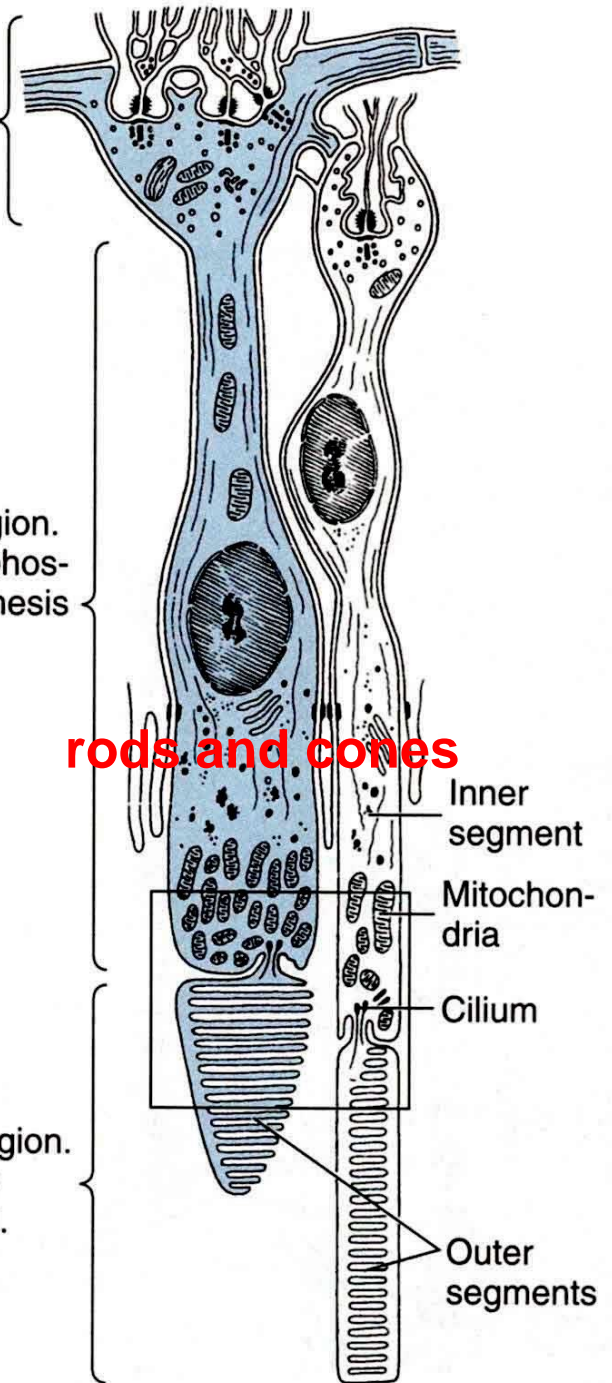


olfactory receptors

External plexiform layer. Synapses with bipolar cells.

Metabolic region. Protein and phospholipid synthesis plus ATP production.

Photosensitive region. Generation of the receptor potential.



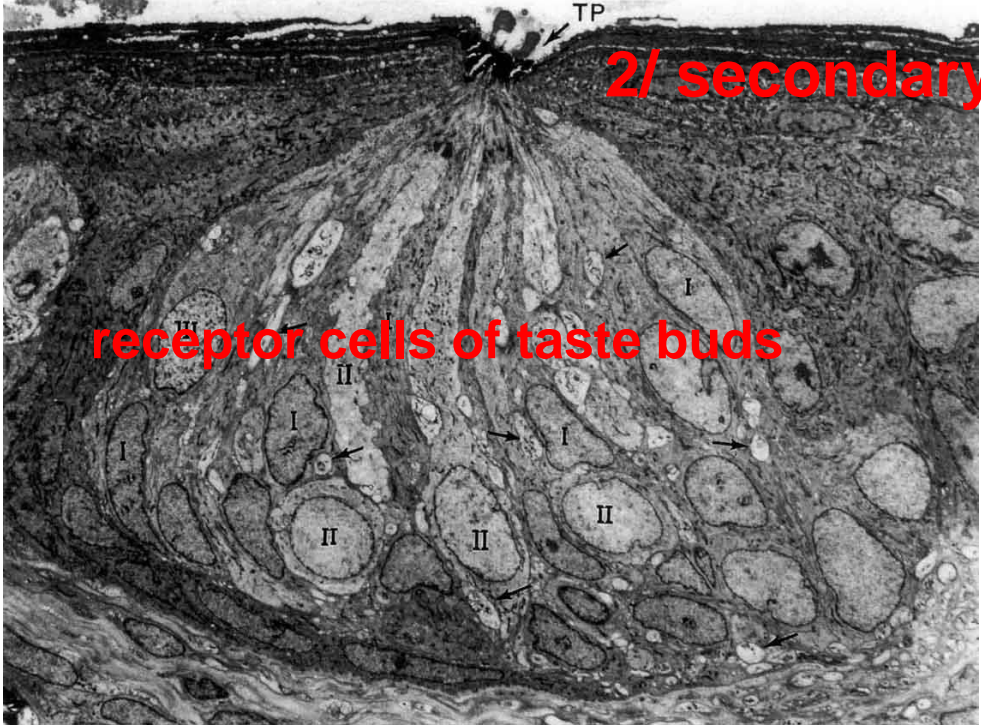
rods and cones

Inner segment

Mitochondria

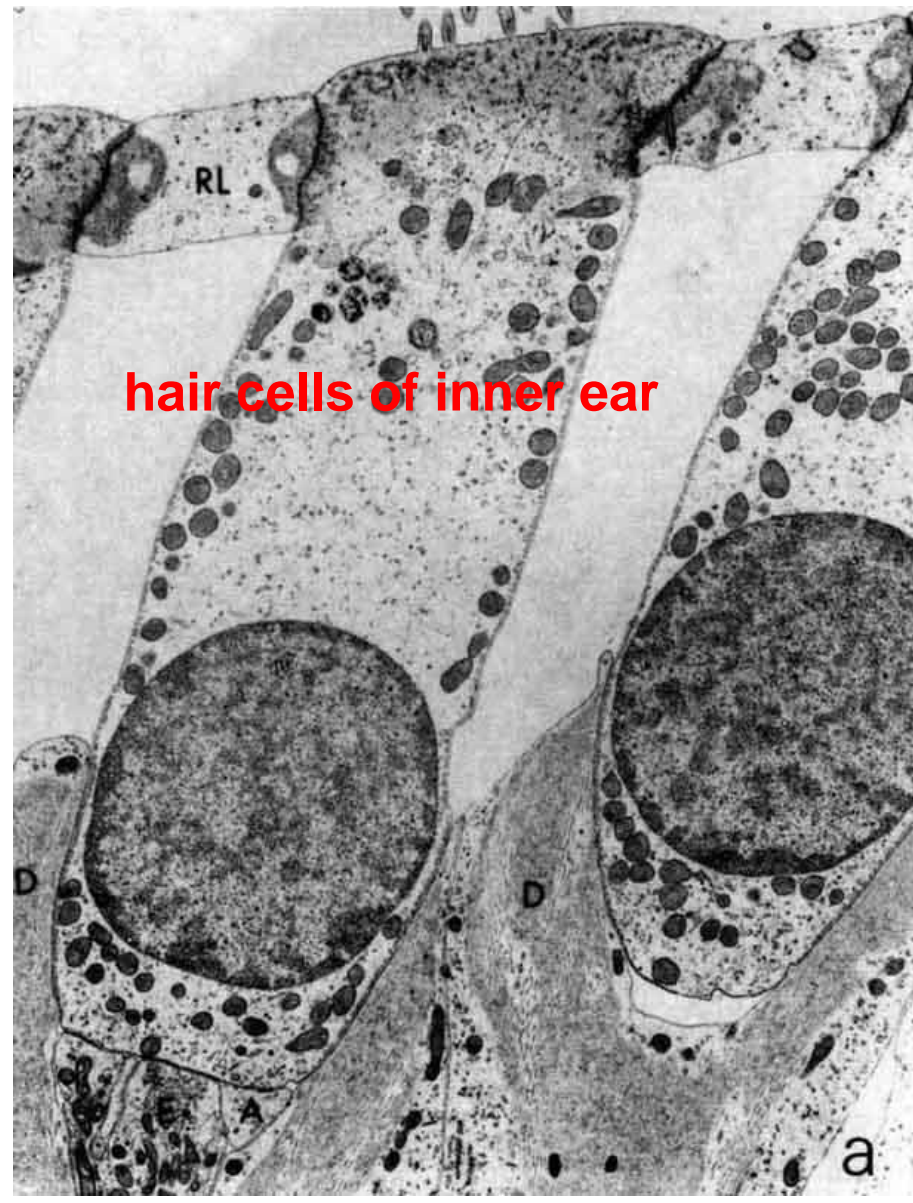
Cilium

Outer segments



2/ secondary receptor cells

receptor cells of taste buds

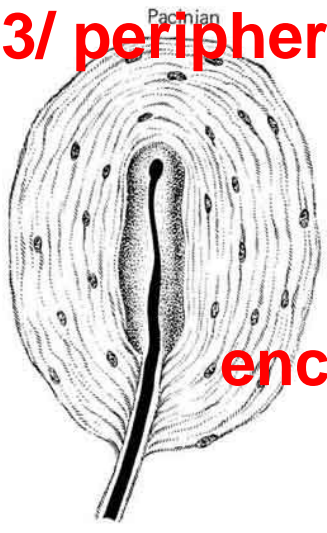


hair cells of inner ear

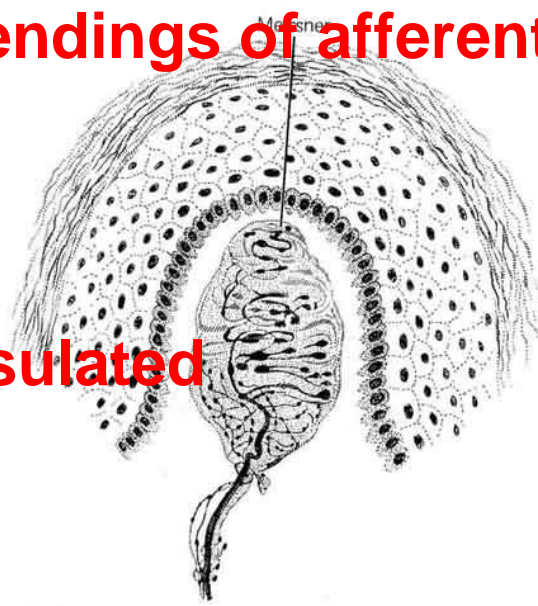


Merkel cells of skin

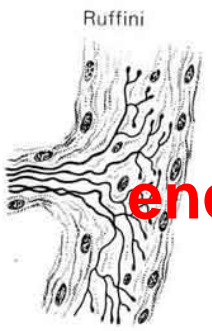
3/ peripheral endings of afferent neurons



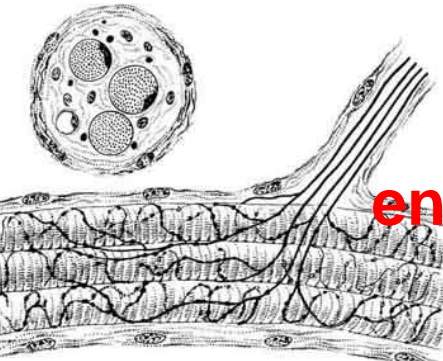
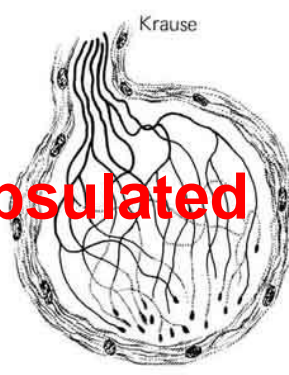
encapsulated



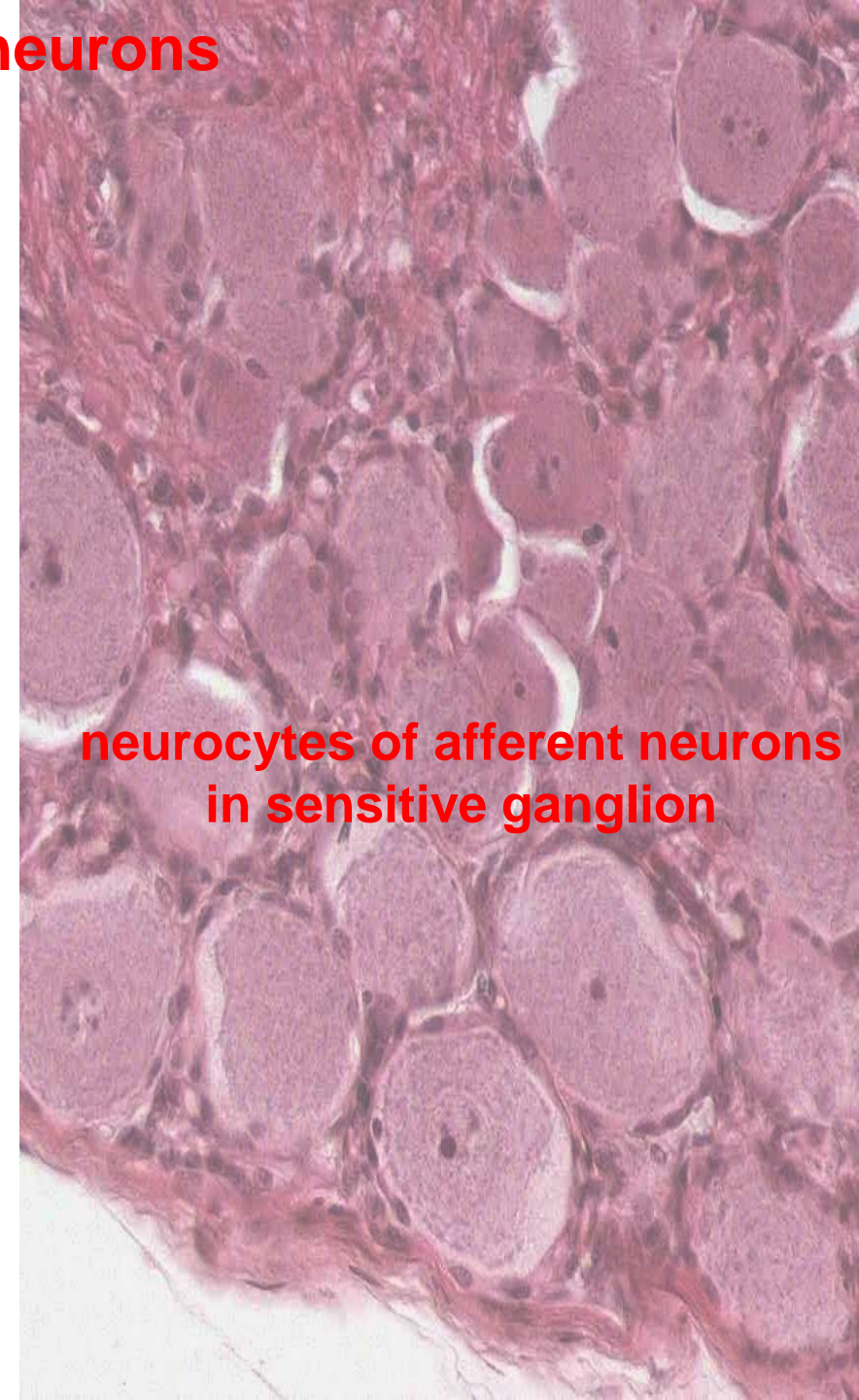
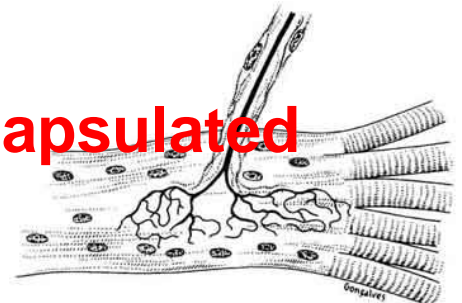
free



encapsulated



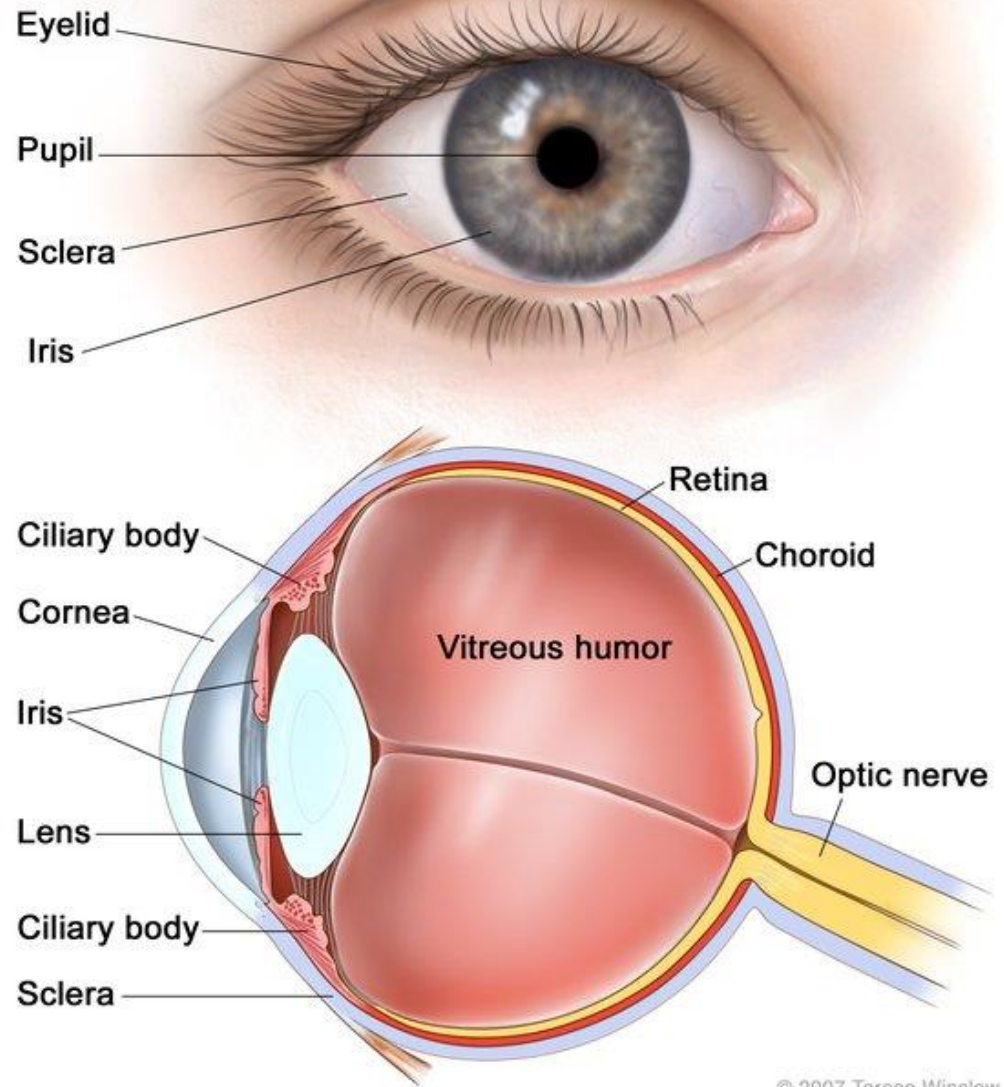
encapsulated



Receptors of sensory organs functional classification

- 1/ photoreceptors – light
- 2/ chemoreceptors – taste, smell, concentration of substances in body fluids
- 3/ mechanoreceptors
 - a/ audioreceptors – sound waves
 - b/ proprioceptors – position in space
 - c/ other mechanoreceptors – pressure, touch, vibrations
- 4/ thermoreceptors – temperature
- 5/ nociceptors – pain

Sense organs I – vision (photoreceptors)



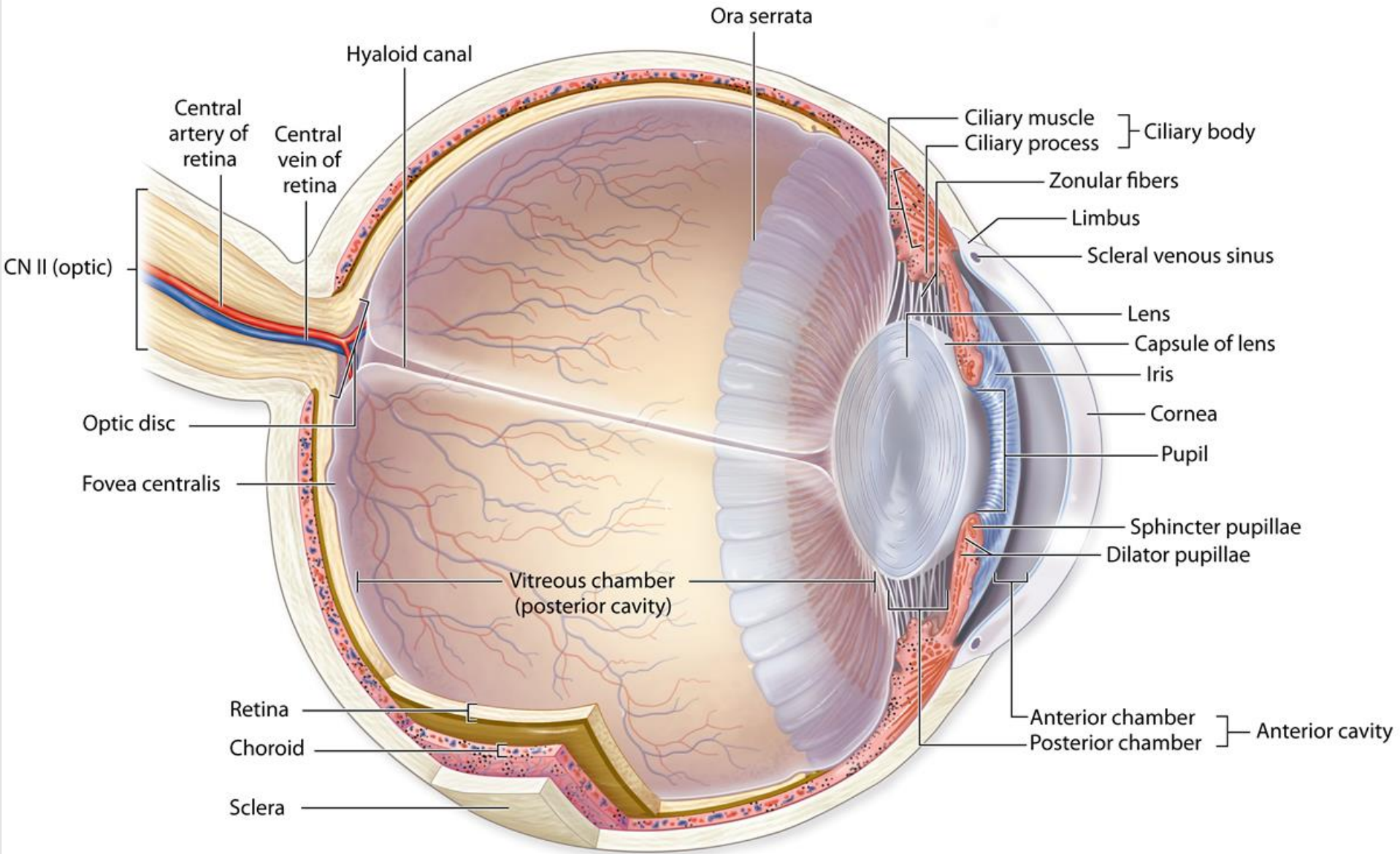
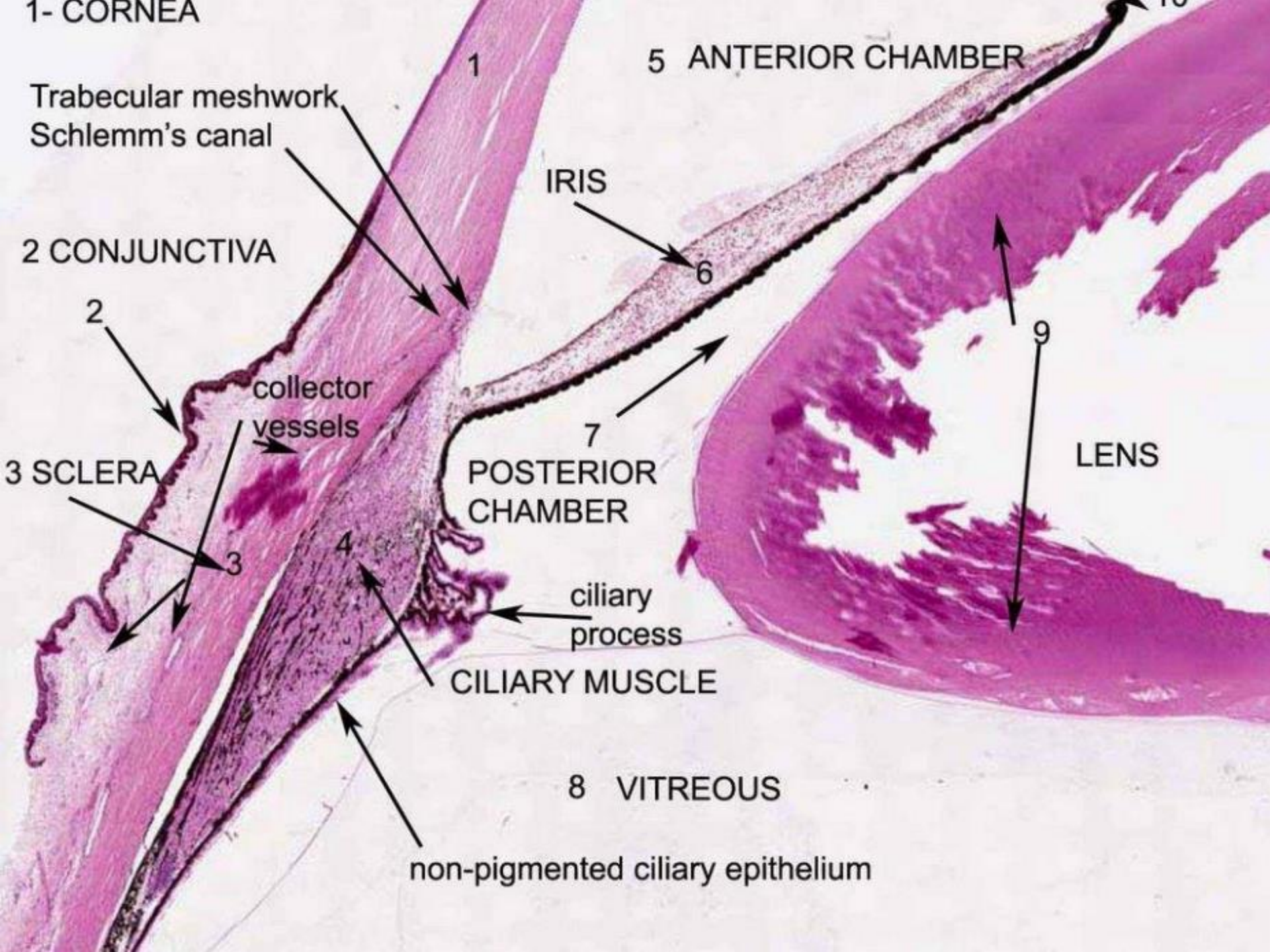
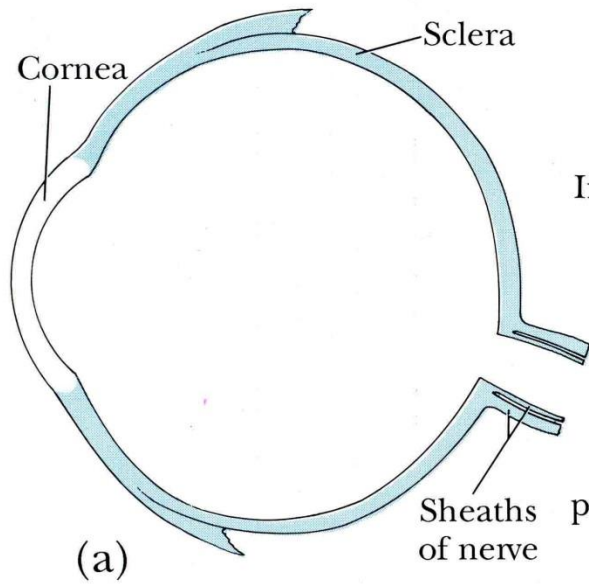


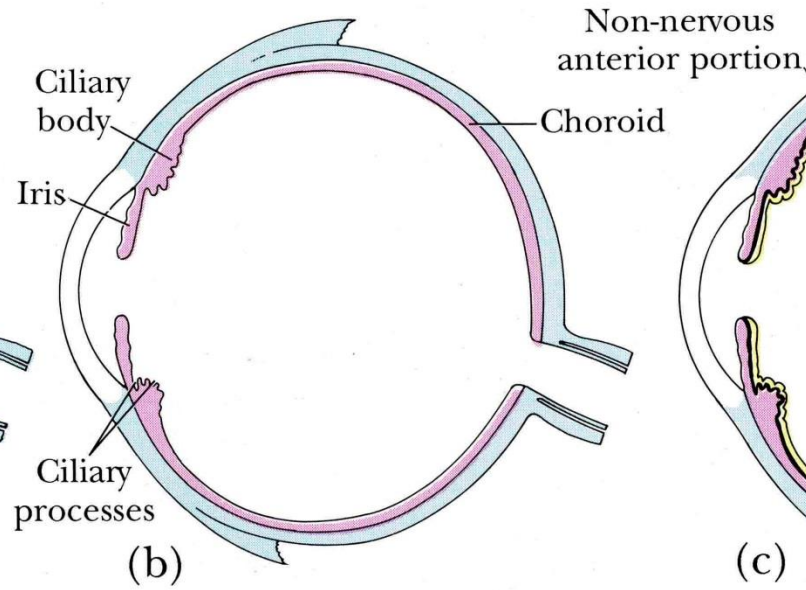
Figure 23-1



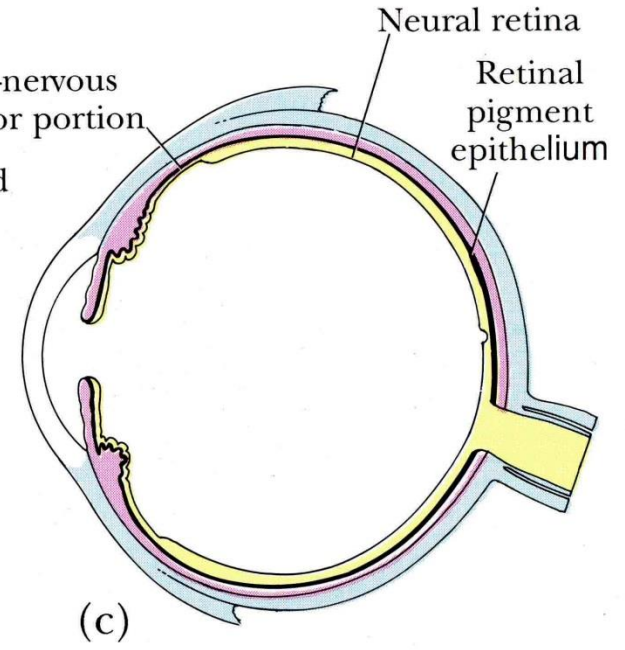
tunica fibrosa



tunica vasculosa

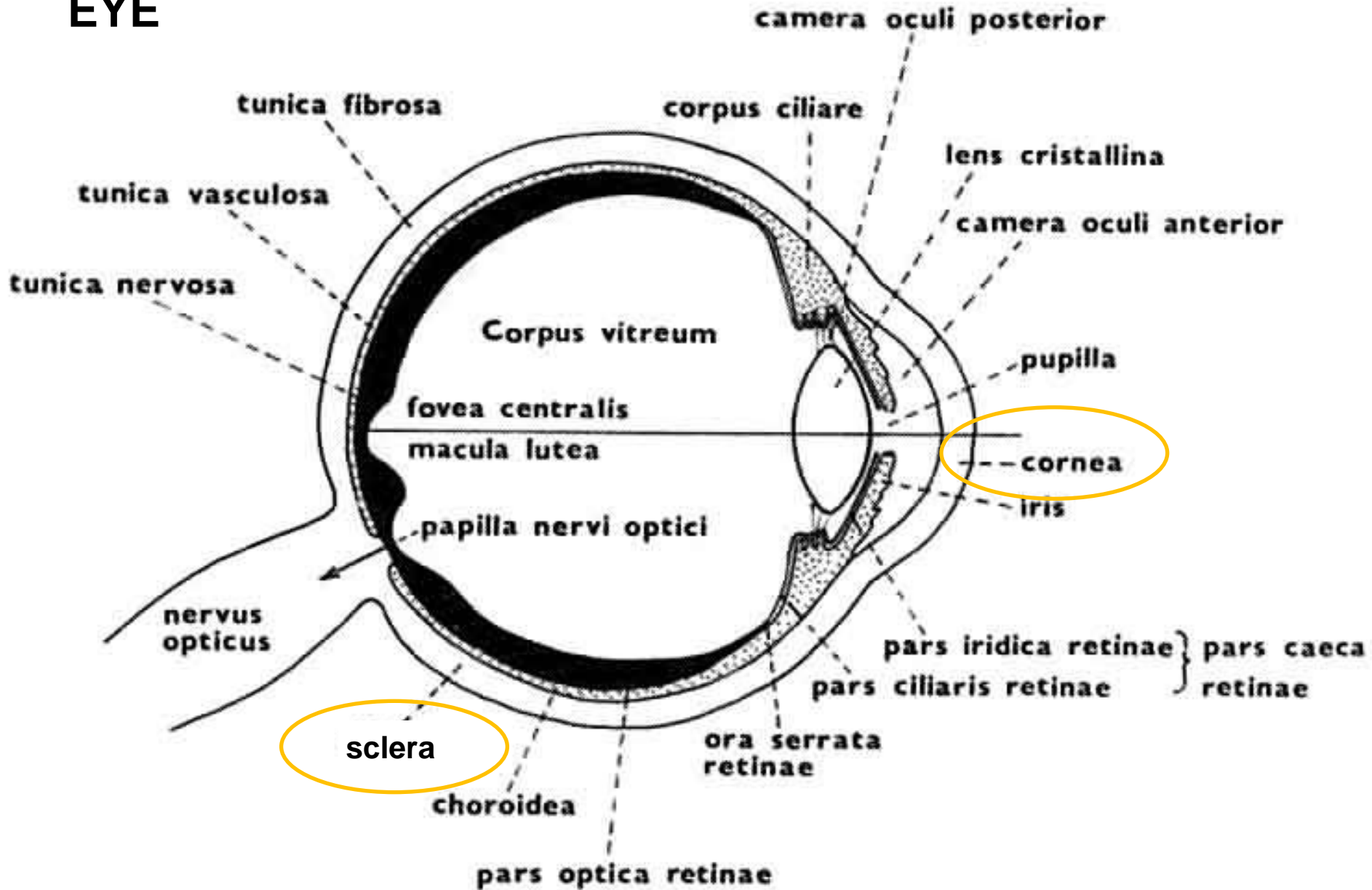


tunica nervosa

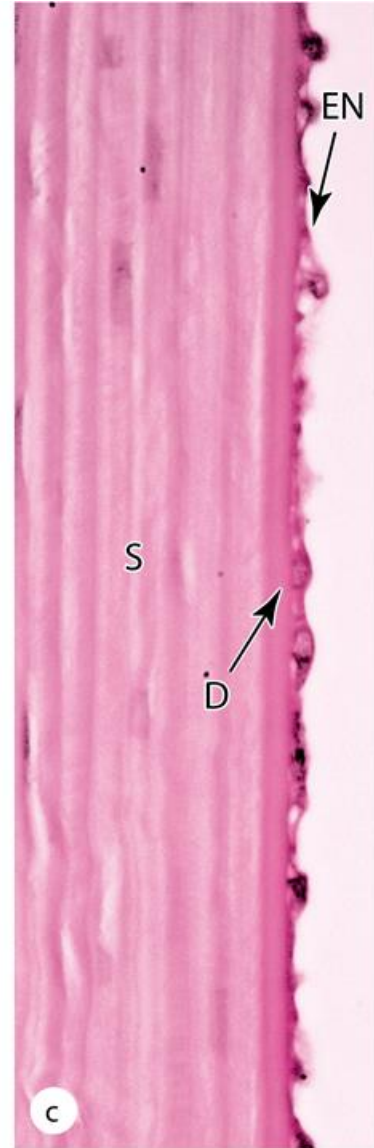
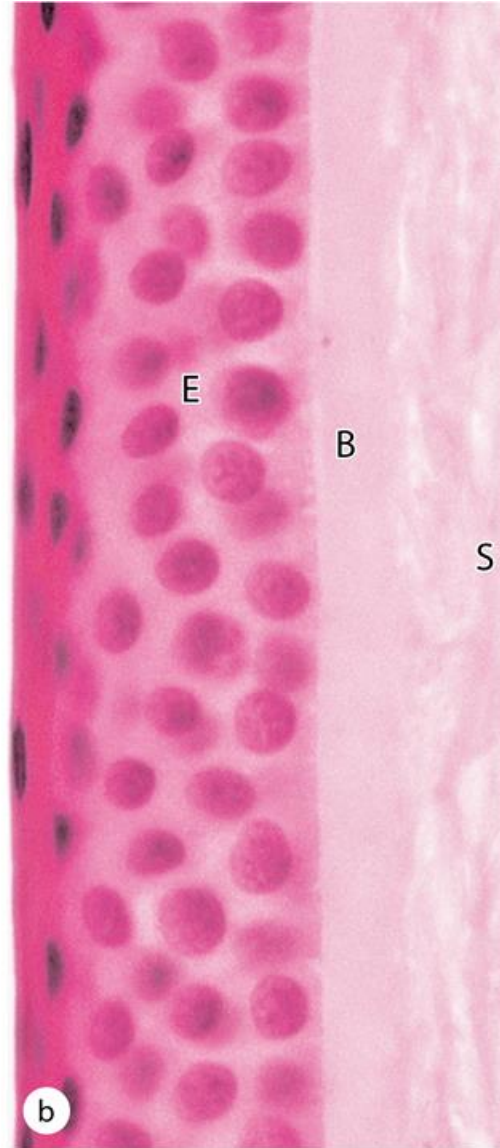
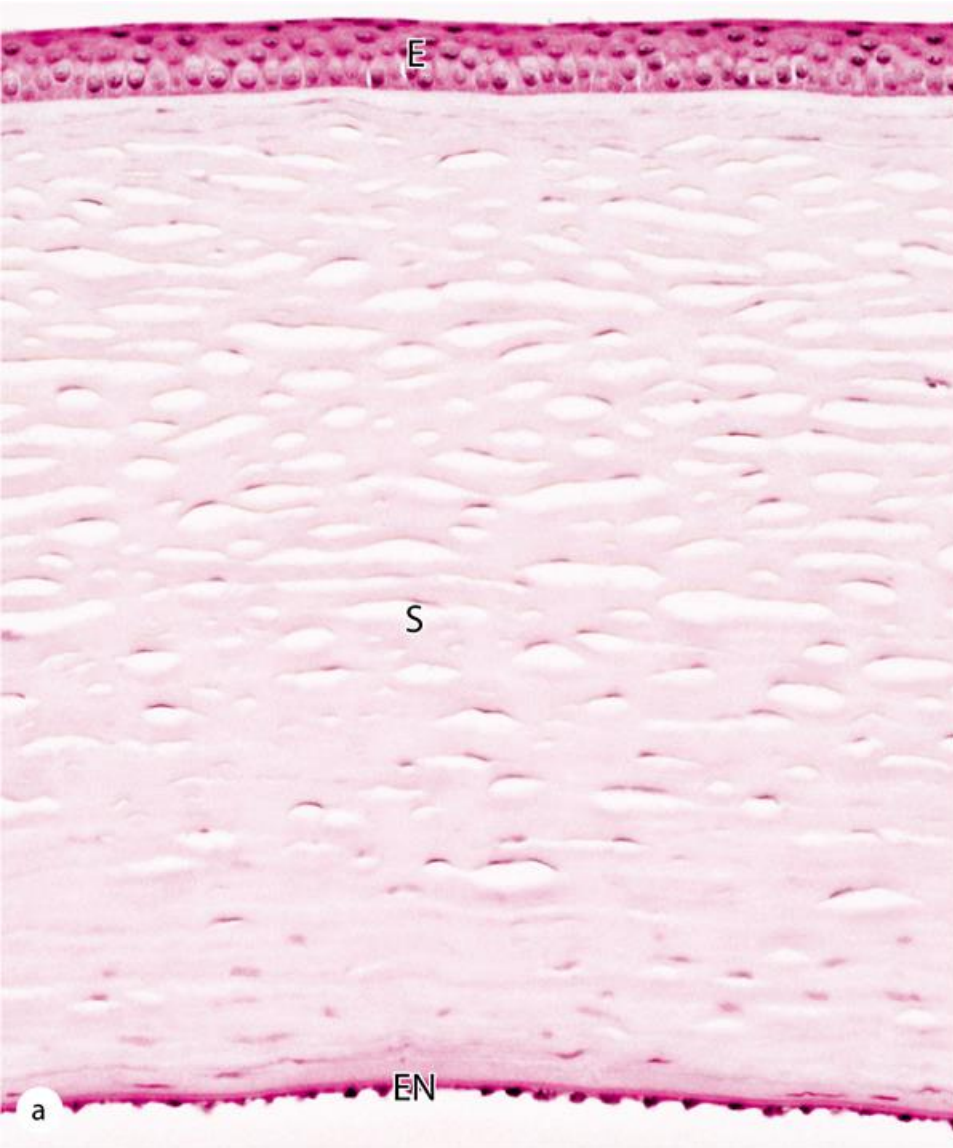


Tunica fibrosa (cornea and sclera)

EYE



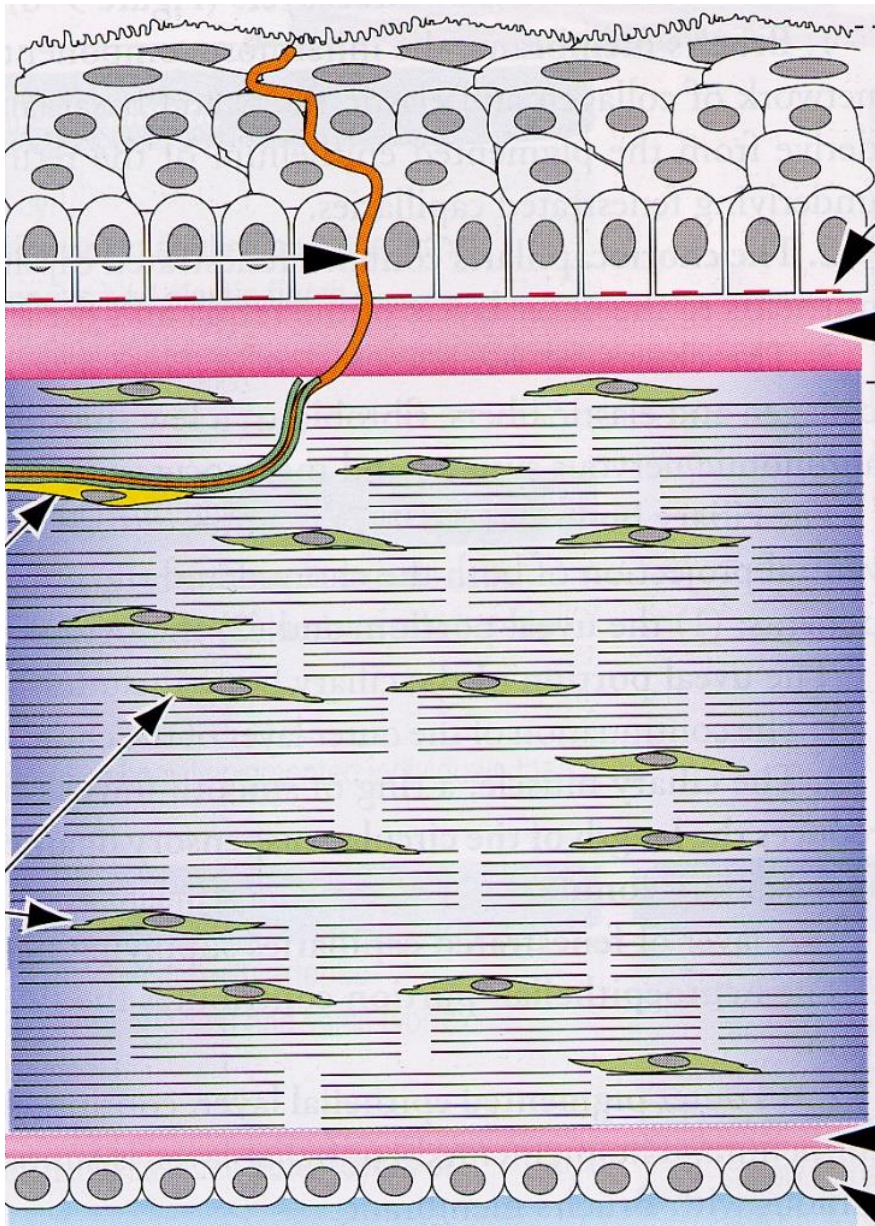
cornea



- **5 layers**
- Epithelium
 - Stratified squamous nonkerat.
- lamina limitans anterior
 - ***Bowman's membrane***
- substantia propria corneae
- lamina limitans posterior
 - ***Descemet's membrane***

Epithelium („endothelium“) posterius corneae

- Simple squamous

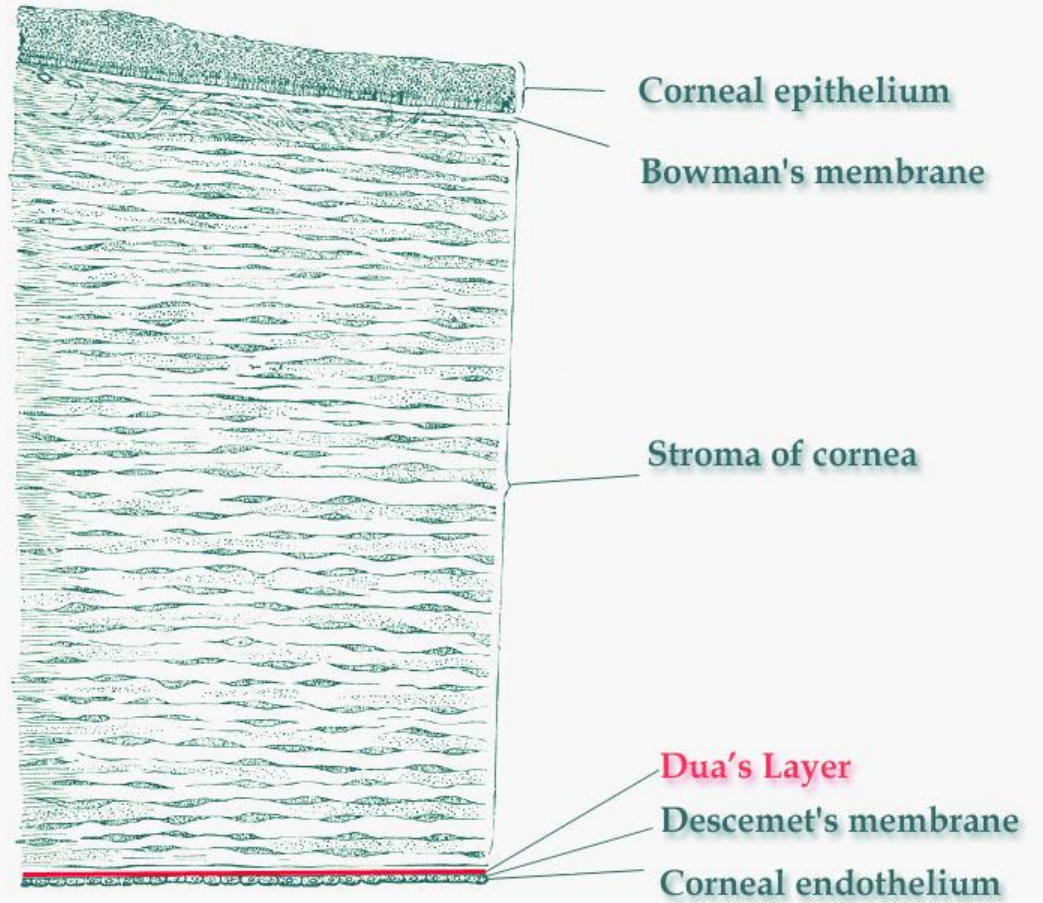
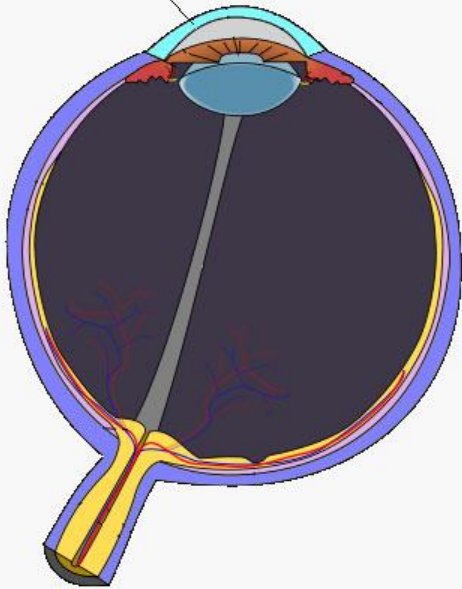


- Epithelial cell- 7 days
- sensory nerve endings
- Stroma – avascular
- nutrition- diffusion from anterior chamber

keratocytes

Fibroblast-like cells

Cornea



Corneal epithelium

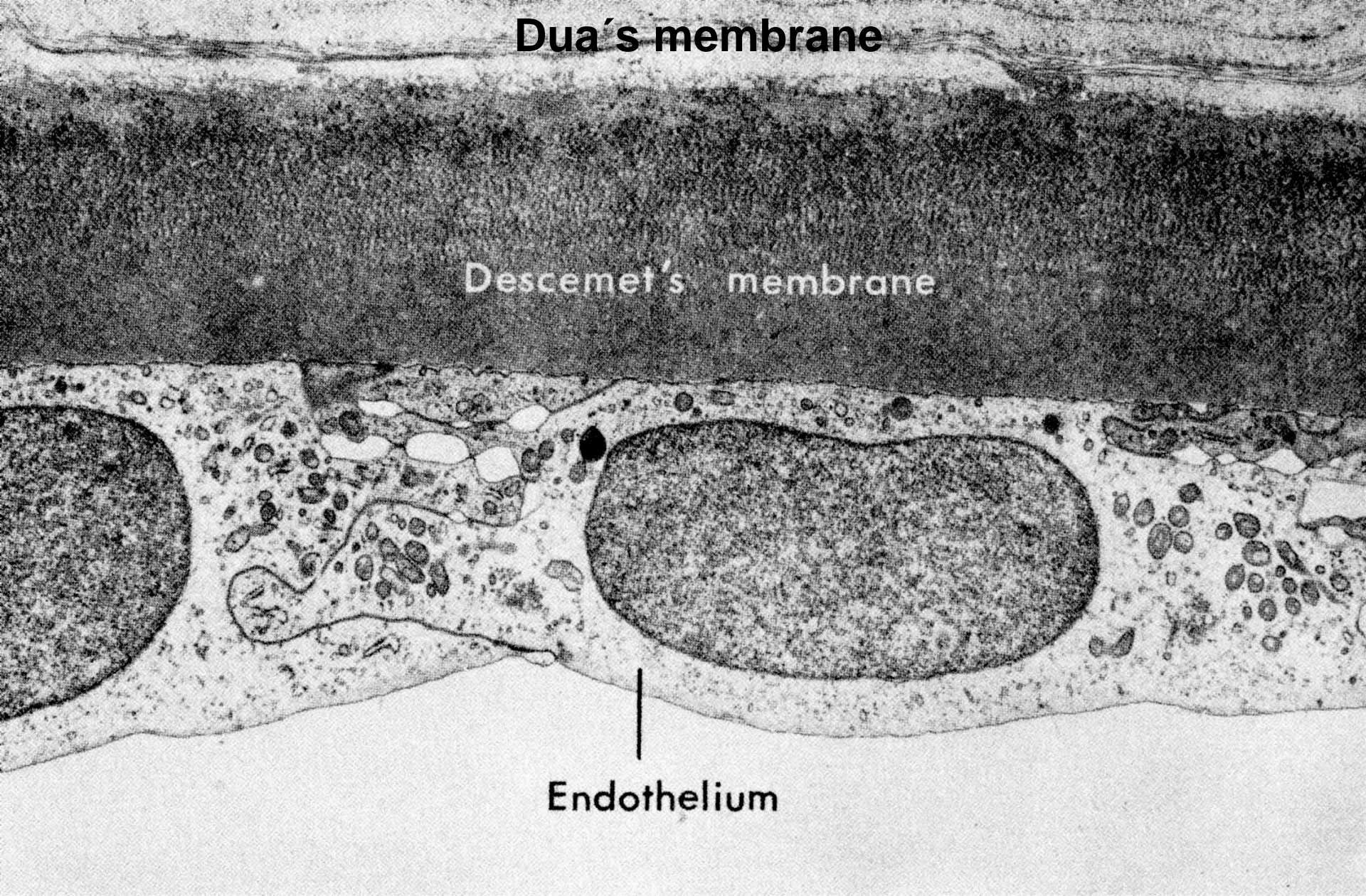
Bowman's membrane

Stroma of cornea

Dua's Layer

Descemet's membrane

Corneal endothelium



Dua's membrane

Descemet's membrane

Endothelium

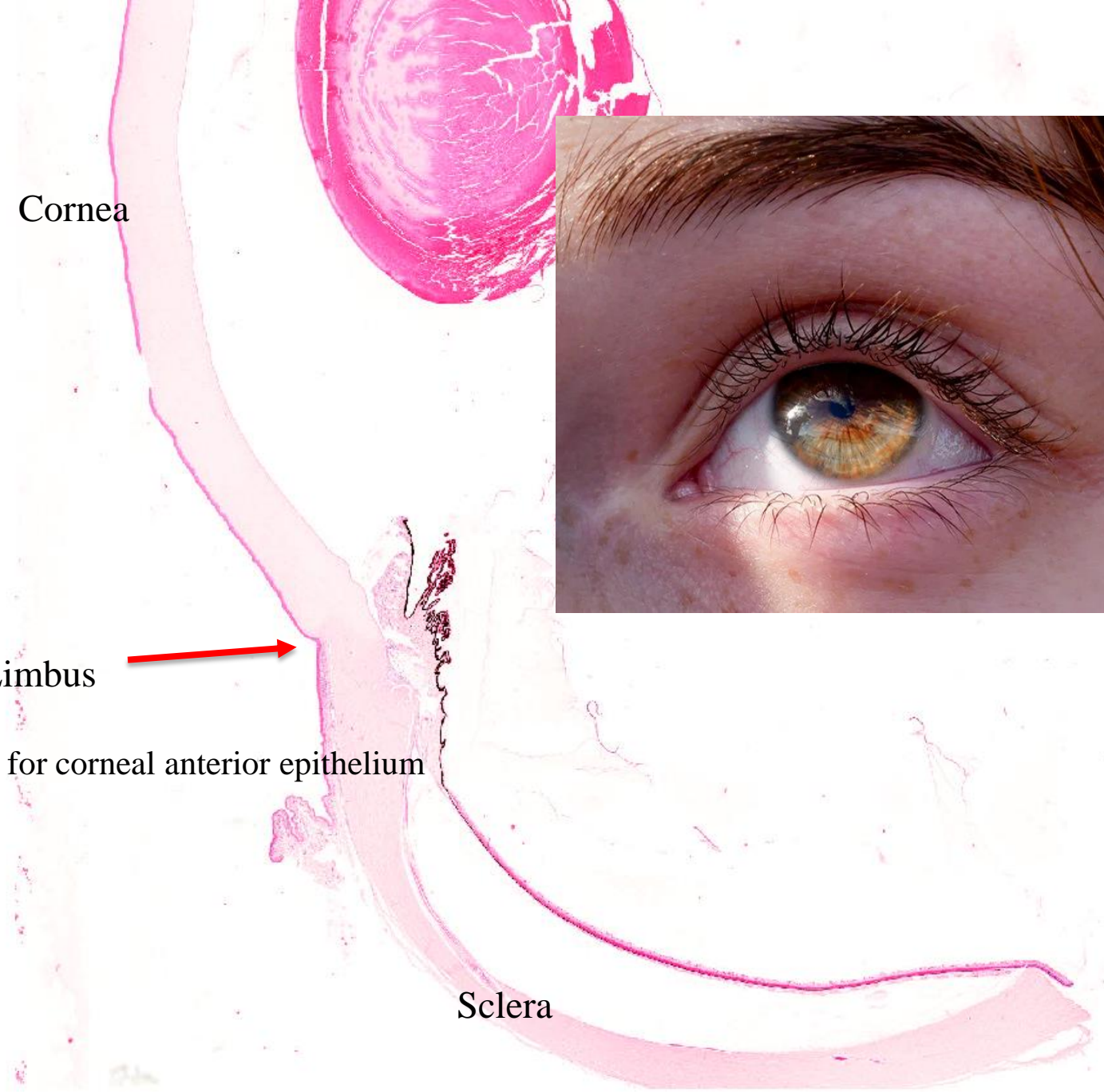
Dua's membrane - 5 – 8 lamellae composed of collagen fibers on the border of substantia propria corneae and Descemet's membrane, thickness to 15 μ m

Cornea

Limbus

Reserve cells for corneal anterior epithelium

Sclera





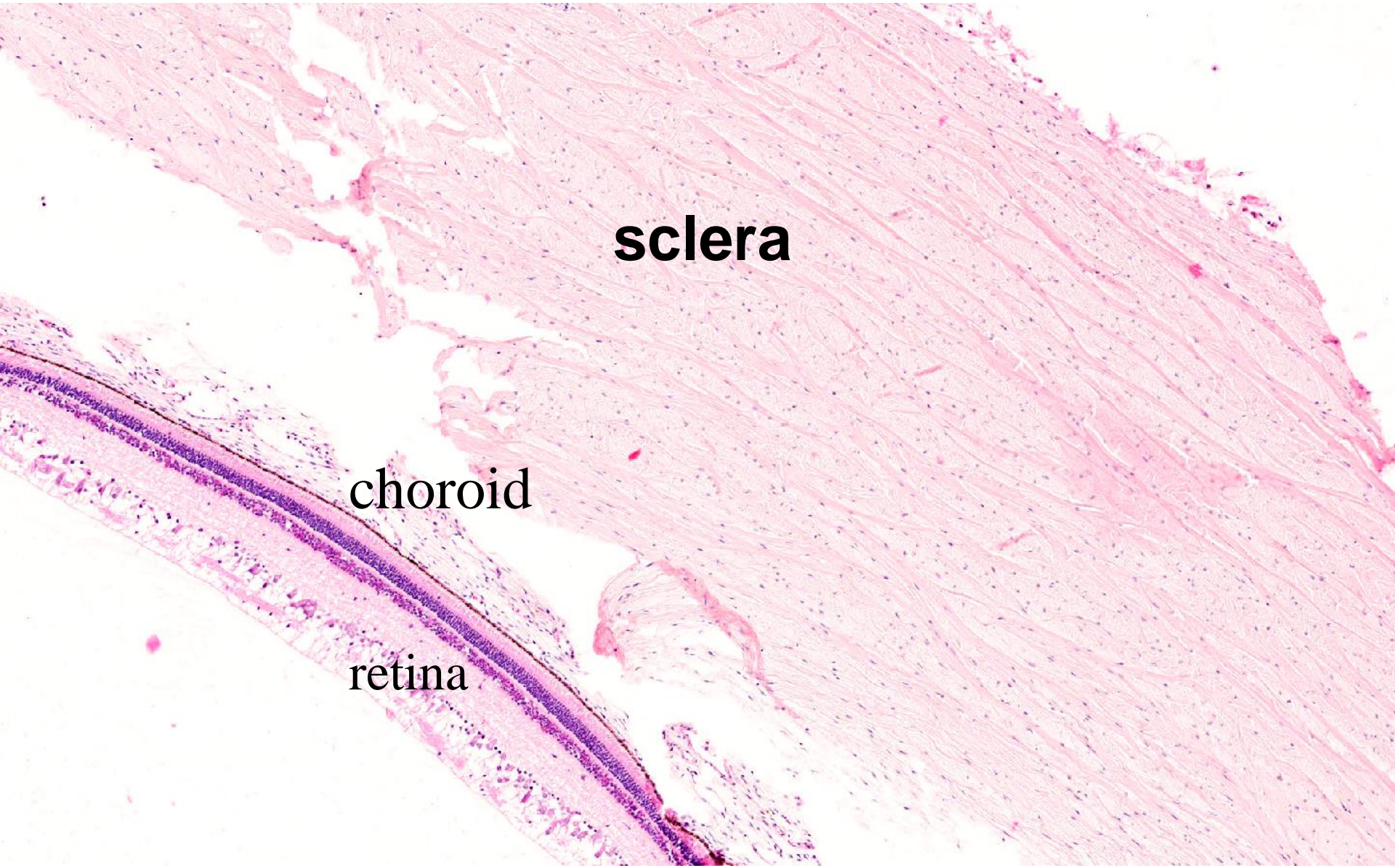
This histological image shows a cross-section of the eye wall. On the left, the conjunctiva is visible, characterized by a thin layer of stratified columnar epithelium and a lamina propria mucosae. A red arrow points to this layer. The majority of the image is composed of the sclera, which is a thick, dense layer of irregular connective tissue. The sclera is stained pink and shows a fibrous, irregular texture. On the right side, the inner layers of the eye wall are visible, including the choroid and the retina, which are stained more intensely pink and purple.

Conjunctiva

- Stratified columnar epithelium + lamina propria mucosae

Sclera

Dense irregular connective tissue



sclera

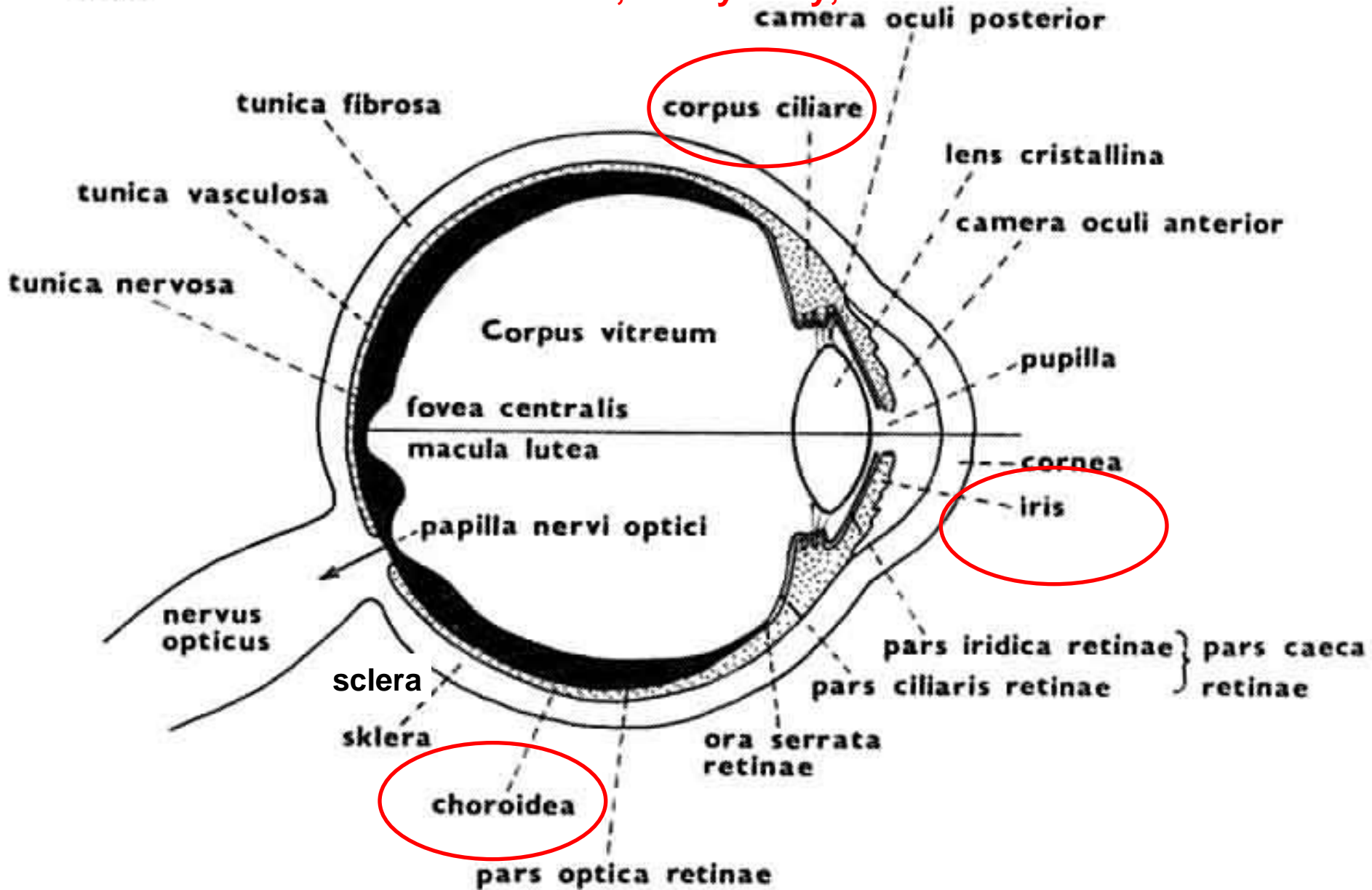
choroid

retina

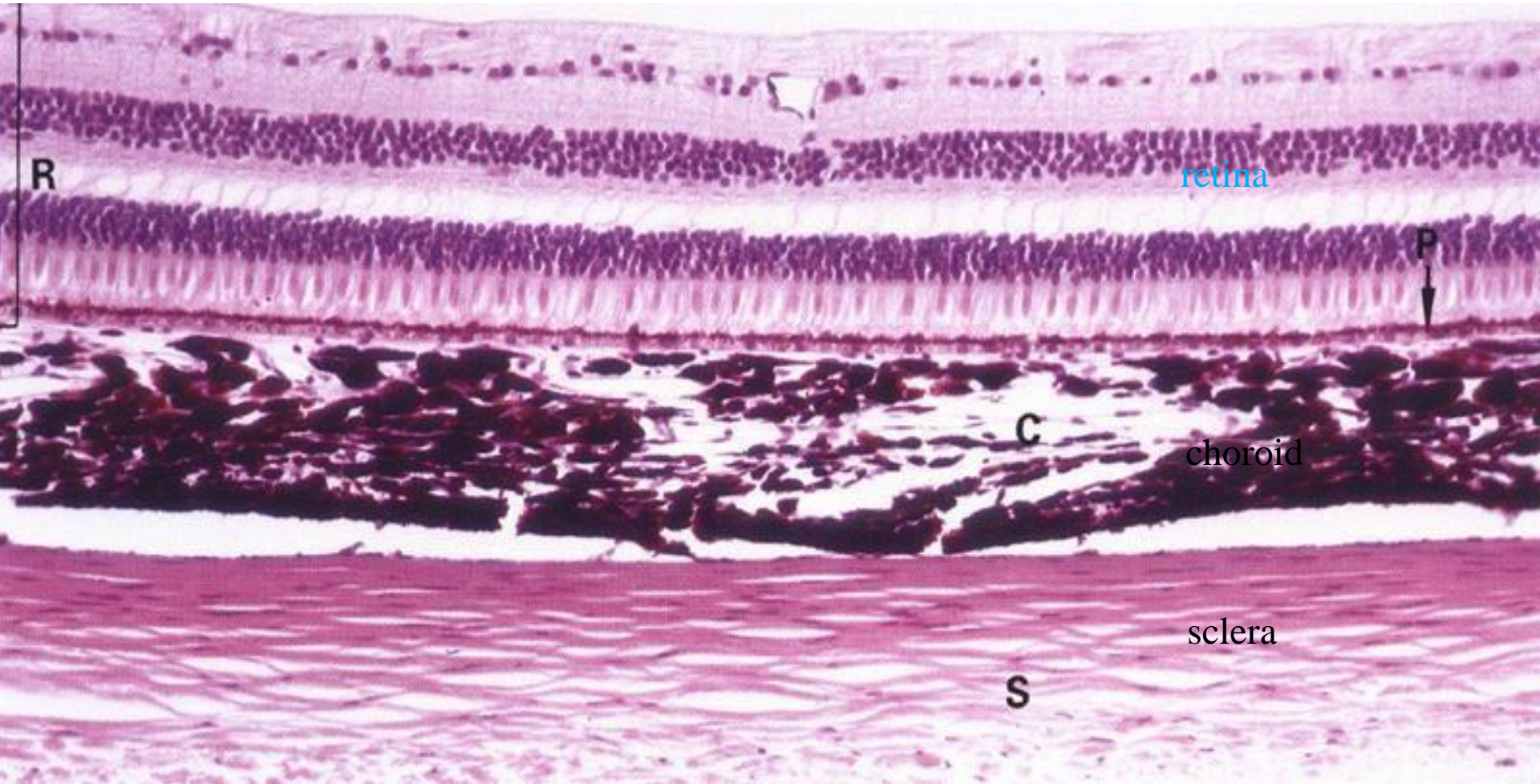
Tunica vasculosa (vascular layer, uvea)

EYE

choroid, ciliary body, iris



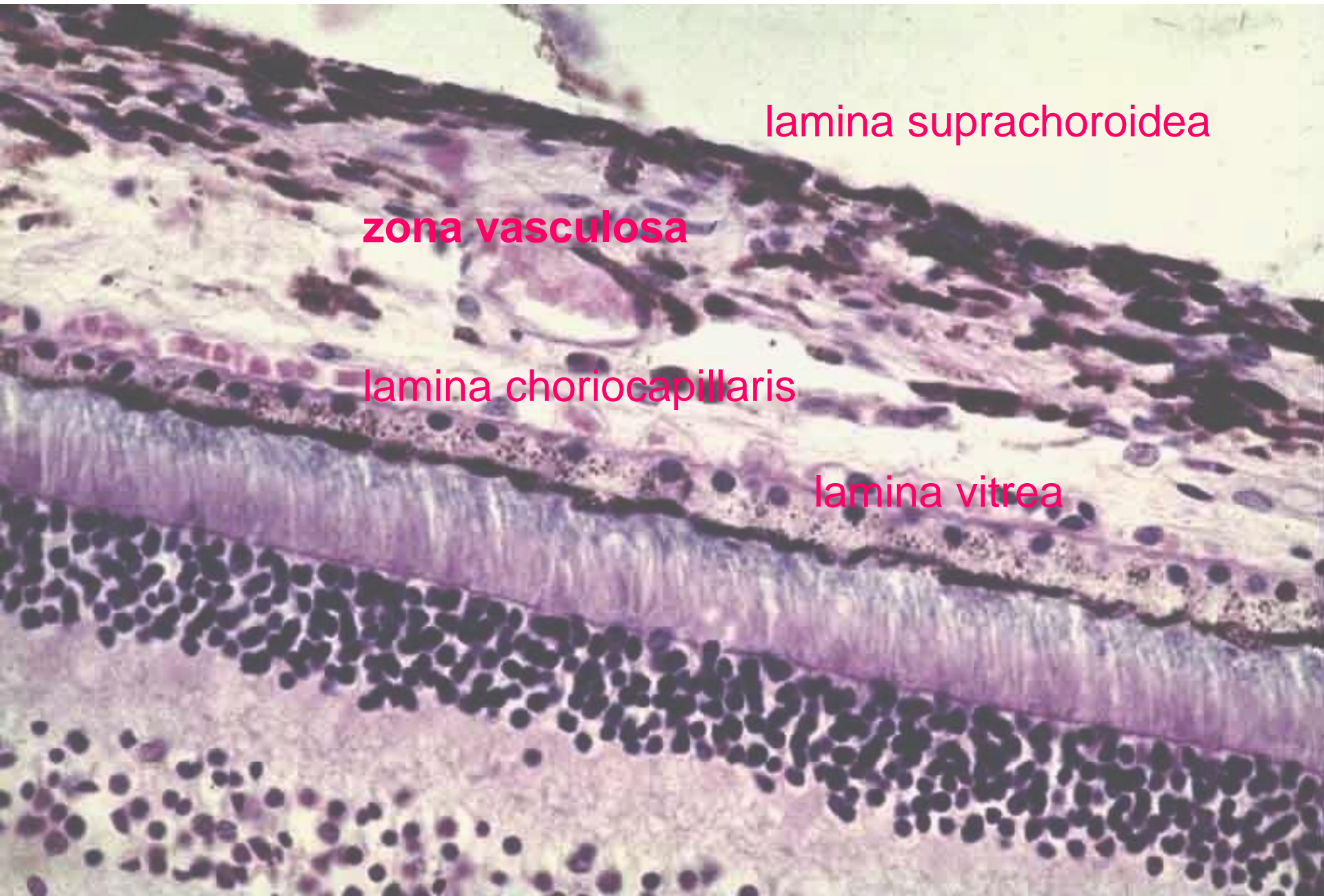
choroid



Tunica vasculosa (media)

Choroidea

- lamina suprachoroidea
- lamina vasculosa (choroid stroma)
 - – vessels, loose connective tissue, smooth muscle cells, nerves
- lamina choroidocapillaris
 - – capillaries
- lamina basalis (lamina vitrea) = *Bruch's* membrane
 - – BM of pigmented retinal epithelium and capillaries



lamina suprachoroidea

zona vasculosa

lamina choriocapillaris

lamina vitrea



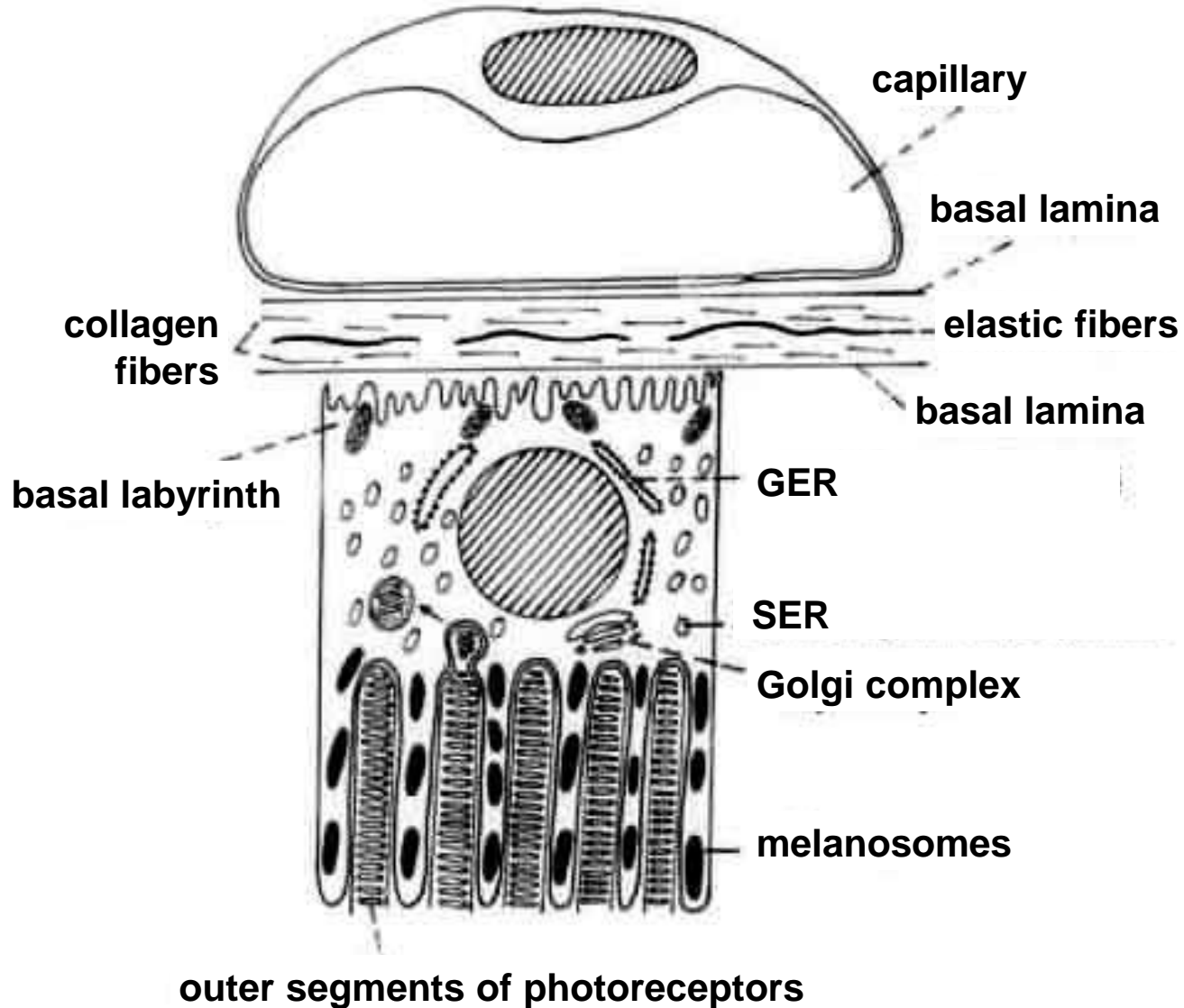
zona vasculosa

This histological section shows the choroid, a layer of vascular tissue. The upper portion is the zona vasculosa, characterized by numerous large, dark-staining, elongated vessels. Below this is the lamina choriocapillaris, a thin layer of capillaries. The lower portion is the lamina vitrea, a dense, fibrous layer. The overall structure is layered and highly vascularized.

lamina choriocapillaris

lamina vitrea

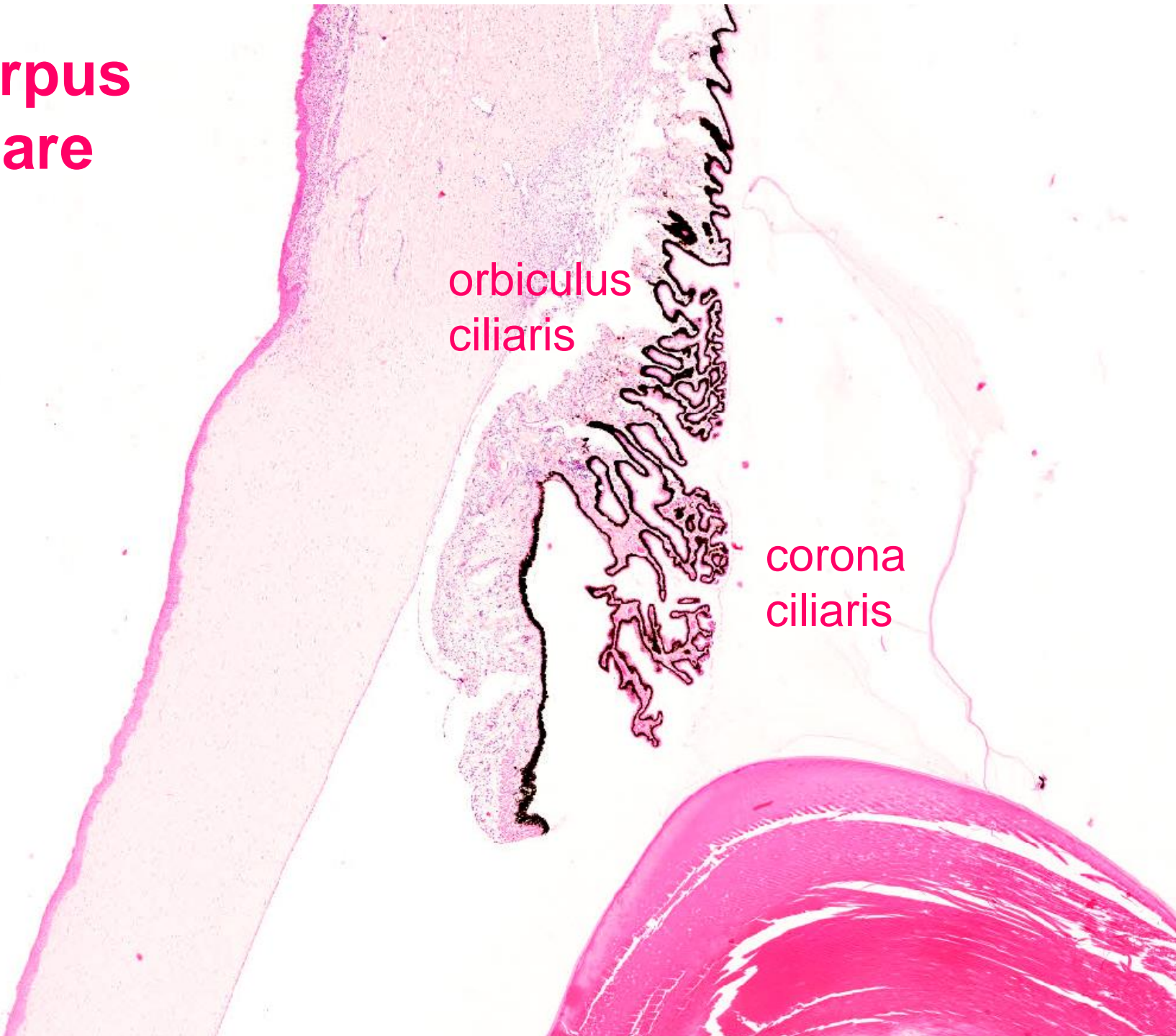
Lamina vitrea (Bruch's membrane) and its relation to the pigment epithelium and to the lamina choriocapillaris



Corpus ciliare

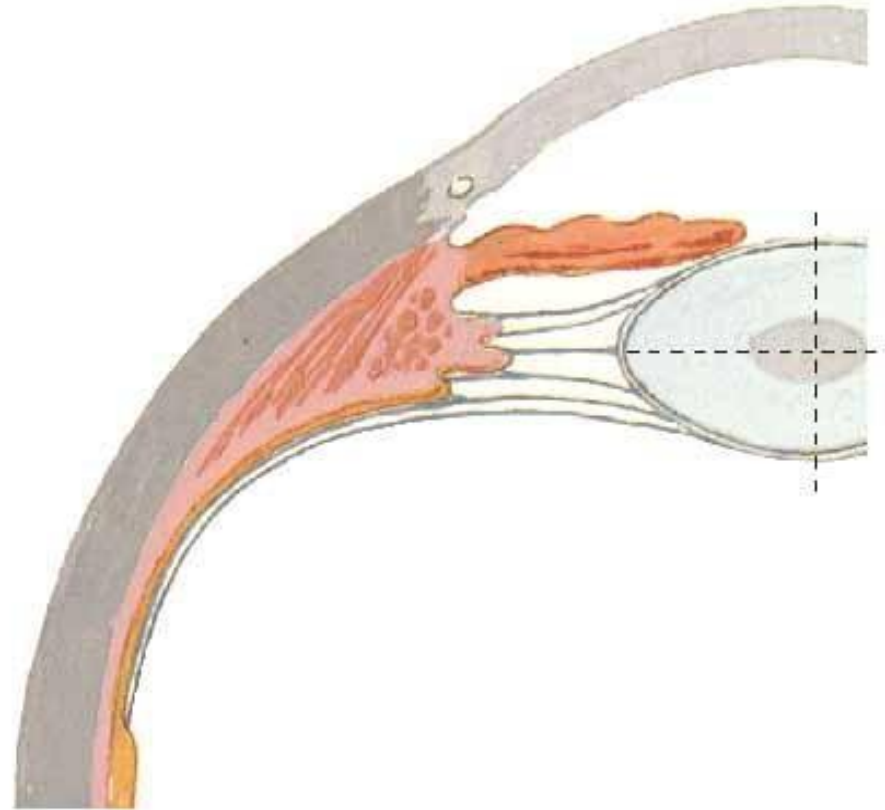
orbiculus ciliaris

corona ciliaris



- musculus ciliaris
- finger-like projections of the ciliary body and fibers of the zonula (oxytalan), which attach to the lens capsule
- production of intraocular fluid

Lens and Supporting Structures
Horizontal Section



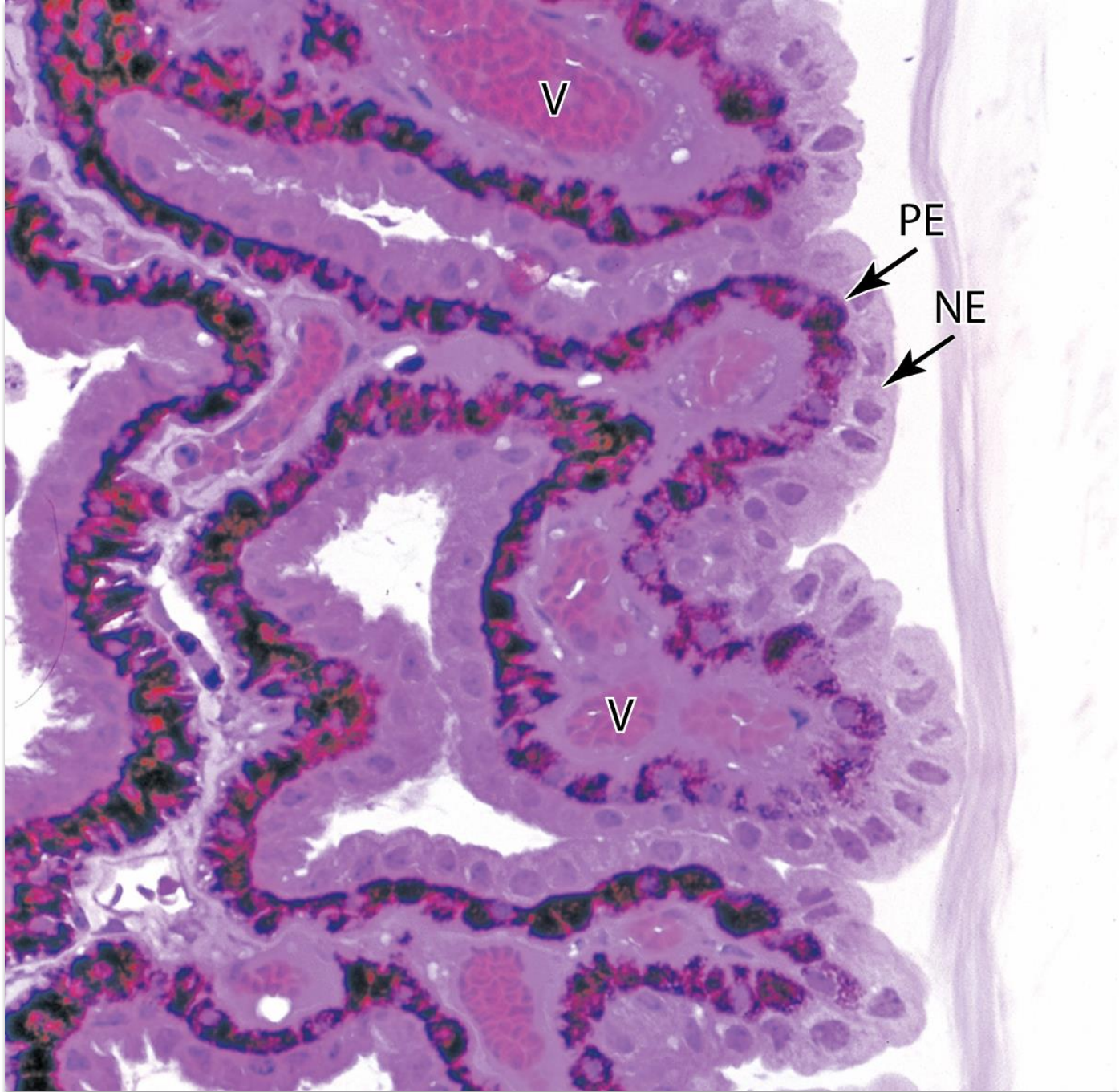
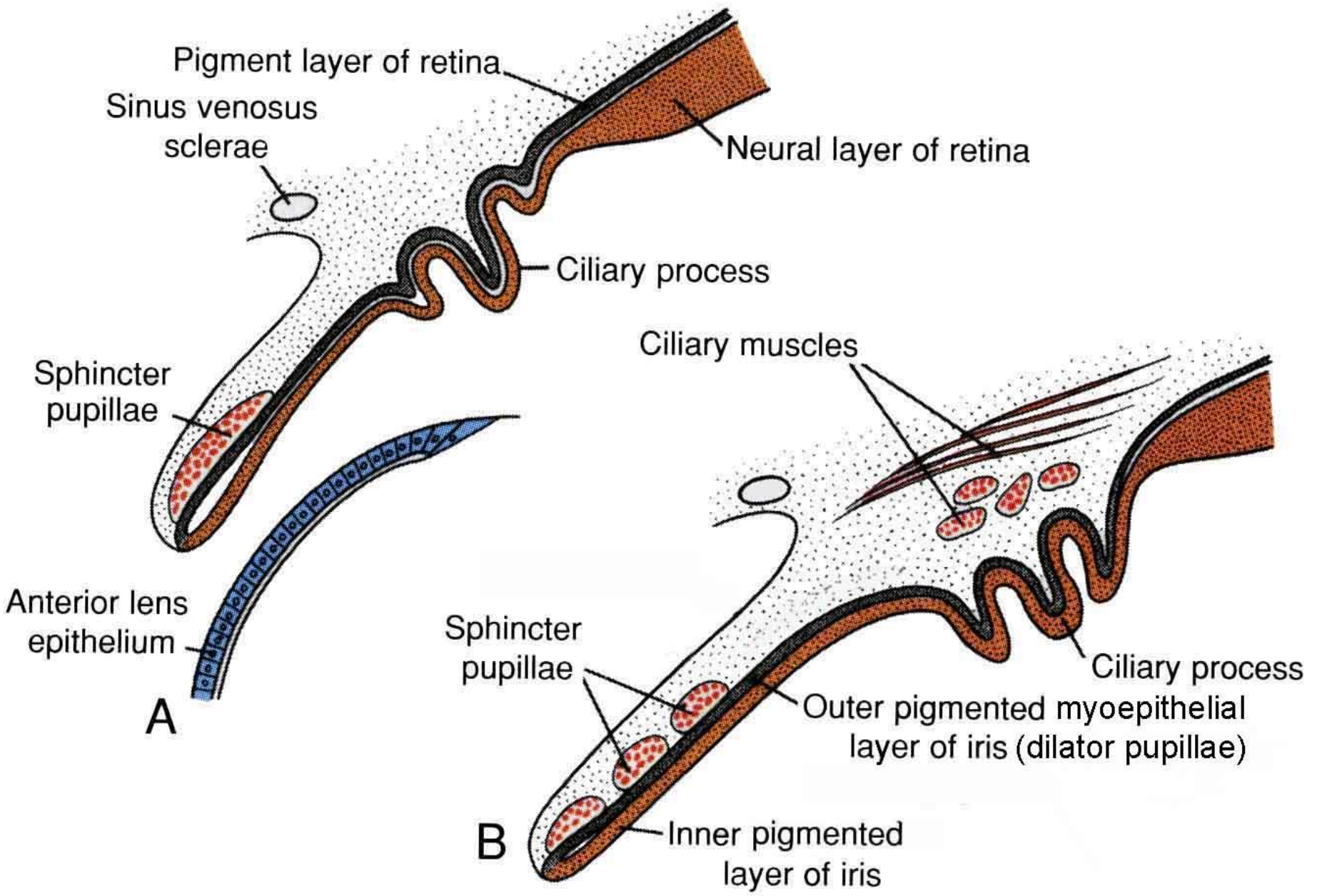


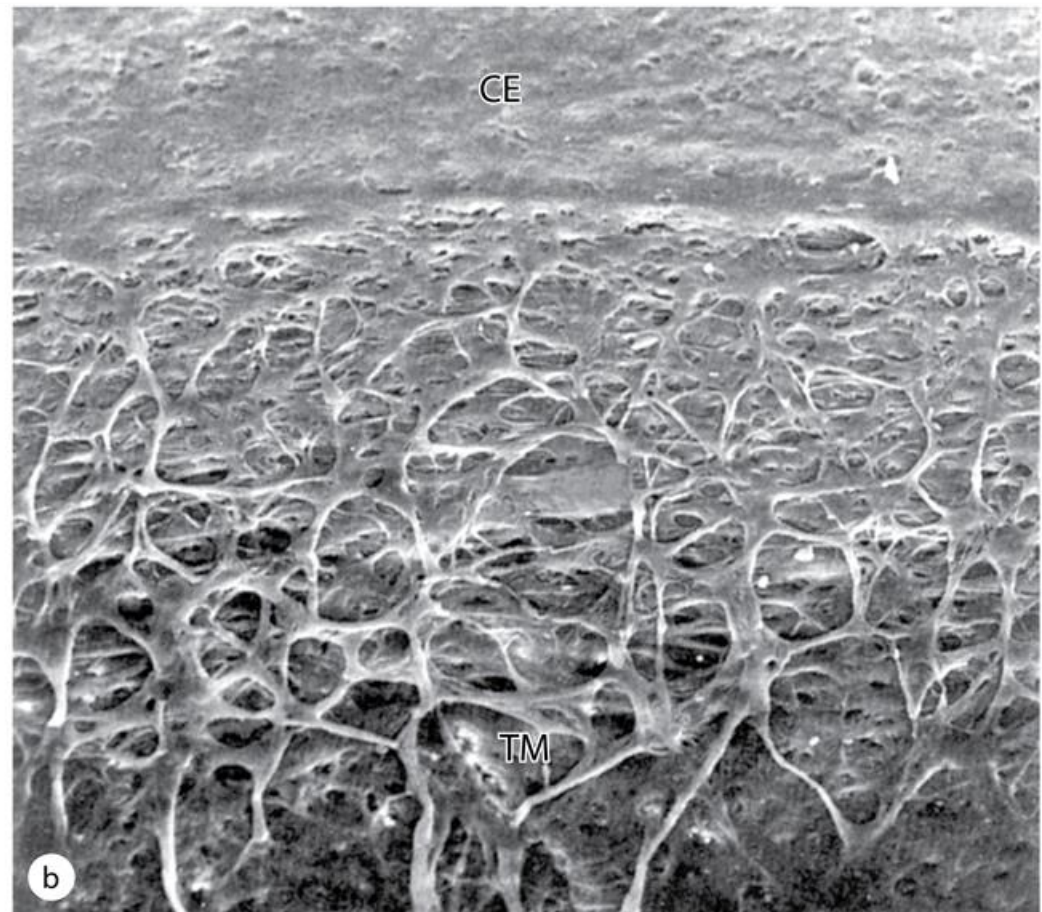
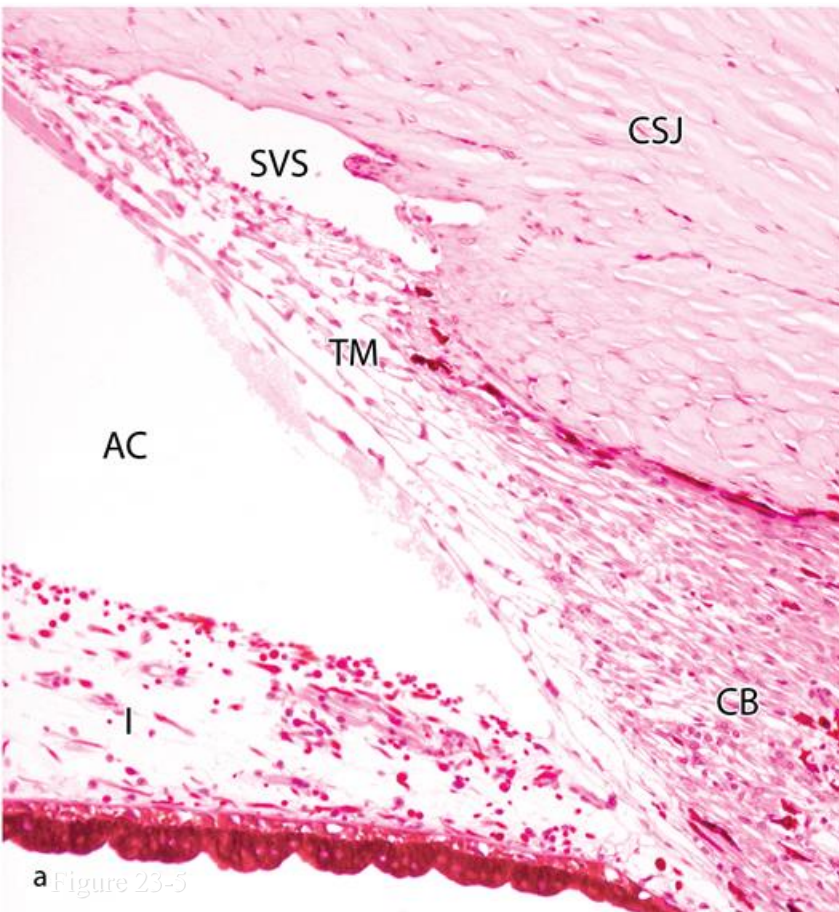
Figure 23-7





Trabecular meshwork and scleral venous sinus.

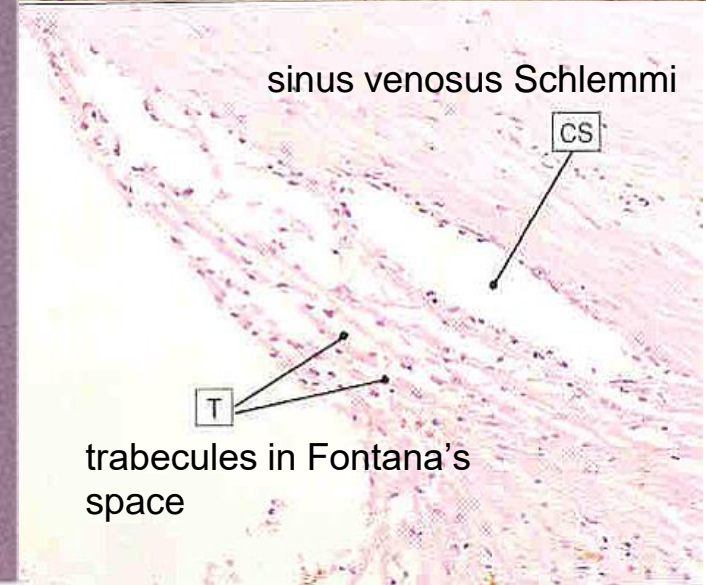
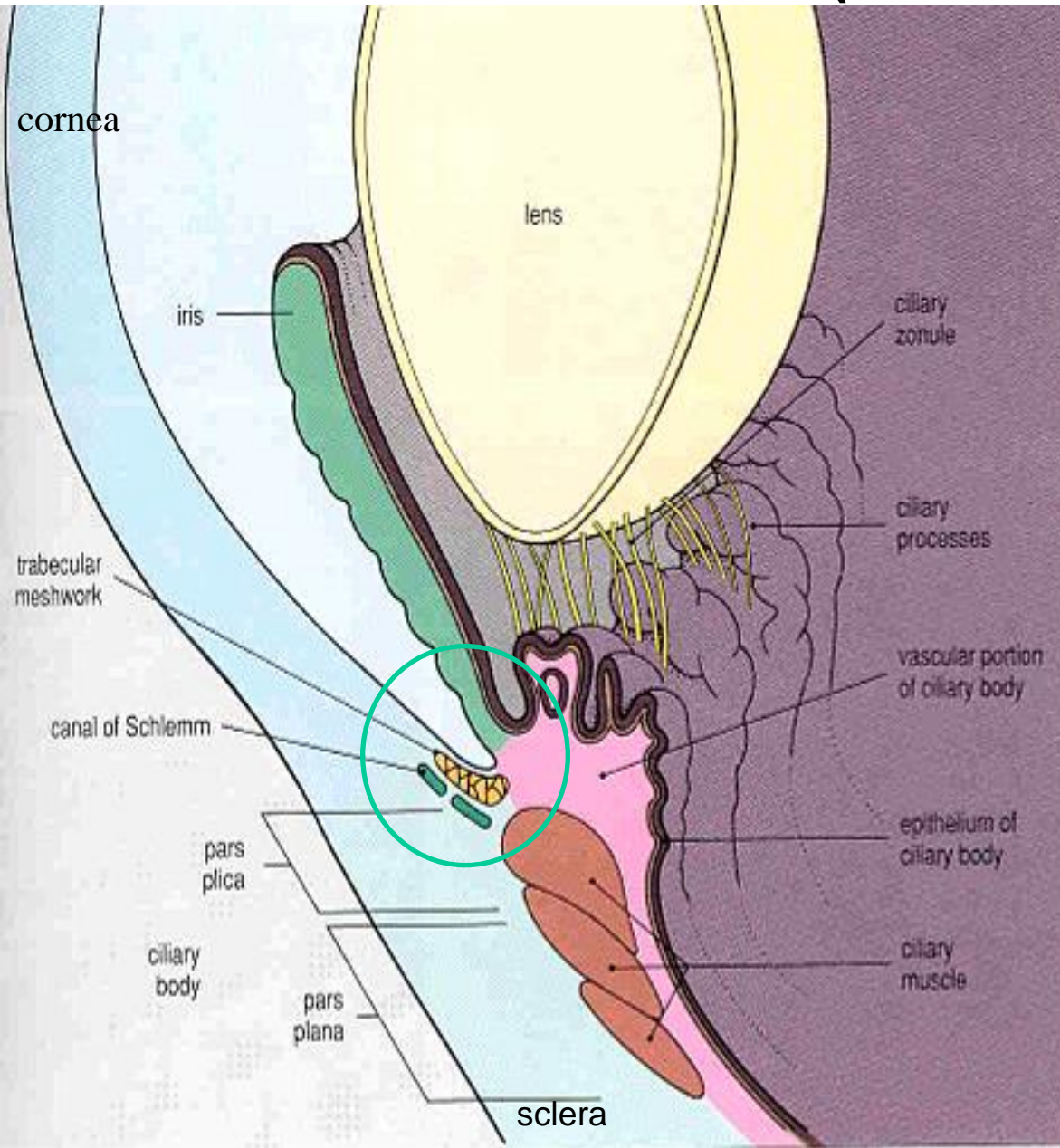
(a) At the corneoscleral junction (CSJ) the posterior endothelium and its underlying Descemet's membrane are replaced by a meshwork of irregular channels lined by endothelium and supported by trabeculae of connective tissue. At the iridocorneal angle between limbus and iris (I), aqueous humor moves from the anterior chamber (AC) into channels of this trabecular meshwork (TM) and is pumped into the adjacent scleral venous sinus

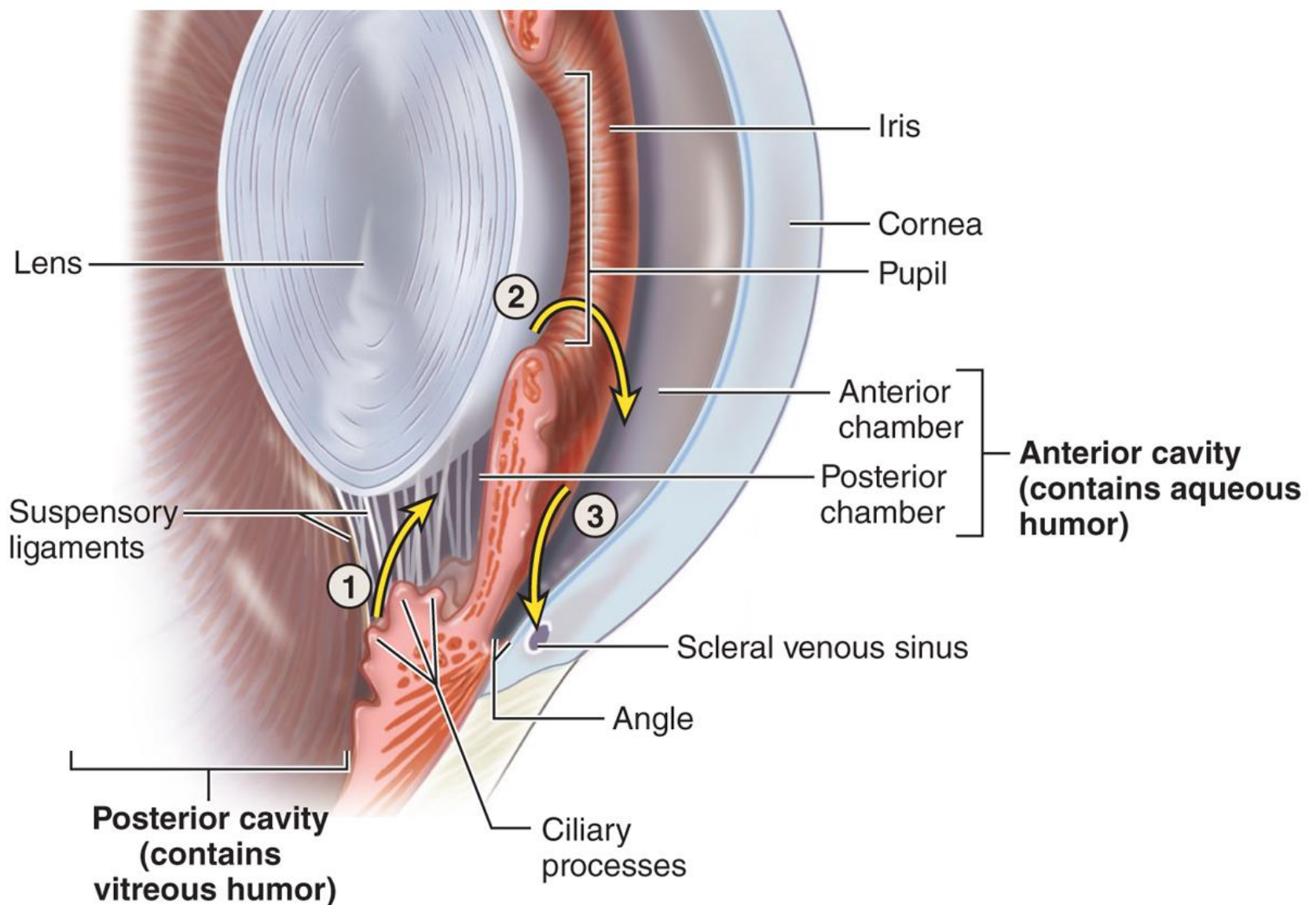


a Figure 23-5

b

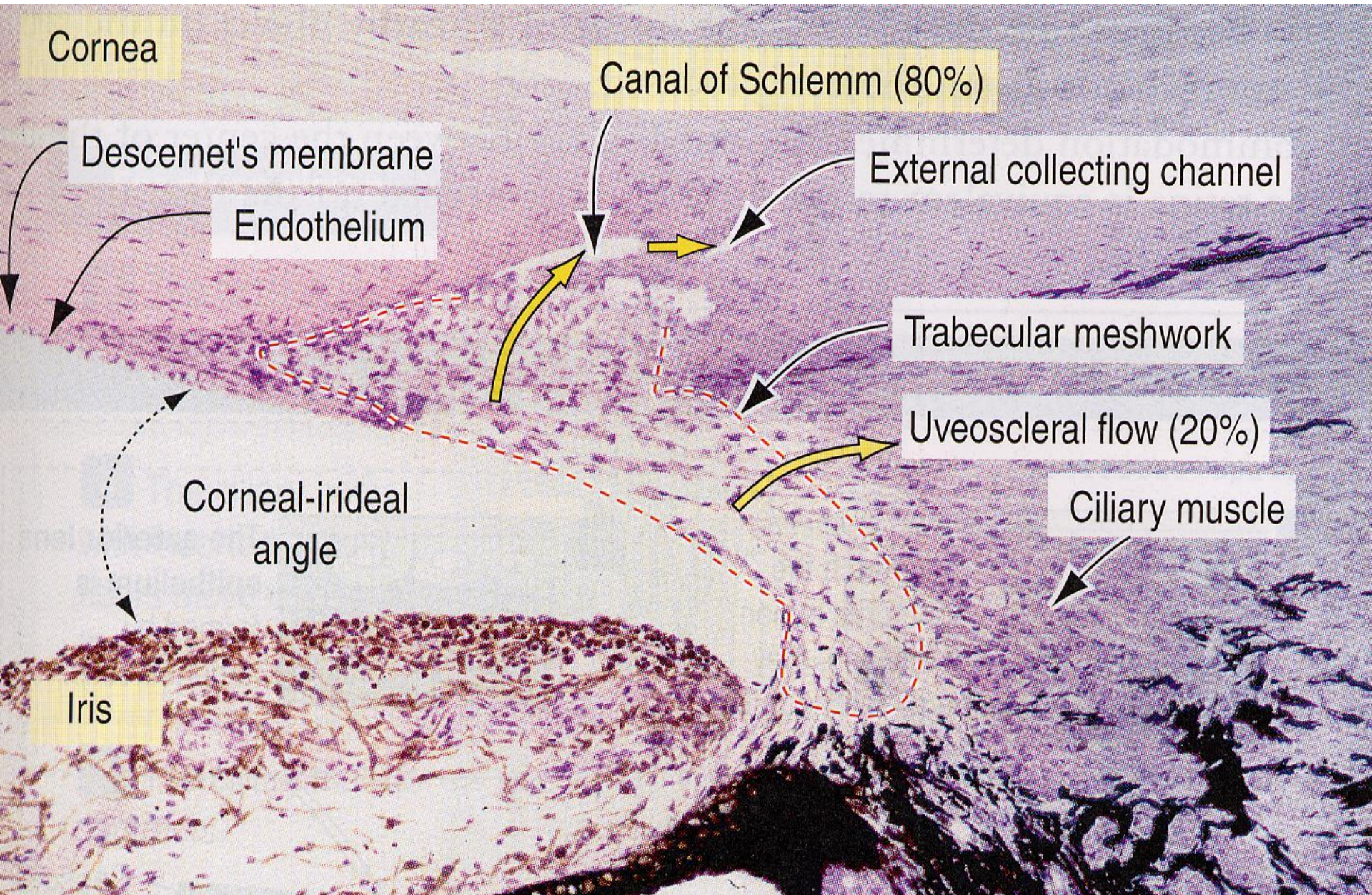
sulcus scleralis (iridocorneal angle)





- ① Aqueous humor is secreted by the ciliary processes into the posterior chamber.
- ② Aqueous humor moves from the posterior chamber, through the pupil, to the anterior chamber.
- ③ Excess aqueous humor is resorbed via the scleral venous sinus.

Figure 23-8



Cornea

Canal of Schlemm (80%)

Descemet's membrane

External collecting channel

Endothelium

Trabecular meshwork

Corneal-irideal angle

Uveoscleral flow (20%)

Ciliary muscle

Iris

Iris

- annular shape, flat
- aperture function
- Pupilla



- m. sphincter pupillae (*parasymp.*) – miosis
- m. dilatator pupillae (*symp.*) – mydriasis (fan-shaped)



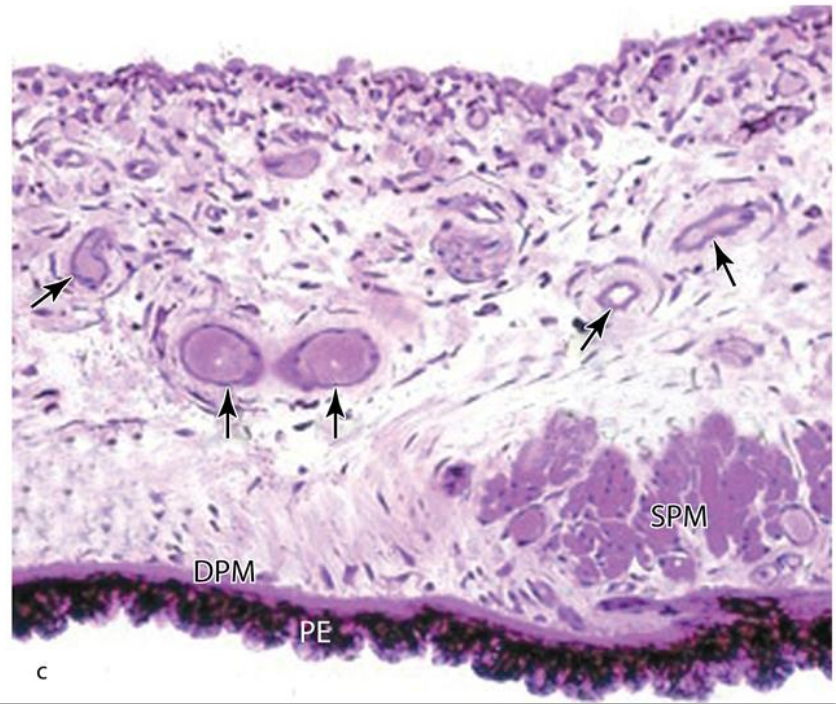
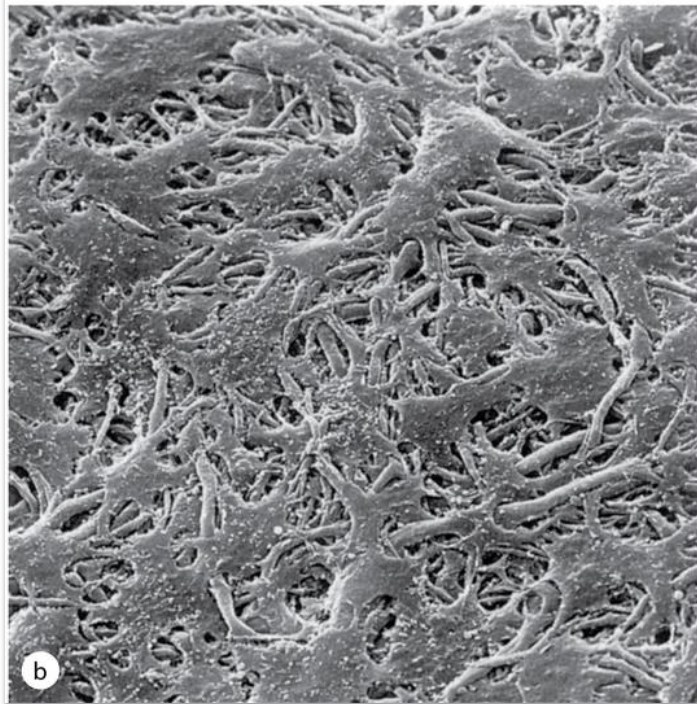
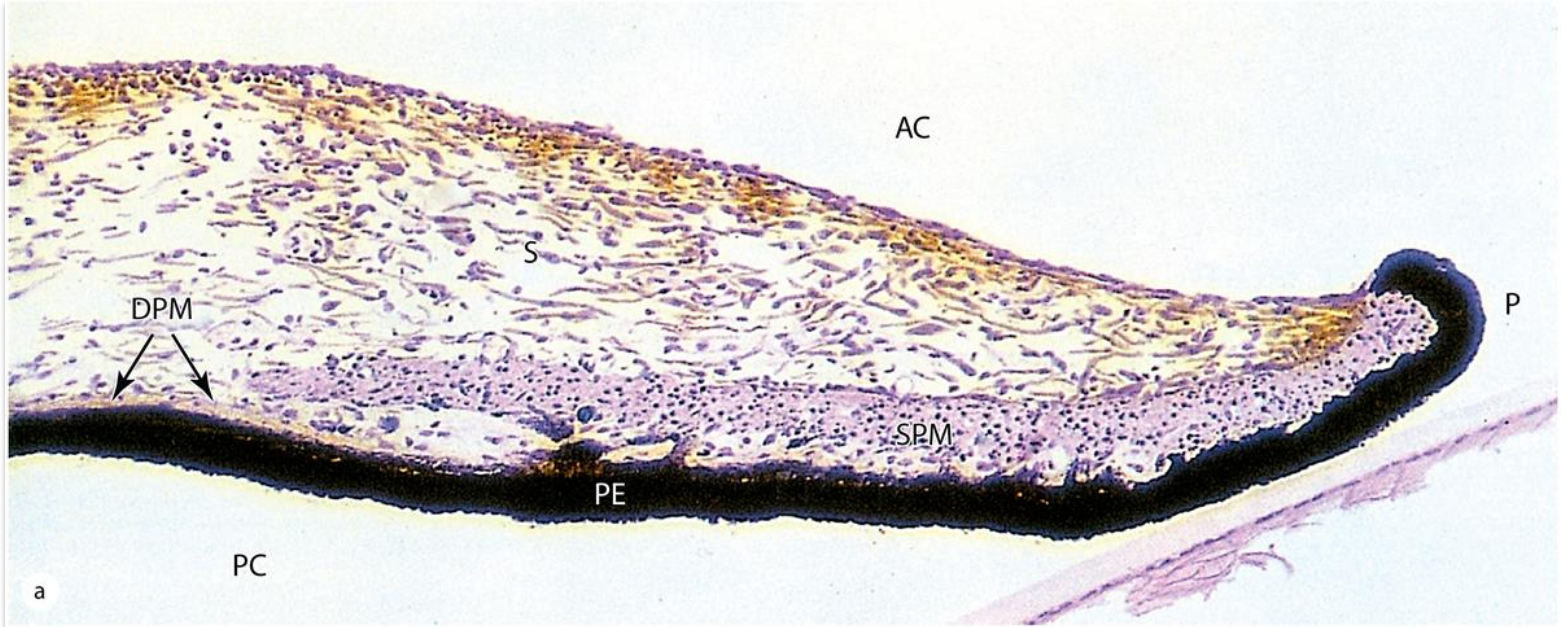
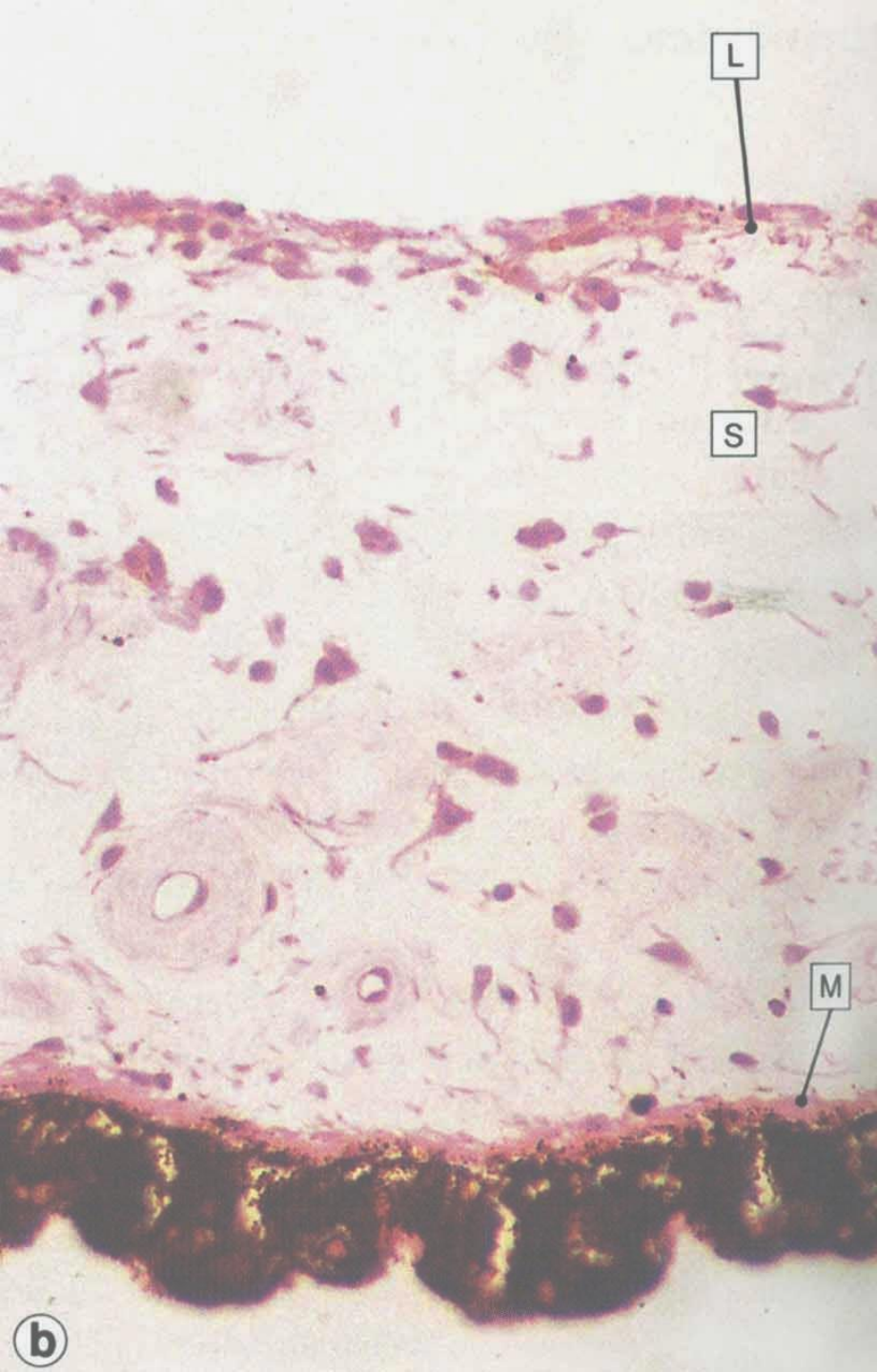


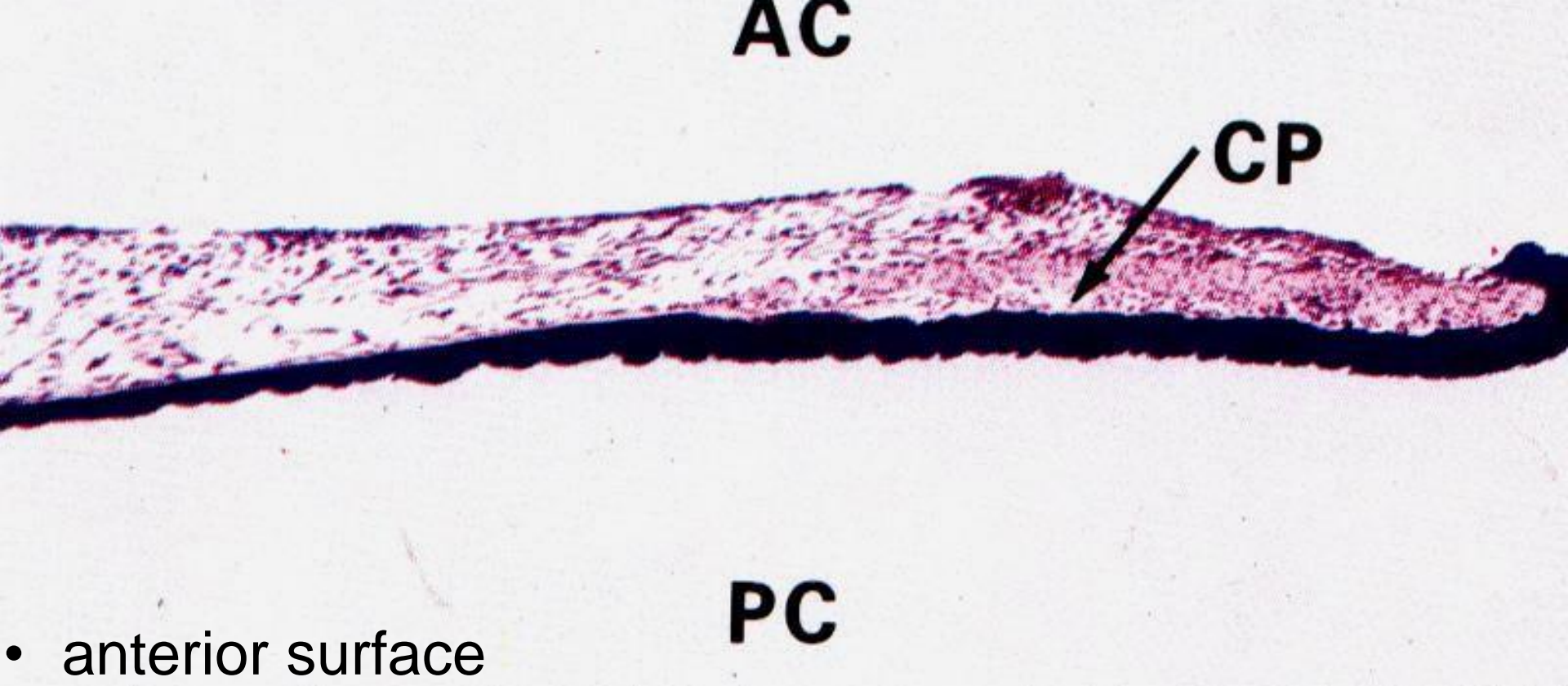
Figure 23-10



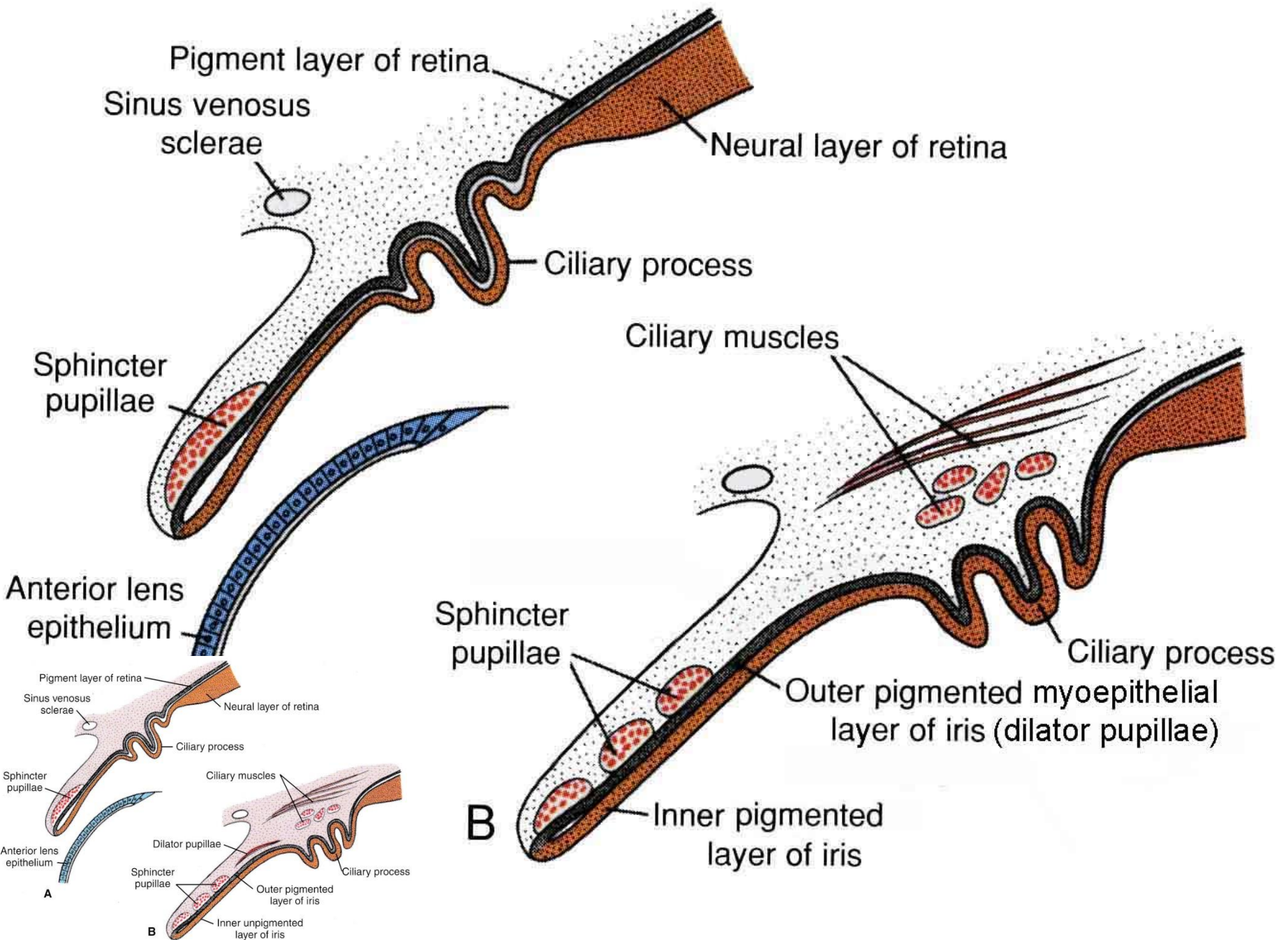
anterior limiting layer

stroma iridis

posterior limiting layer (m. dilat.)
posterior epithelium (pigment)

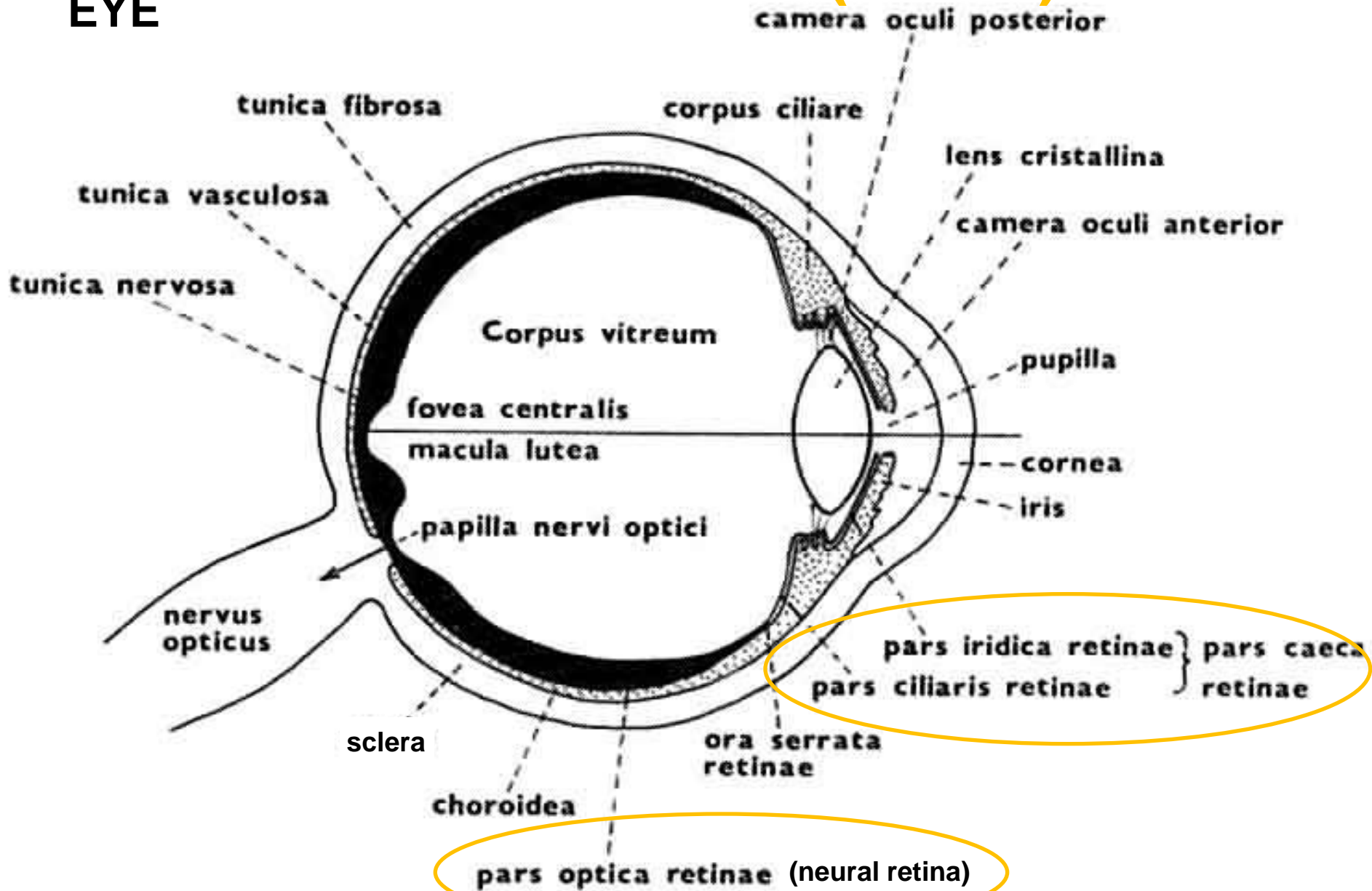


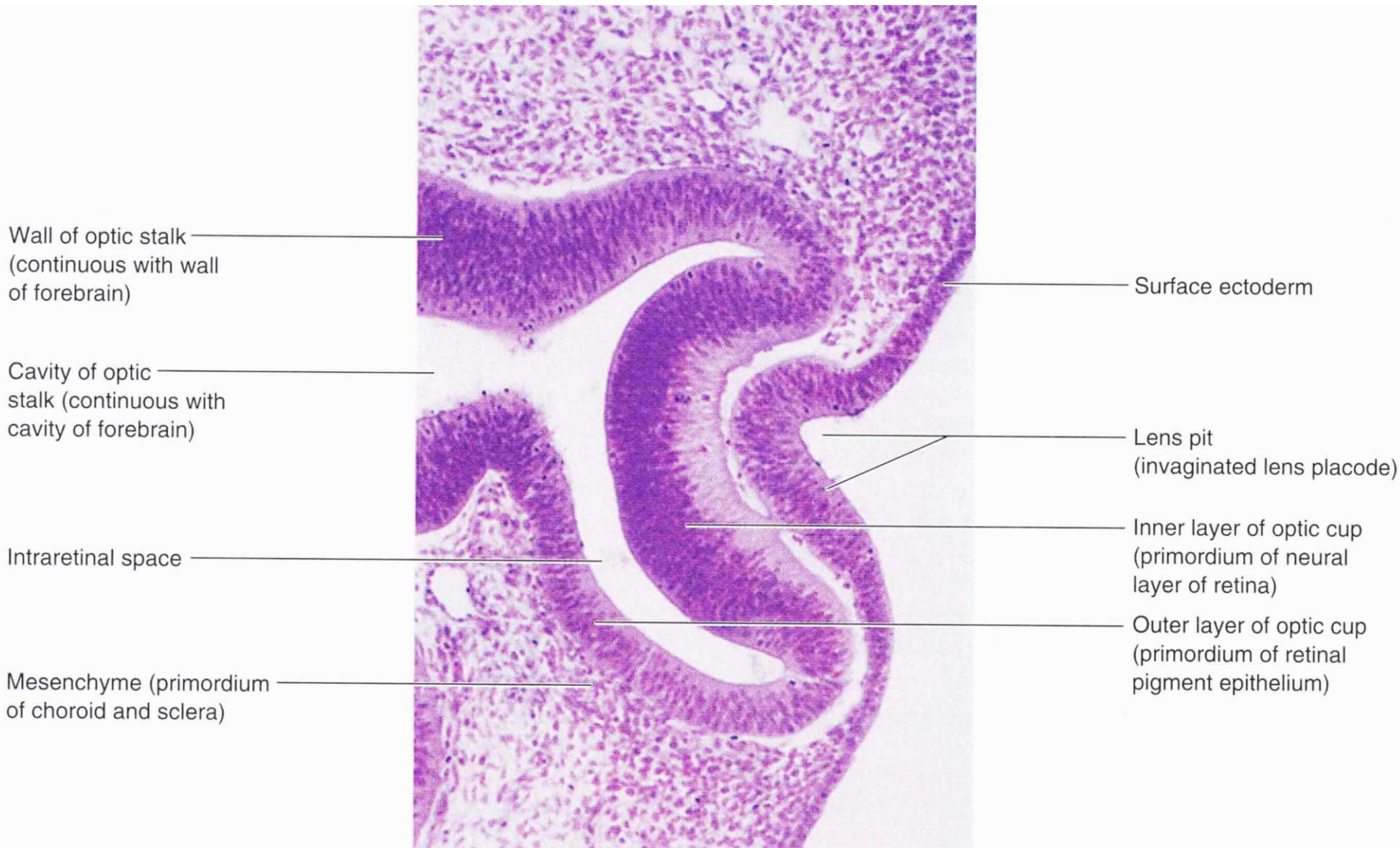
- anterior surface
 - non-continuous epithelium (*stratum limitans anterius*)
 - fibroblasts a melanocytes (color)
- posterior surface
 - two pigmented layers
 - inner pigmented epithelium
 - outer pigmented myoepithelium
- m. dilatator pupillae



Tunica nervosa (retina)

EYE





Wall of optic stalk
(continuous with wall
of forebrain)

Cavity of optic
stalk (continuous with
cavity of forebrain)

Intraretinal space

Mesenchyme (primordium
of choroid and sclera)

Surface ectoderm

Lens pit
(invaginated lens placode)

Inner layer of optic cup
(primordium of neural
layer of retina)

Outer layer of optic cup
(primordium of retinal
pigment epithelium)

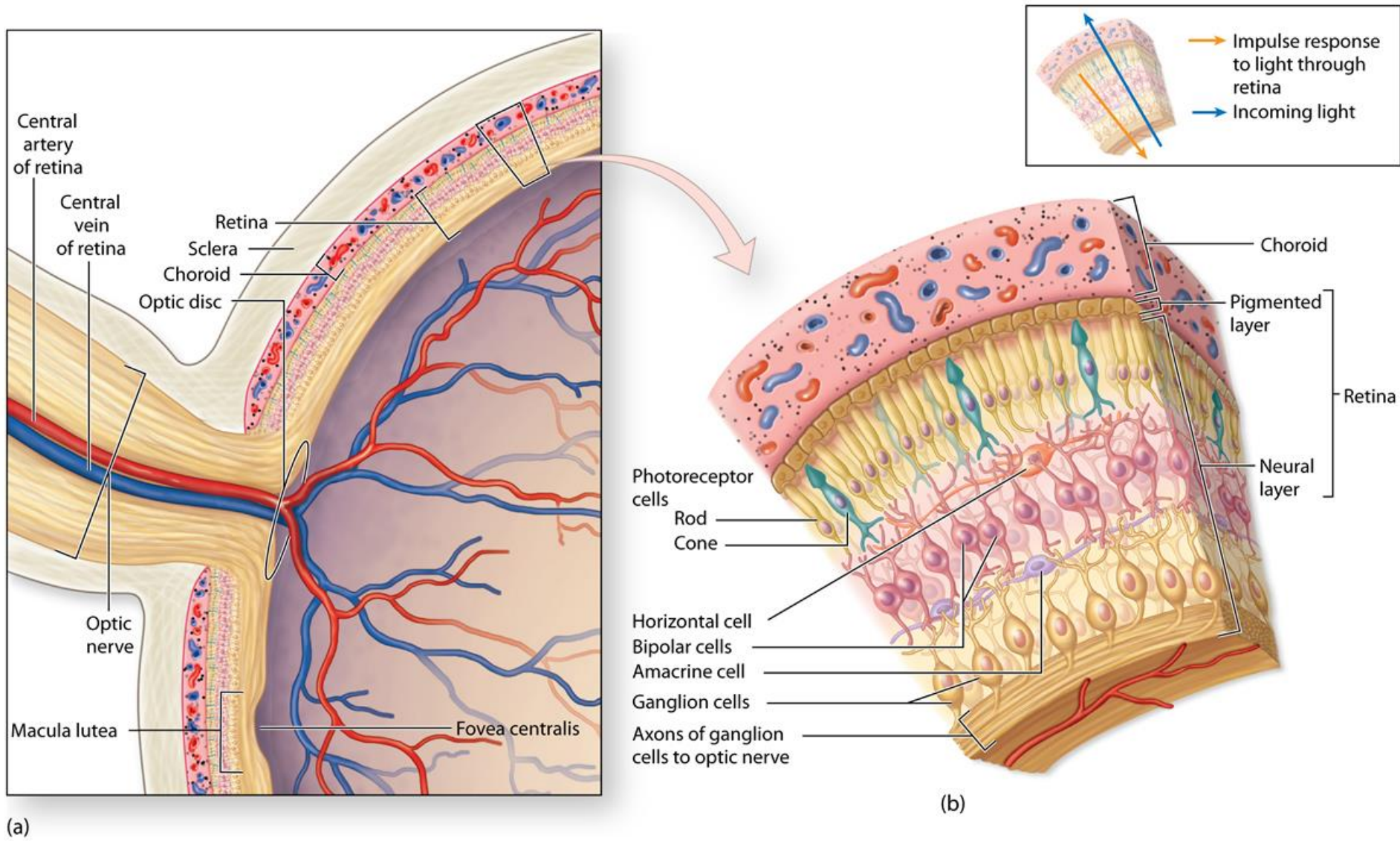
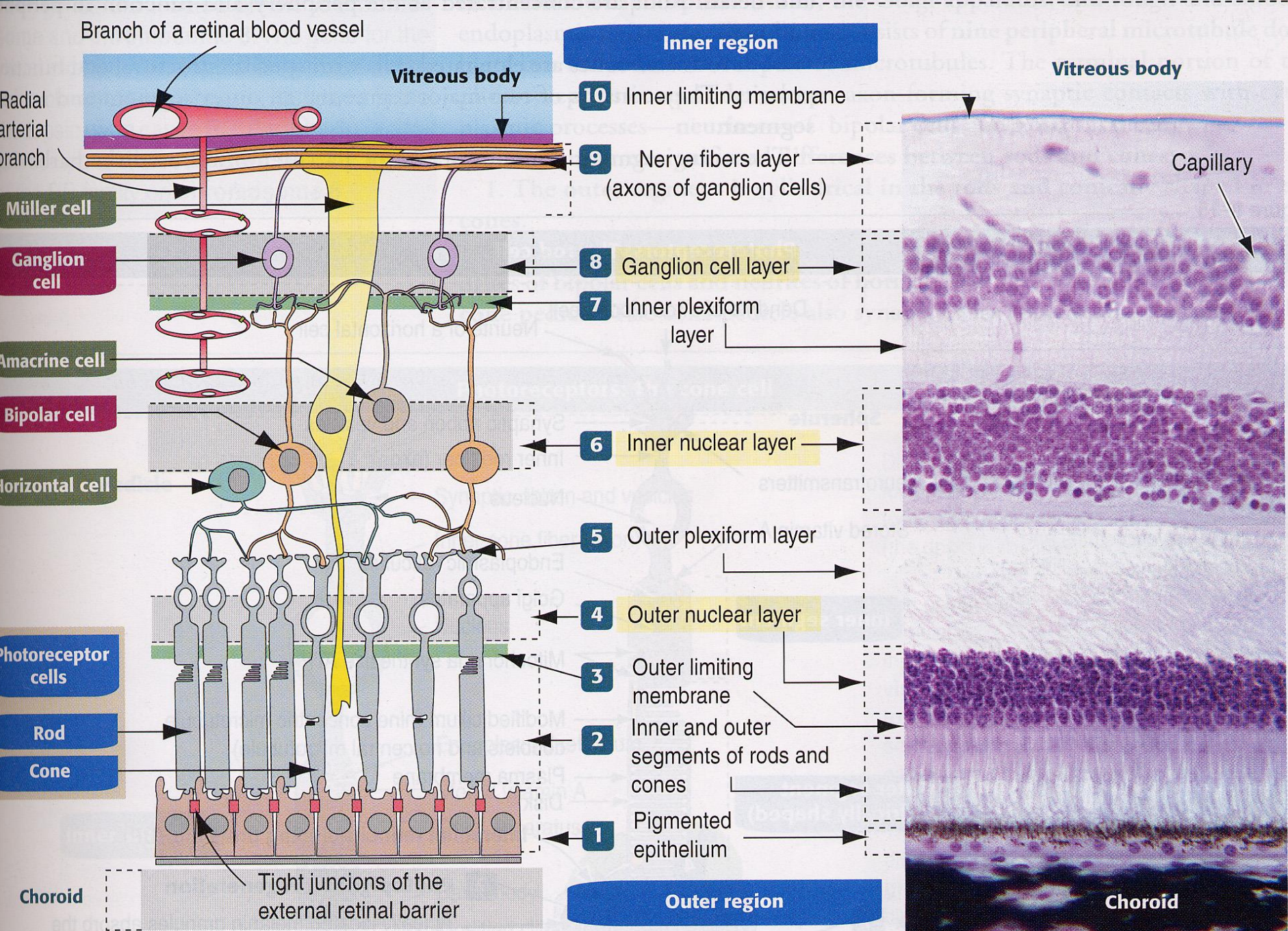


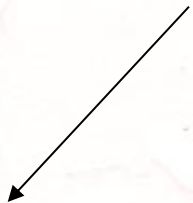
Figure 23-14

The layers of the retina

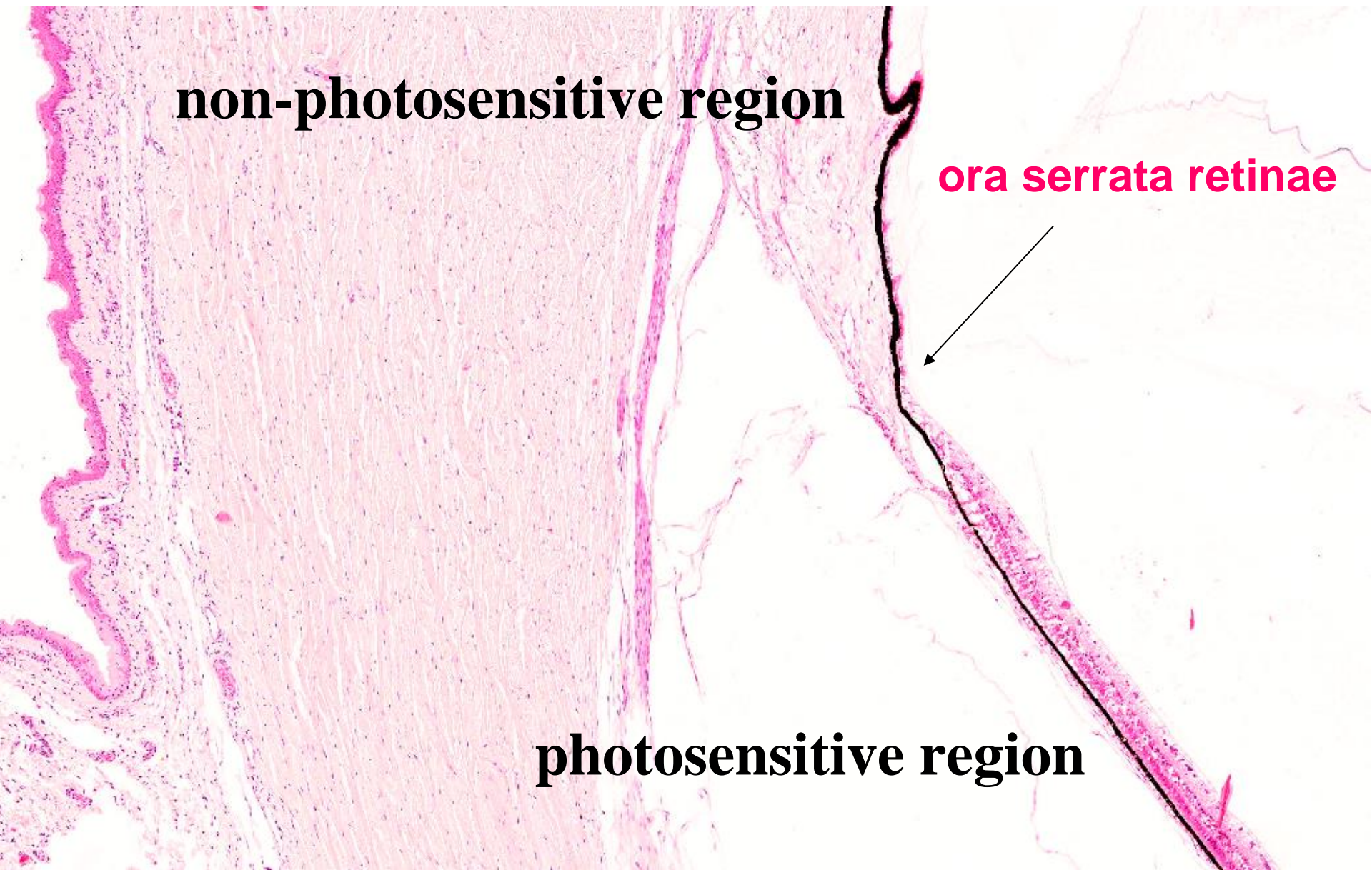


non-photosensitive region

ora serrata retinae

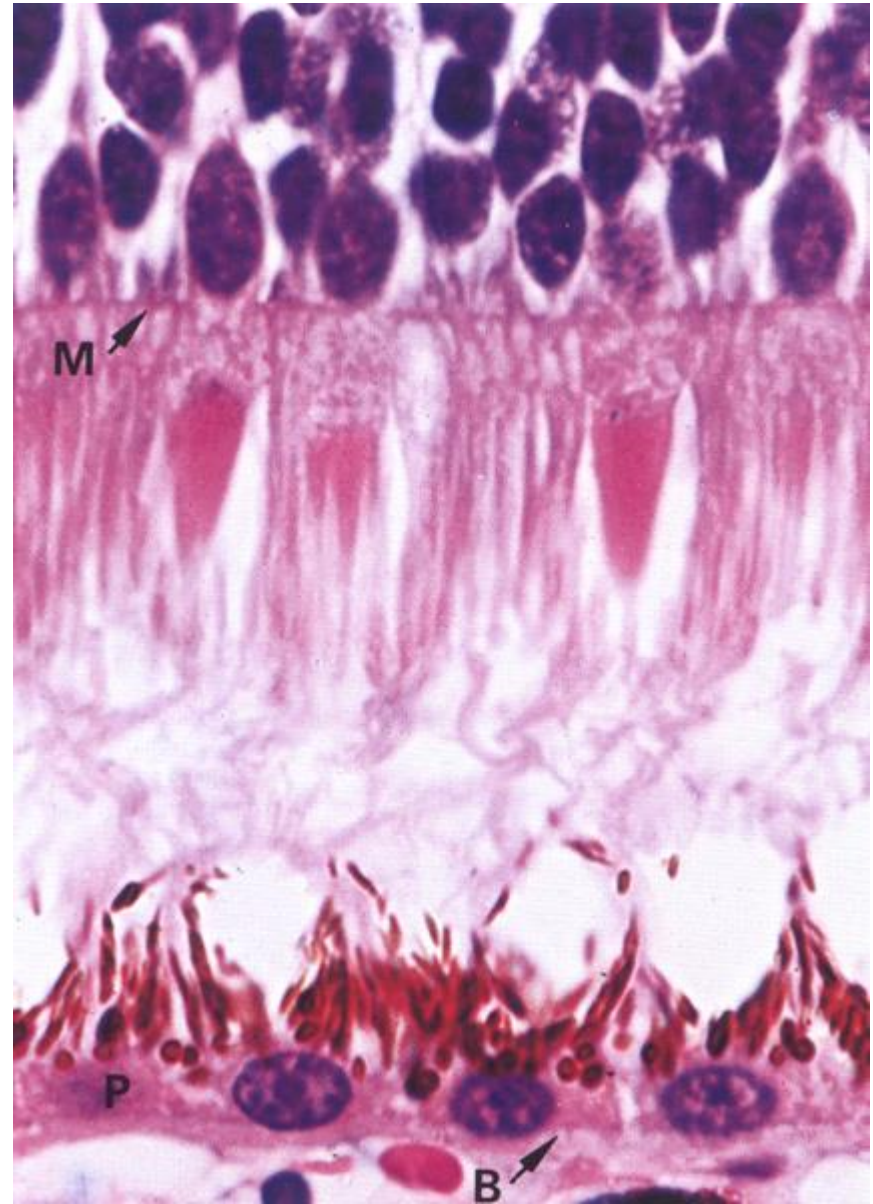
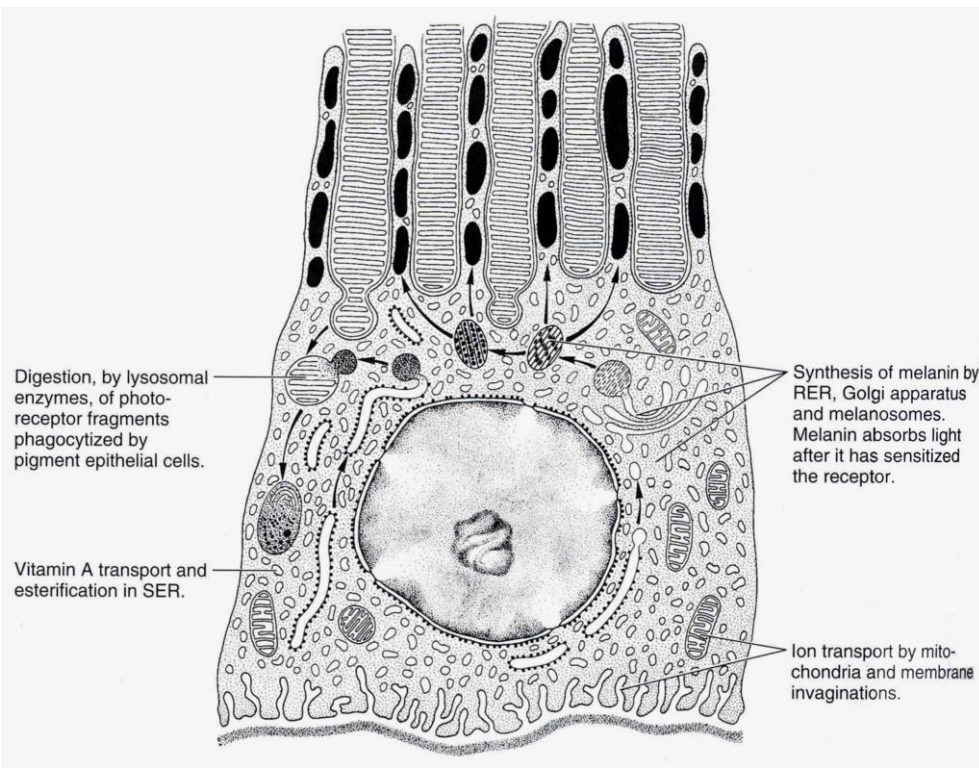


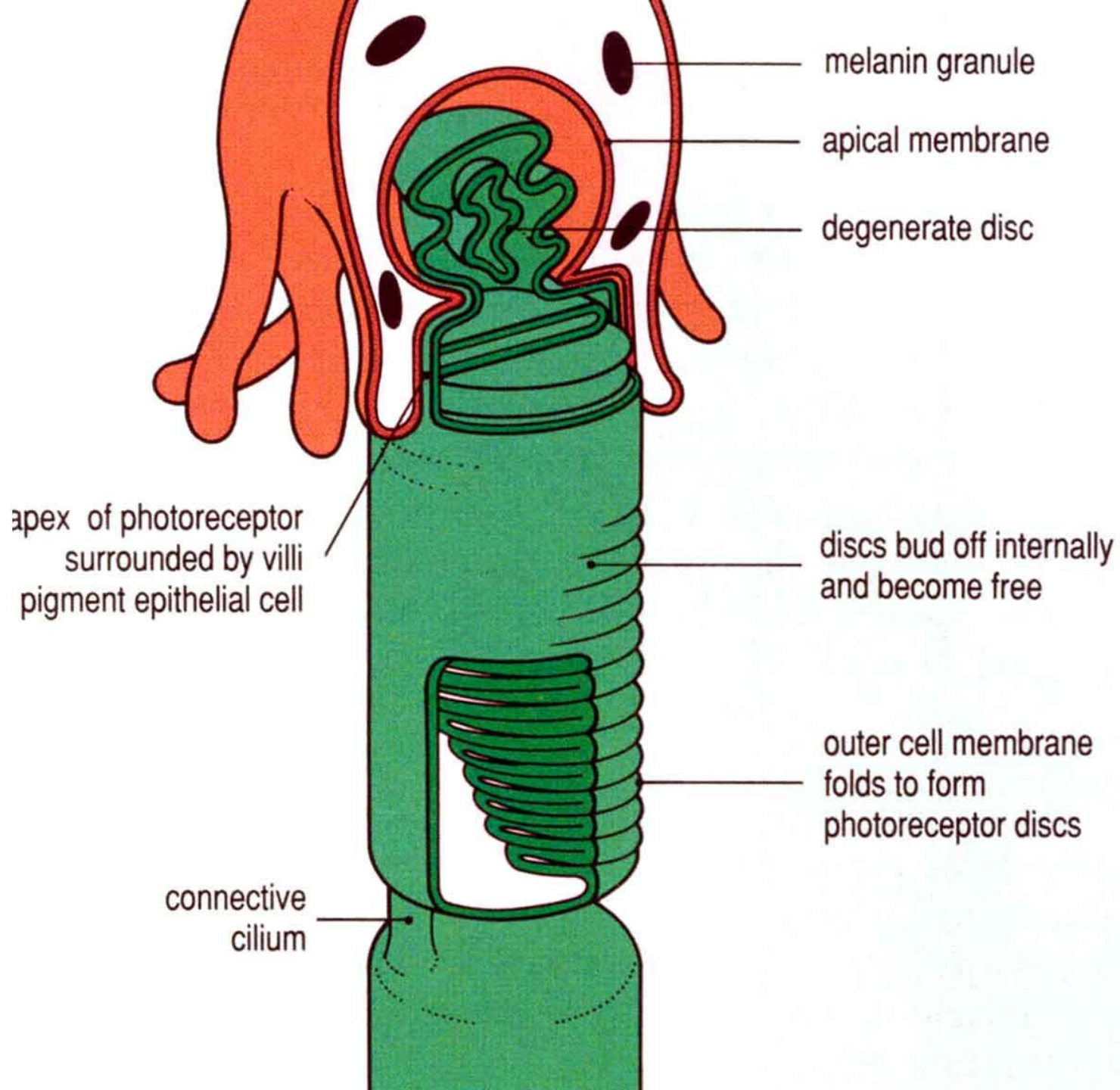
photosensitive region

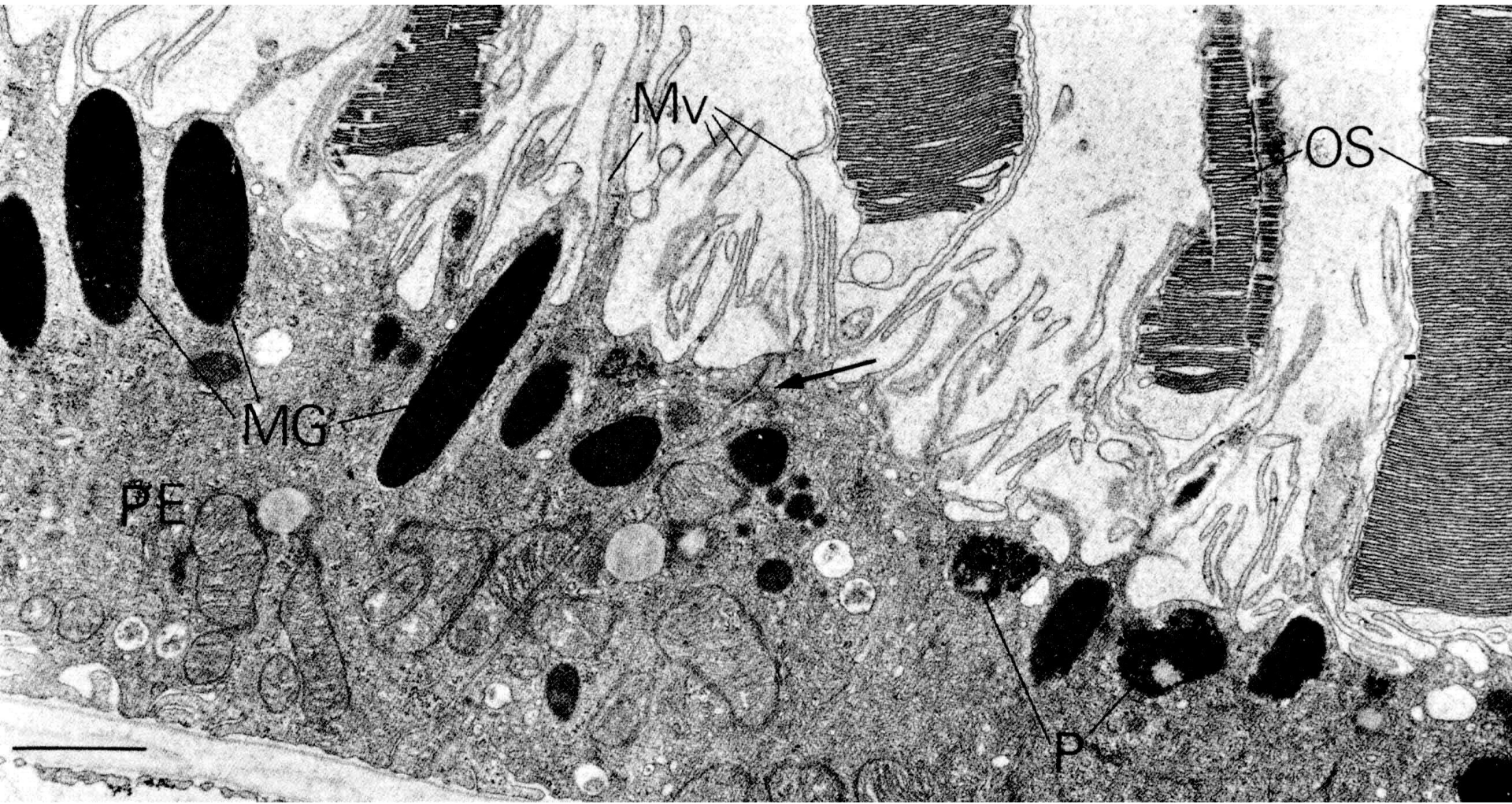


1st layer of retina - pigmented epithelium

- absorb light
- barrier
- restoring photosensitivity
- phagocytosis



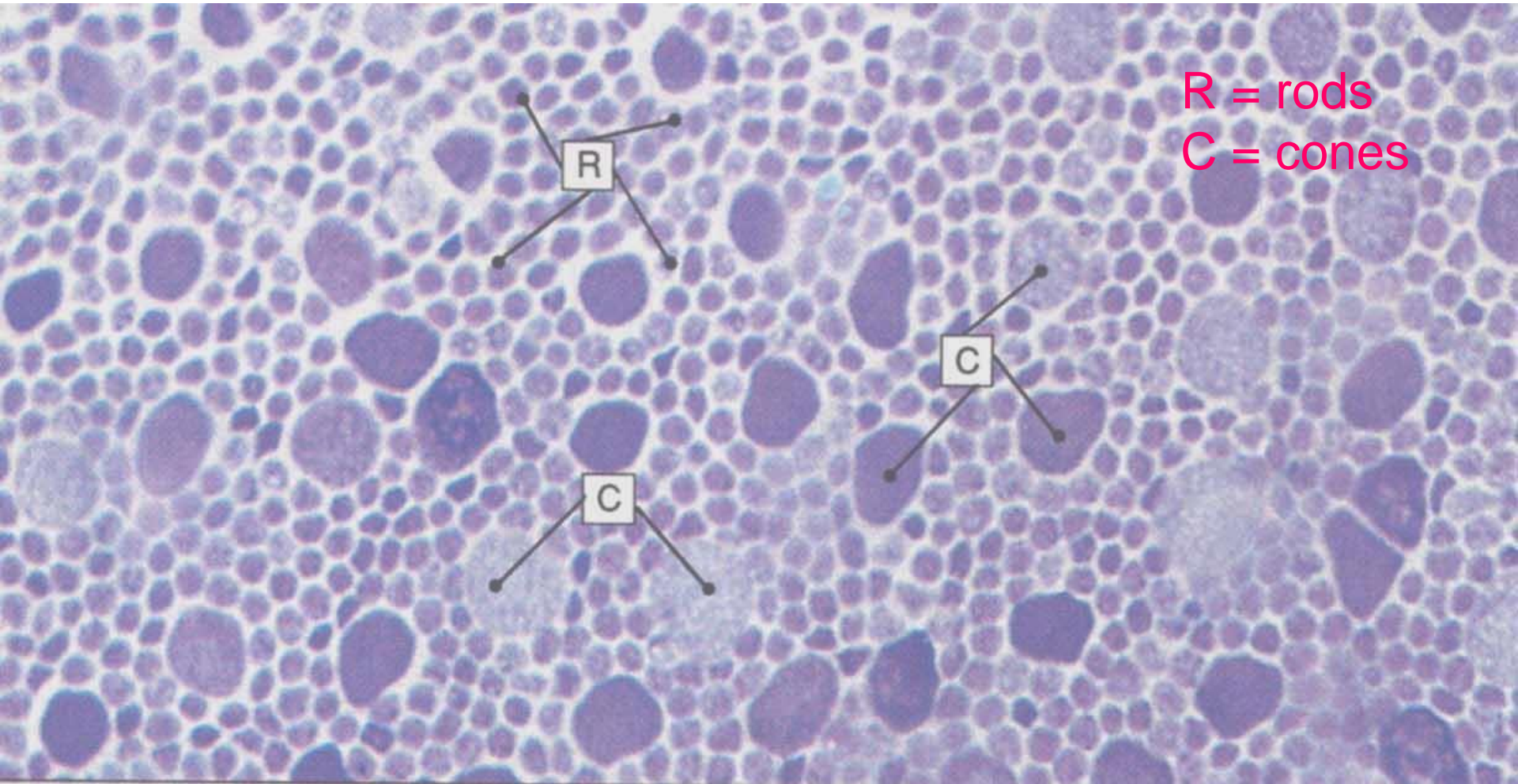




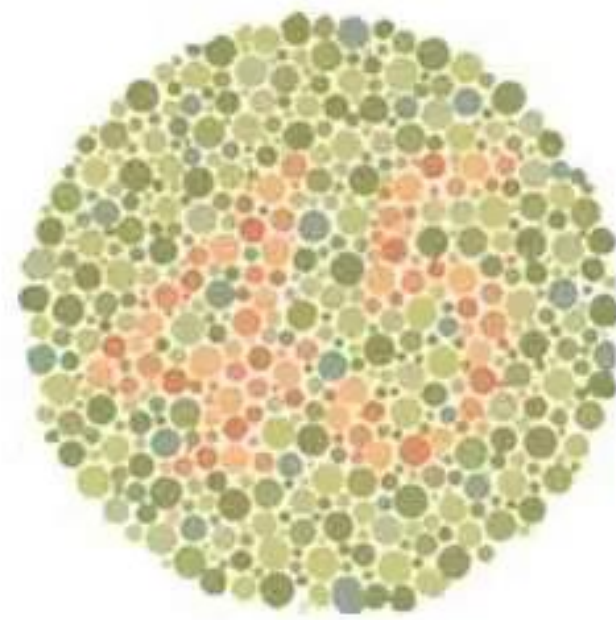
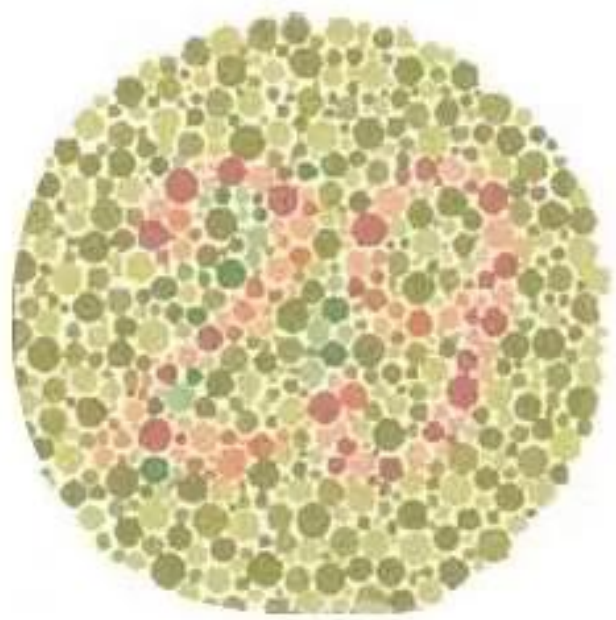
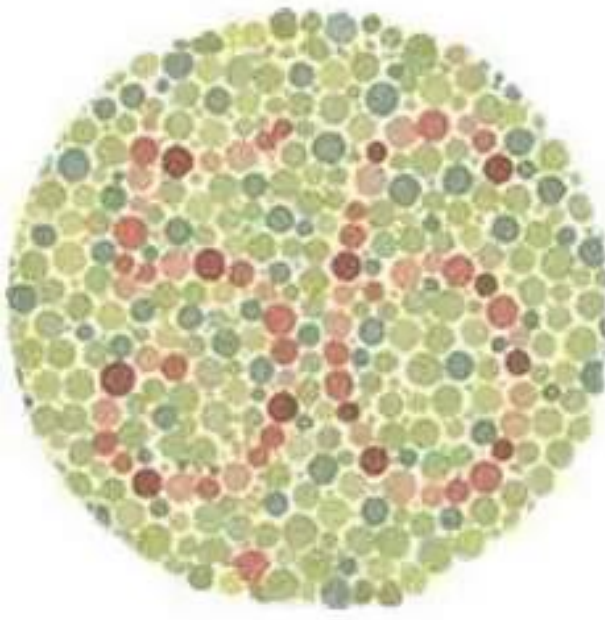
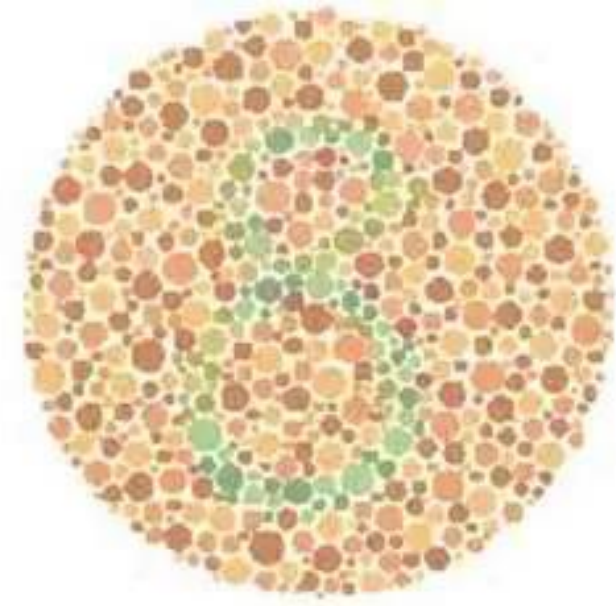
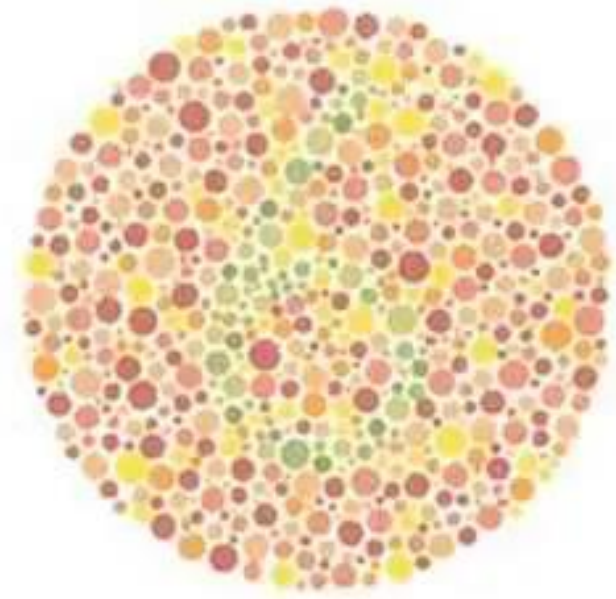
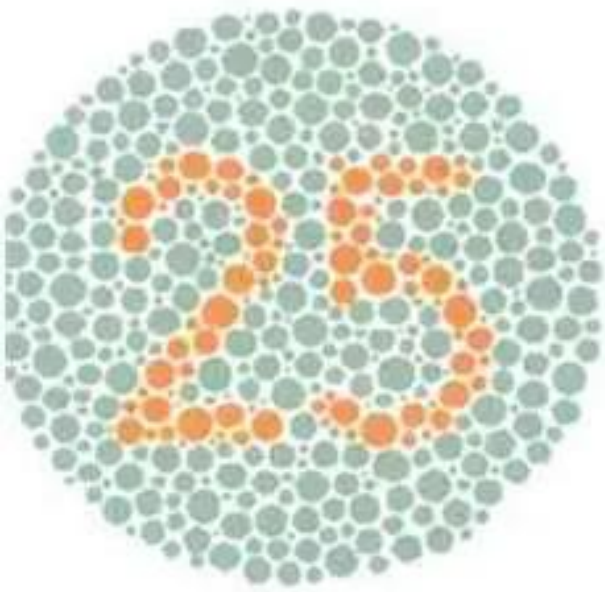
Visual photoreception – ciliary photoreceptors

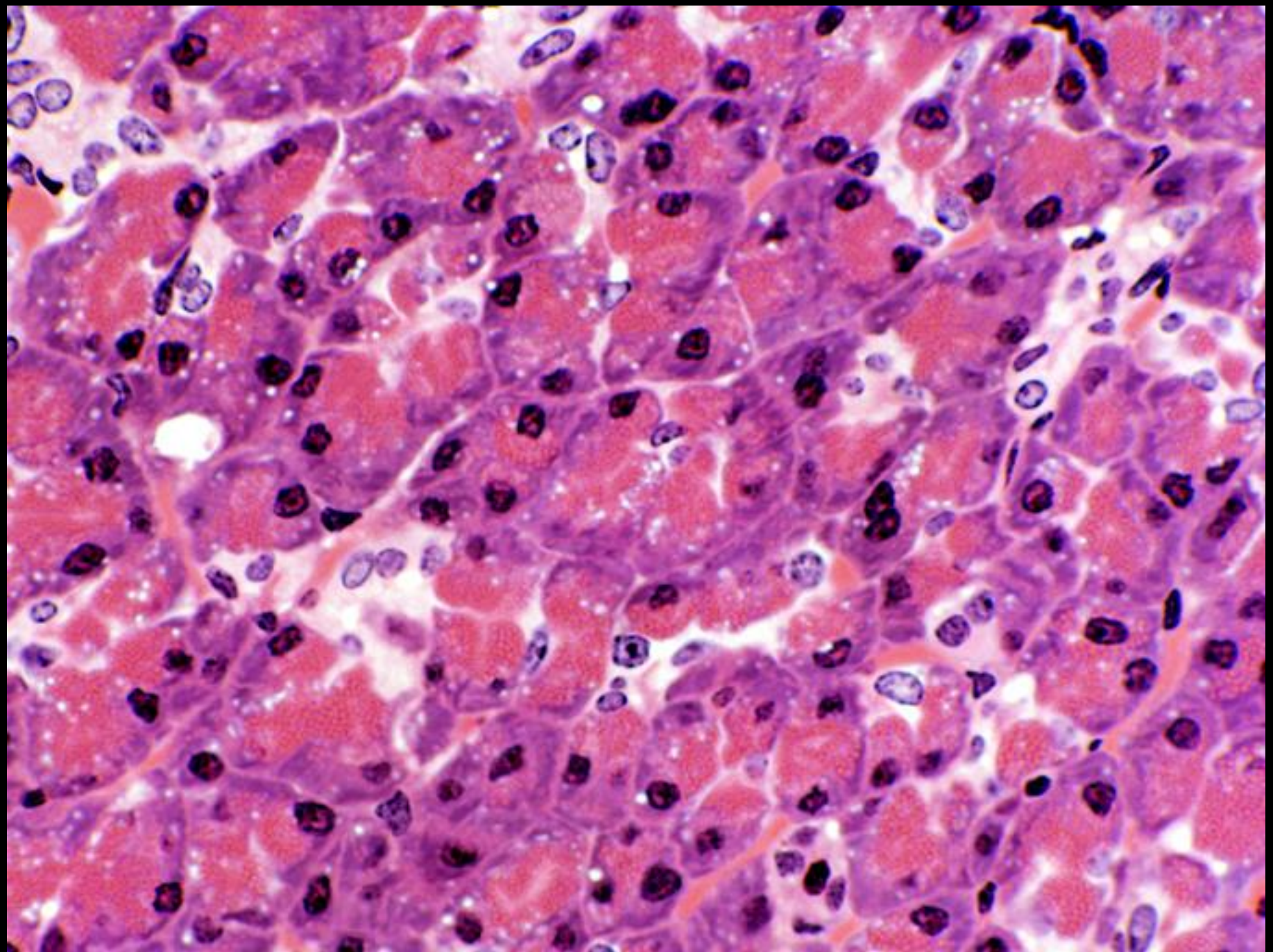
rods - rhodopsin (visual purple)

cones - iodopsin, 3 types
420 nm – blue (S) short
535 nm – green (M) medium
565 nm – red (L) long



R = rods
C = cones





120 million

Rod

Cone

7 million

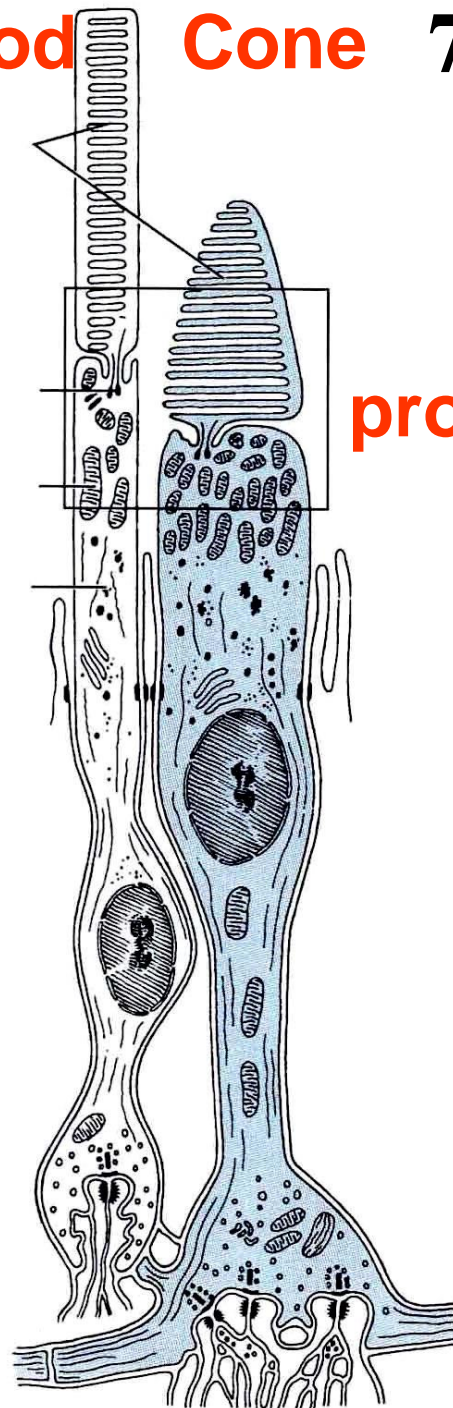
outer segment

constriction

inner segment

area of nucleus

area of synapses



proper rod (cone)

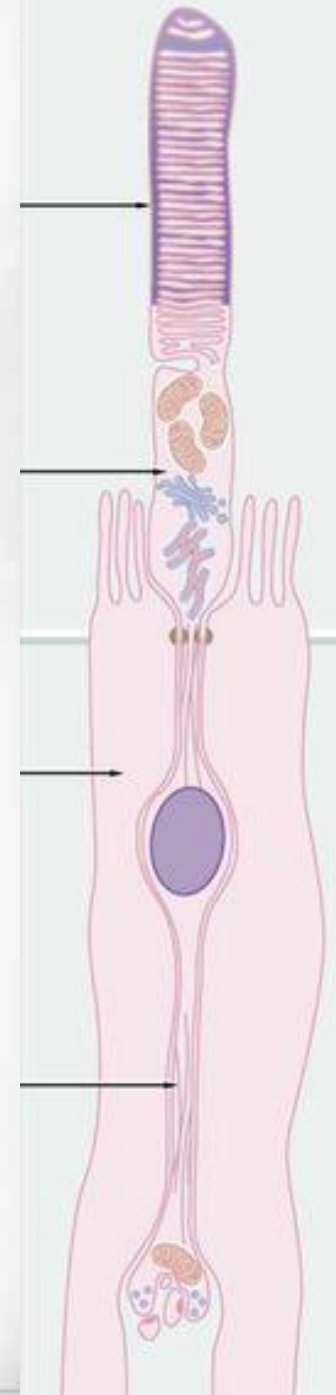
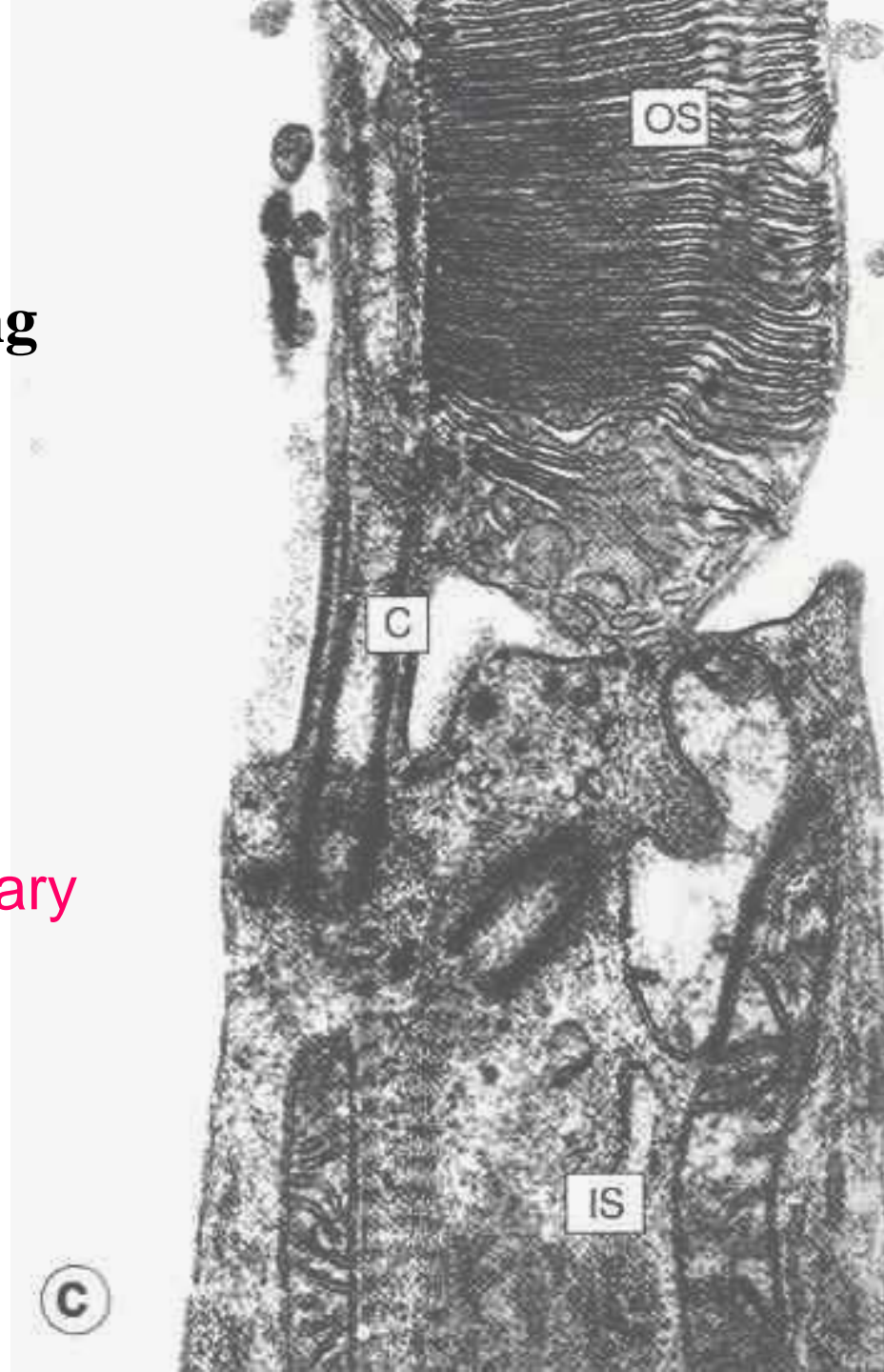
Rod

outer segment

discs containing
rhodopsin

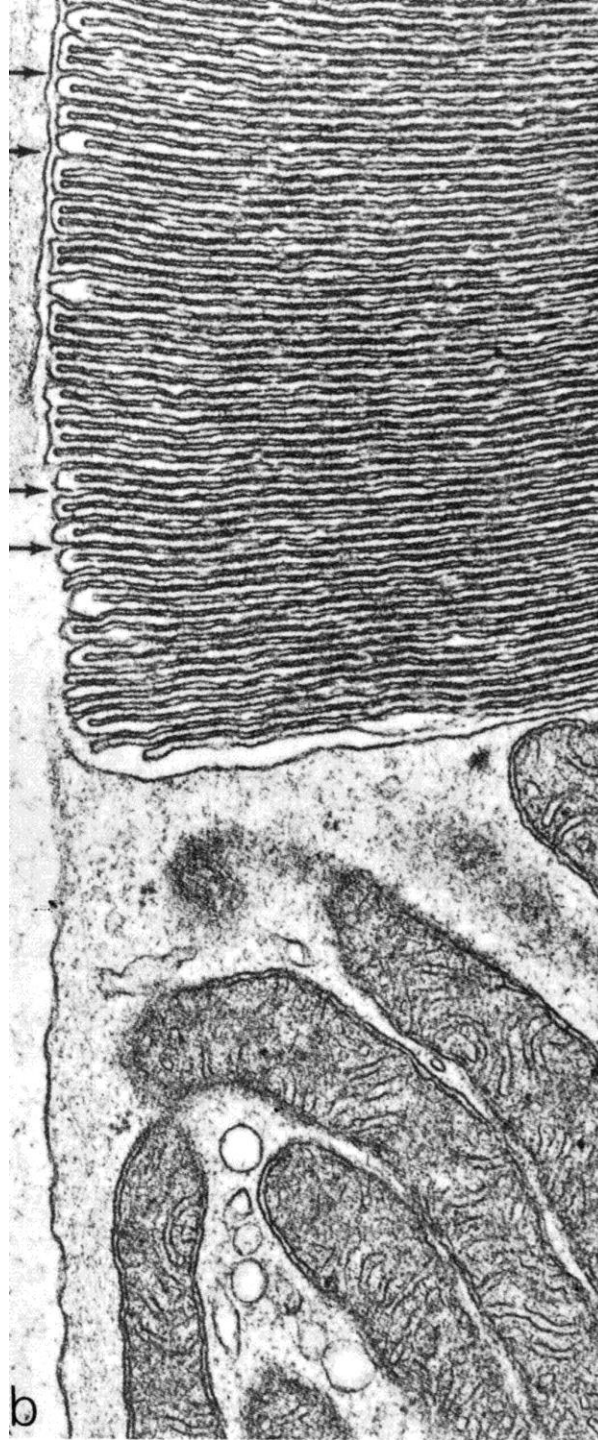
constriction (ciliary
apparatus)

inner segment



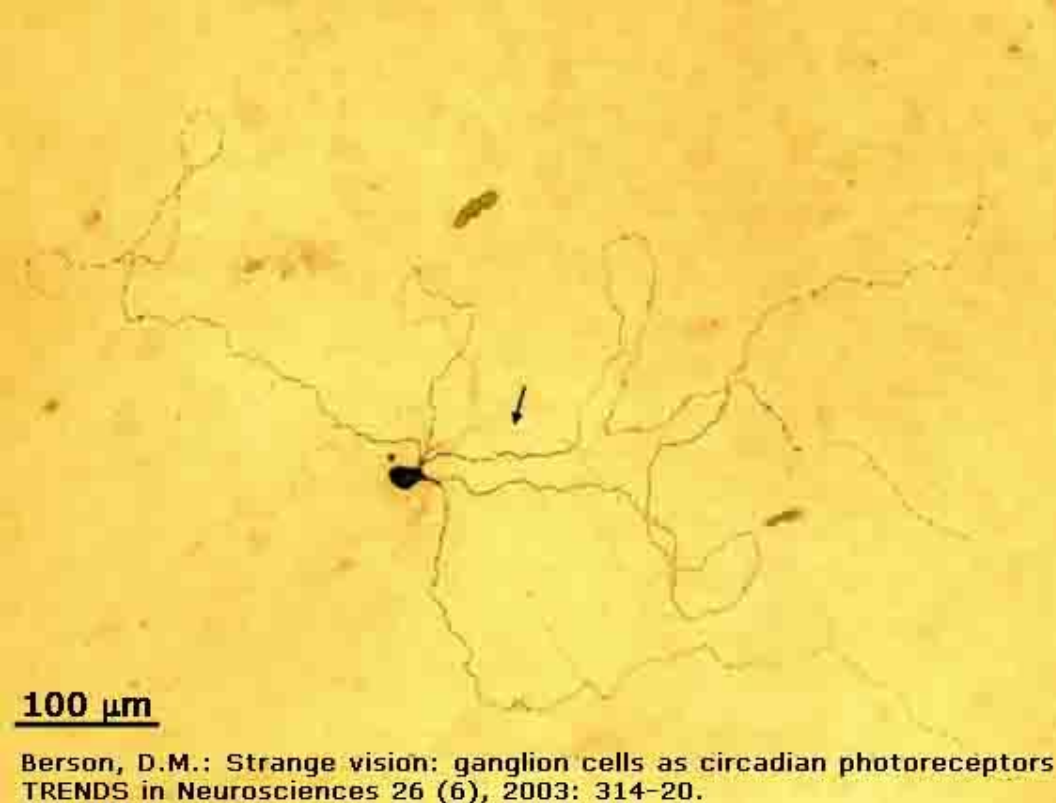
Cone

discs containing
iodopsin are
continuous with
plasma
membrane



Non-visual photoreception

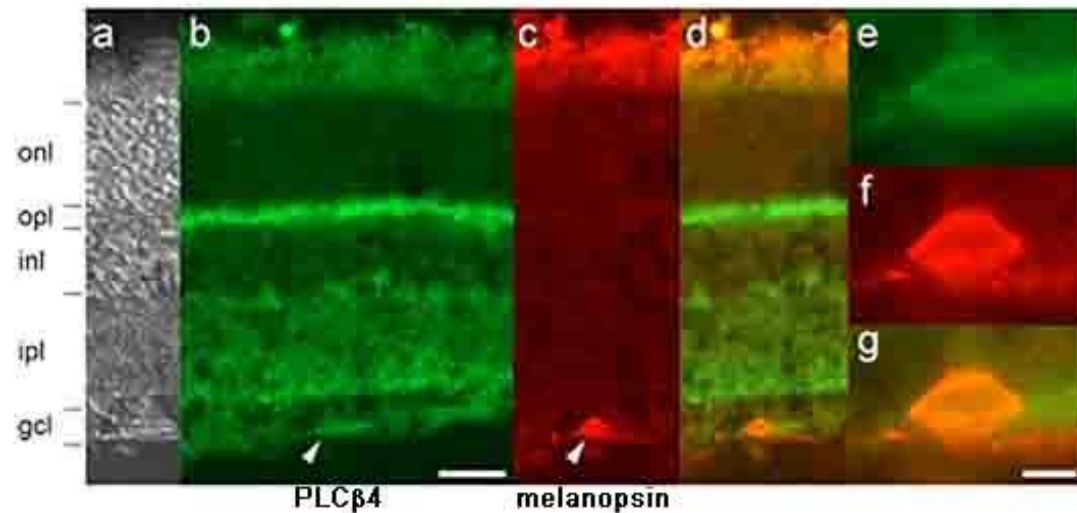
phototransducing ganglion cells - melanopsin



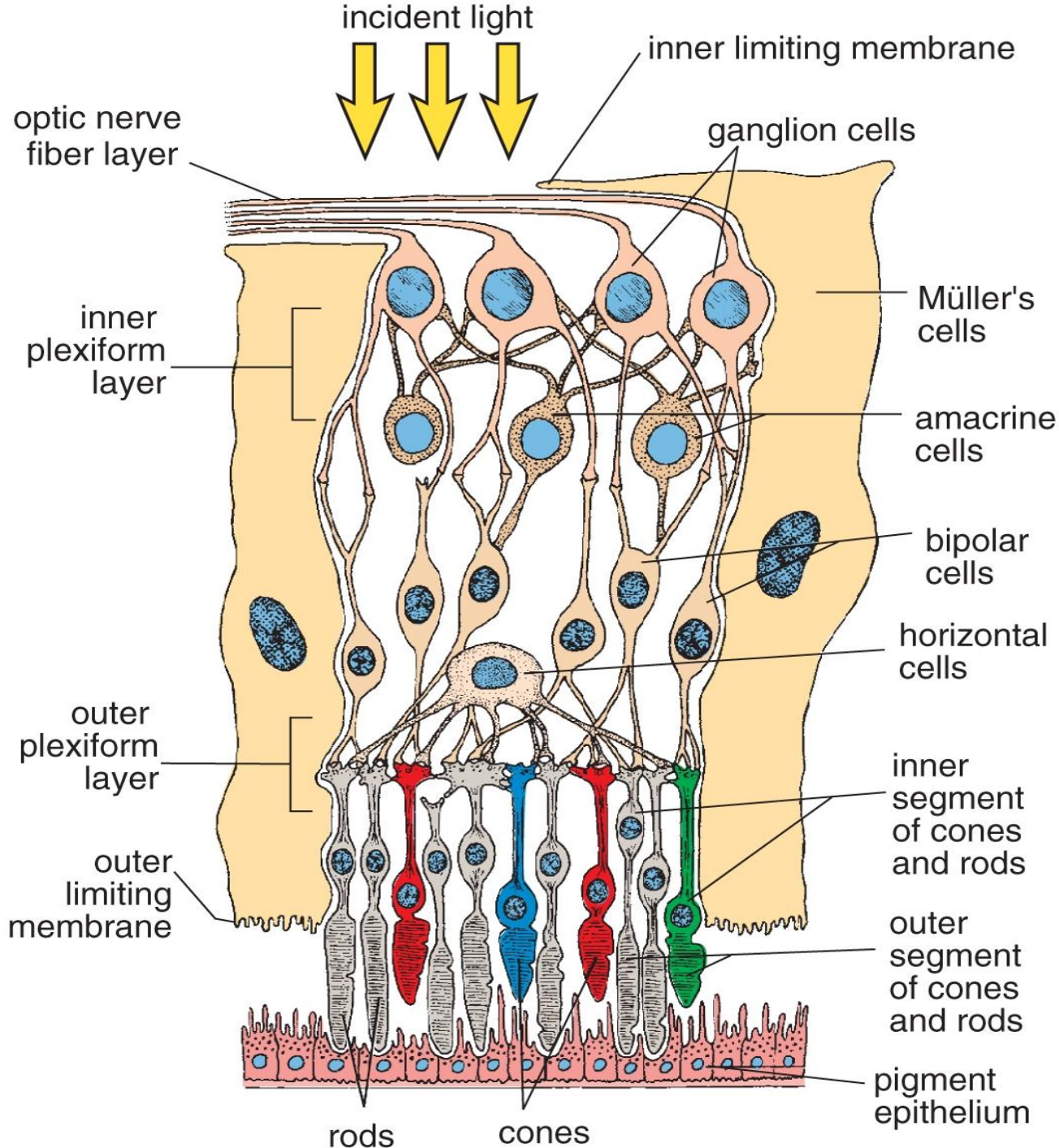
100 μm

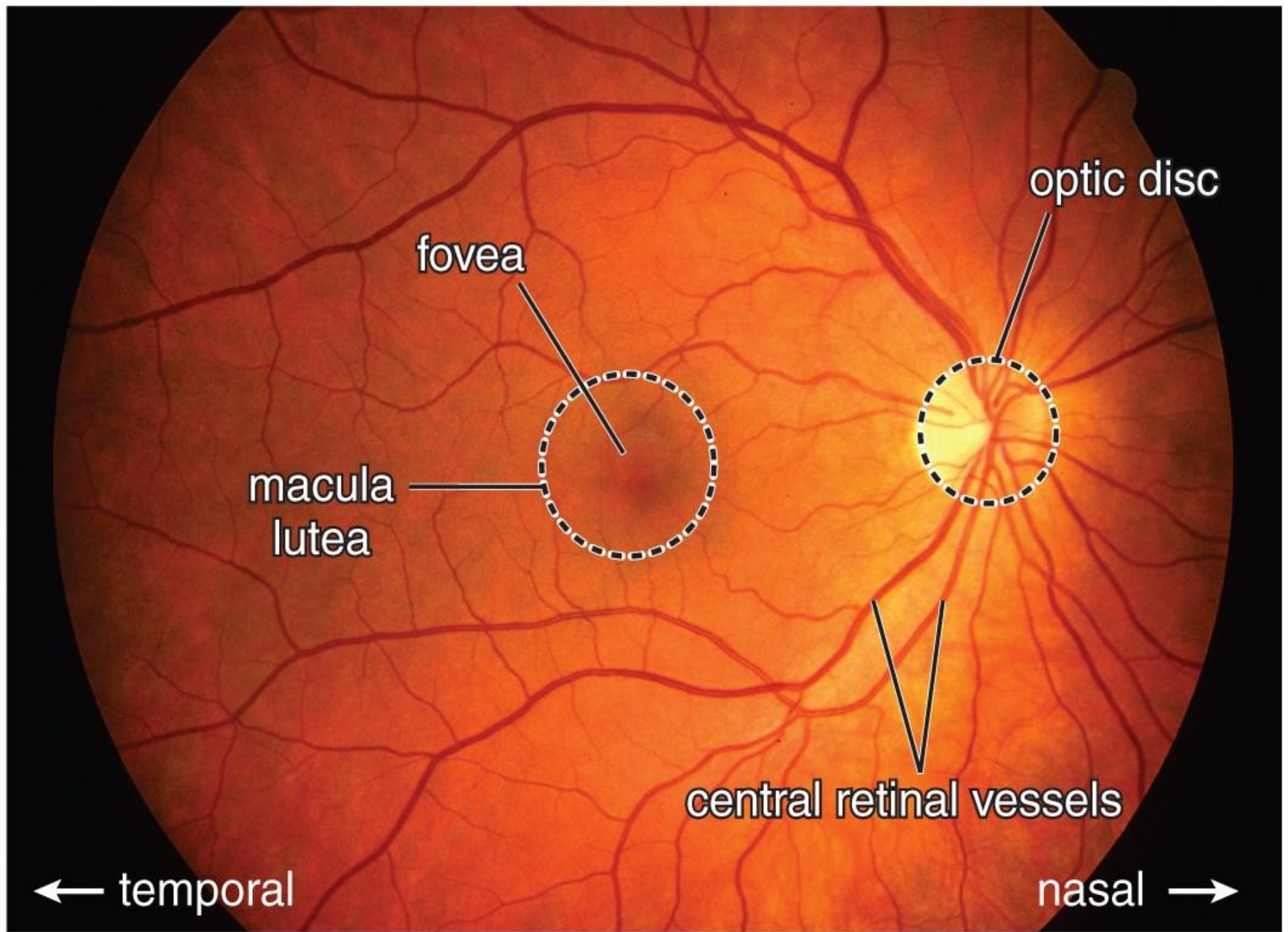
Berson, D.M.: Strange vision: ganglion cells as circadian photoreceptors. *TRENDS in Neurosciences* 26 (6), 2003: 314-20.

non-image-forming visual functions, including hormone secretion, entrainment of circadian rhythms, cognitive and affective processes.



Graham, D.M.: Melanopsin Ganglion Cells: A Bit of Fly in the Mammalian Eye. *Webvision - The Organization of the Retina and Visual System*, 2011.





optic disc

fovea

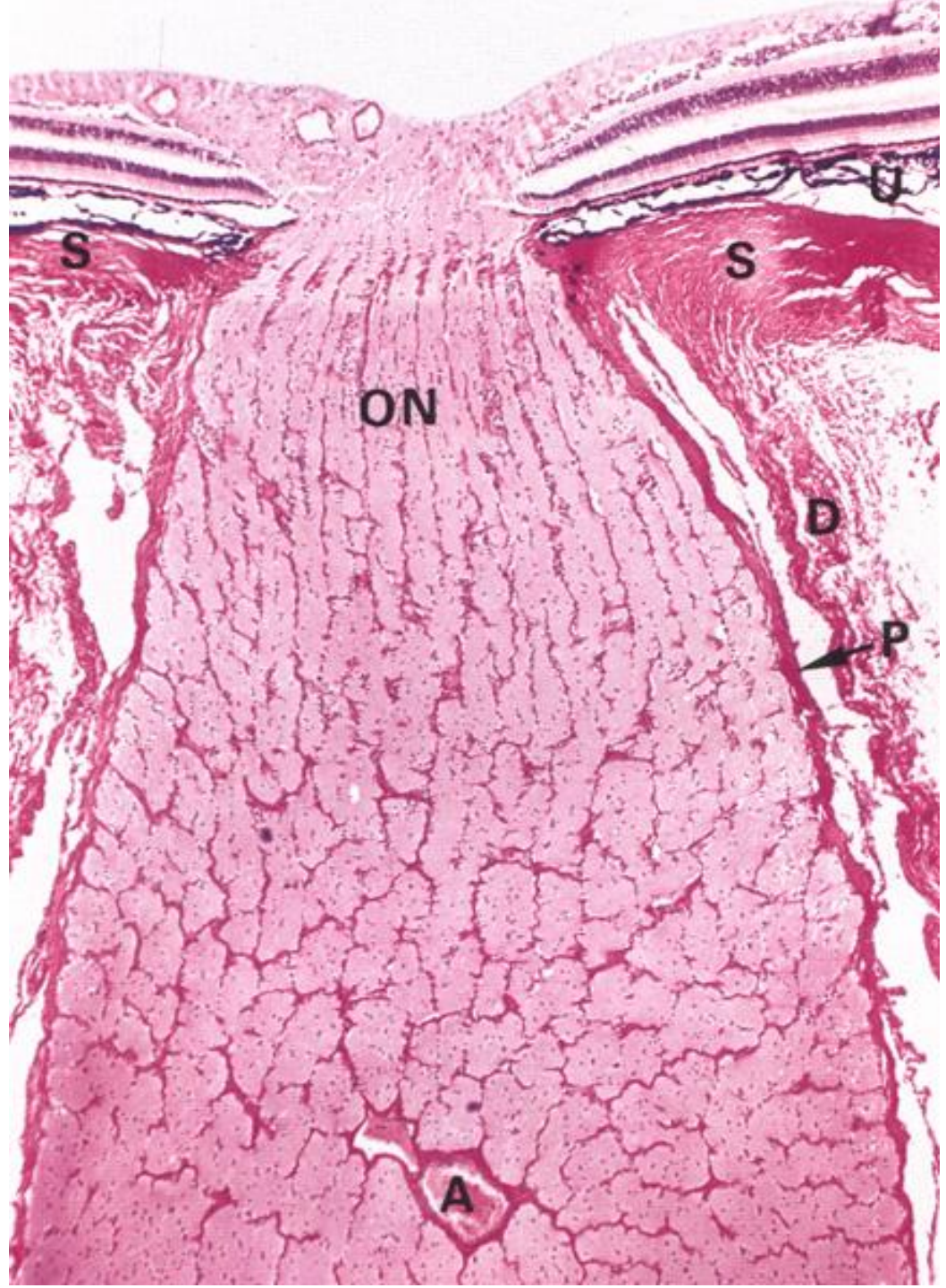
macula
lutea

central retinal vessels

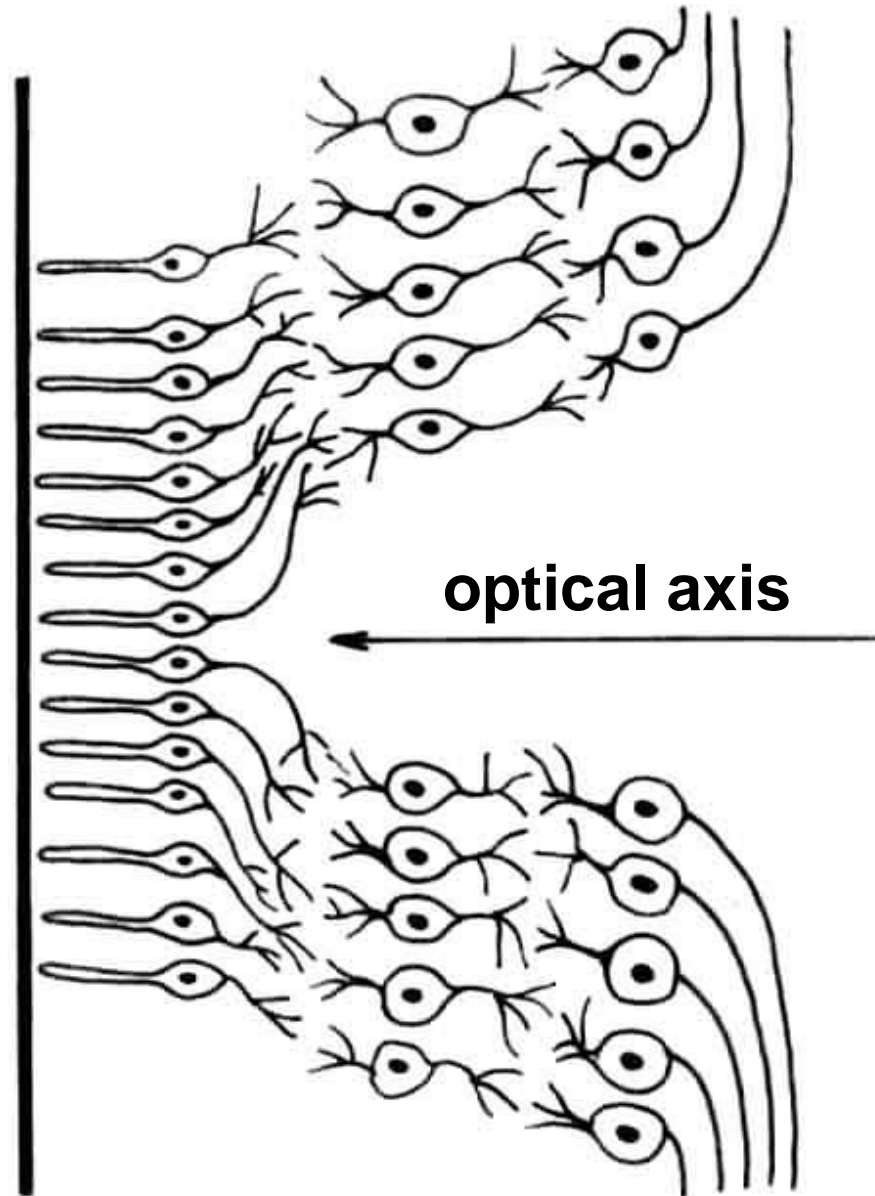
← temporal

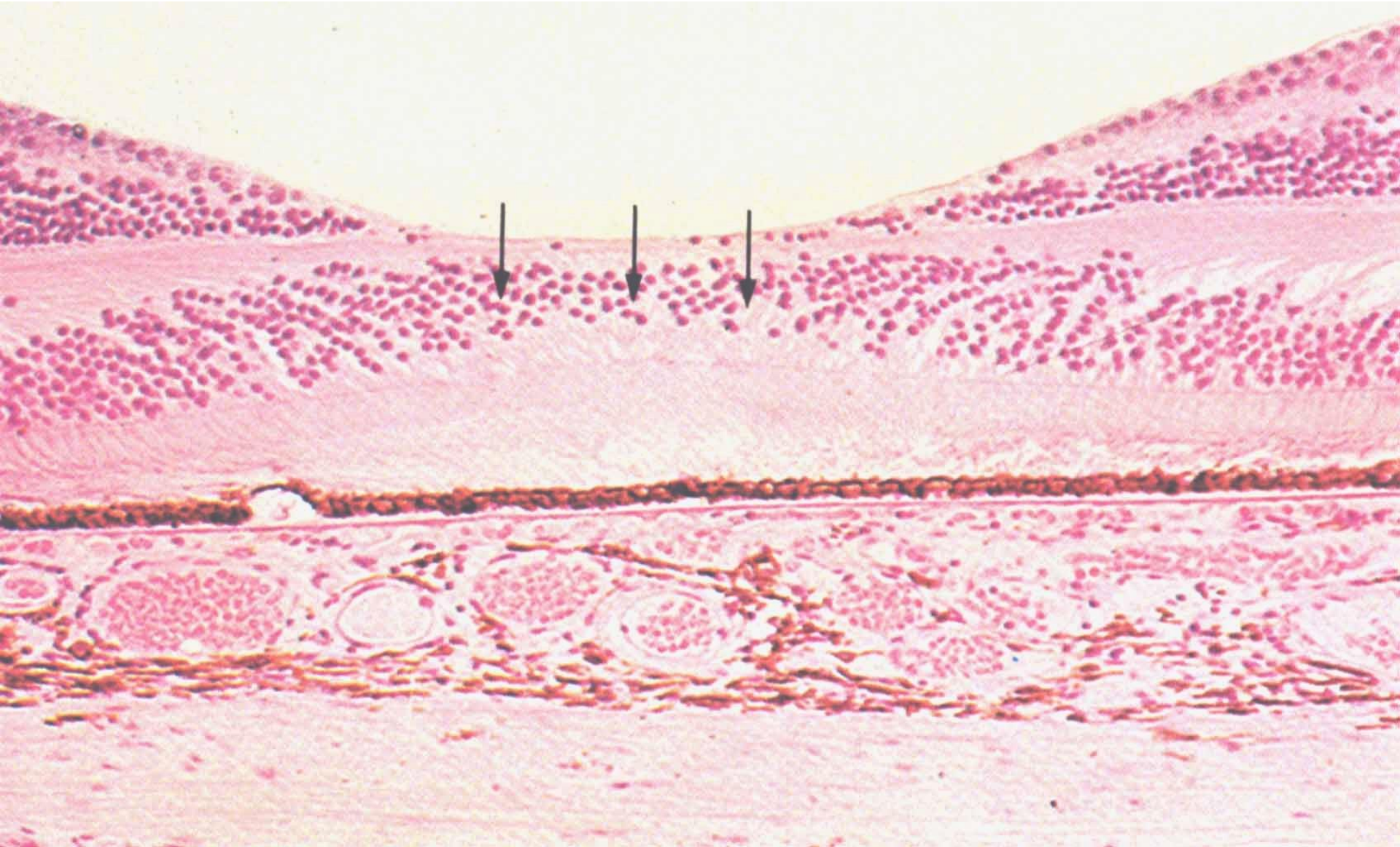
nasal →

Discus n.optici



FOVEA CENTRALIS





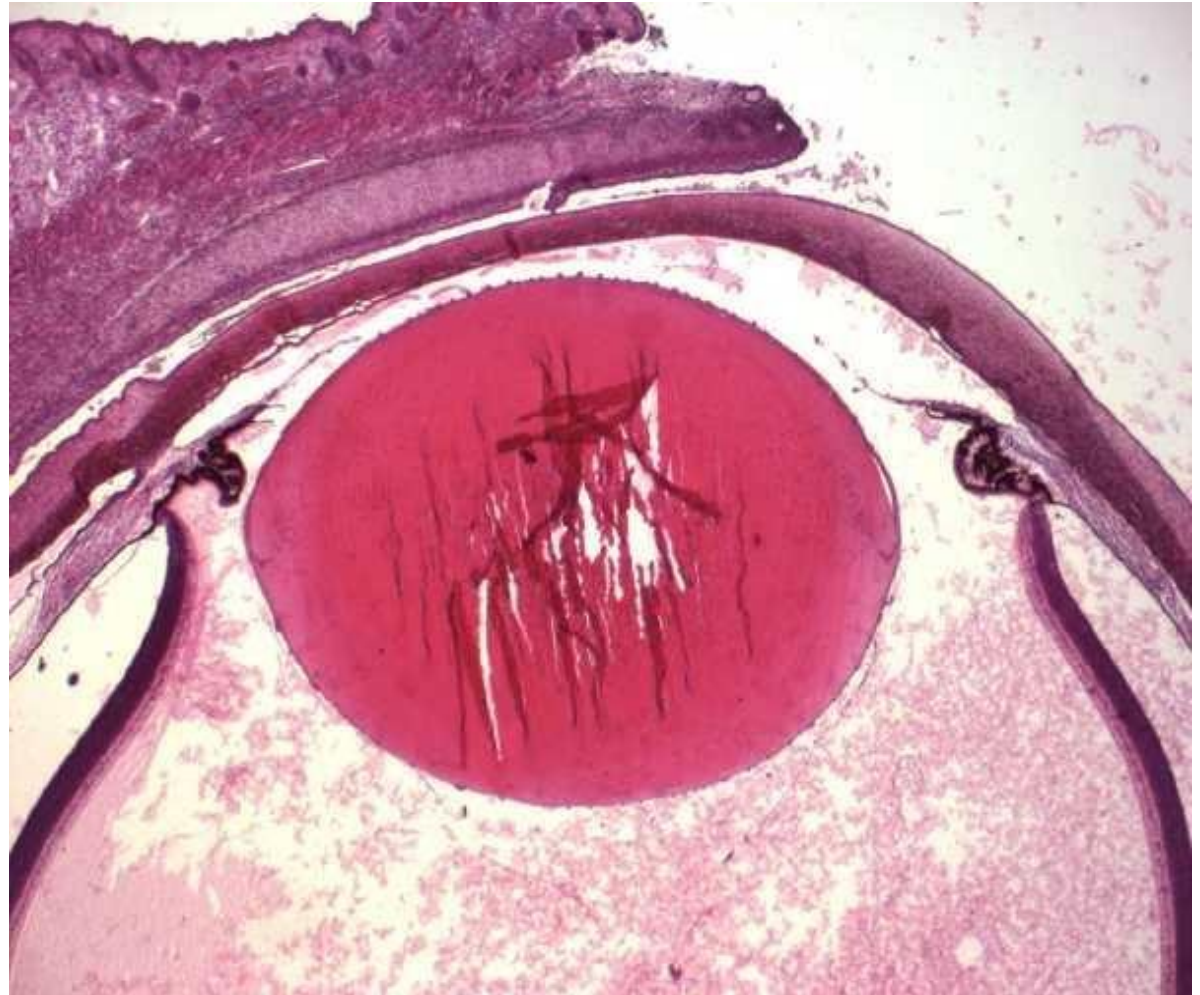
Refractive structures of the eye

cornea

aqueous humor

crystalline lens

vitreous body



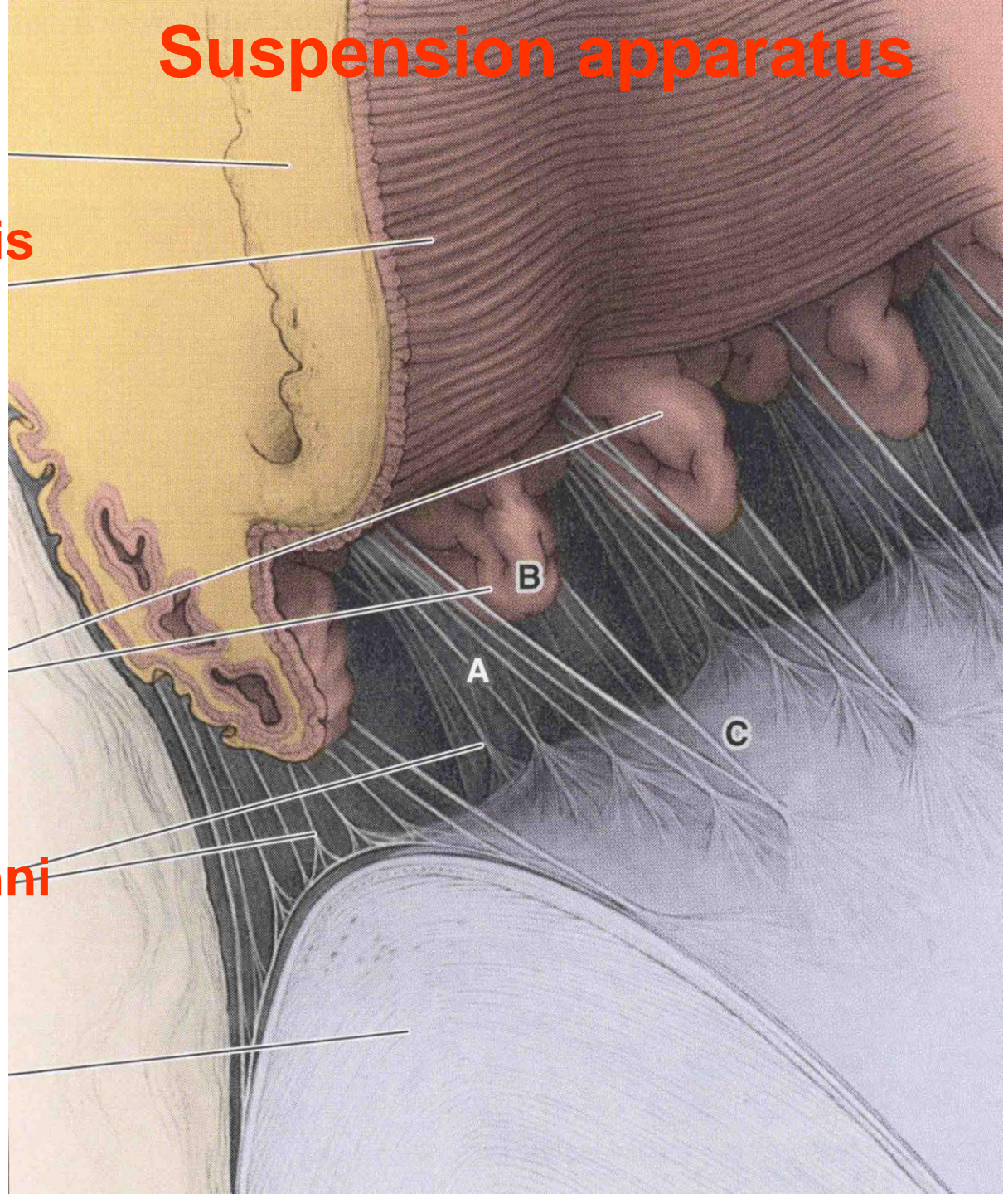
Suspension apparatus

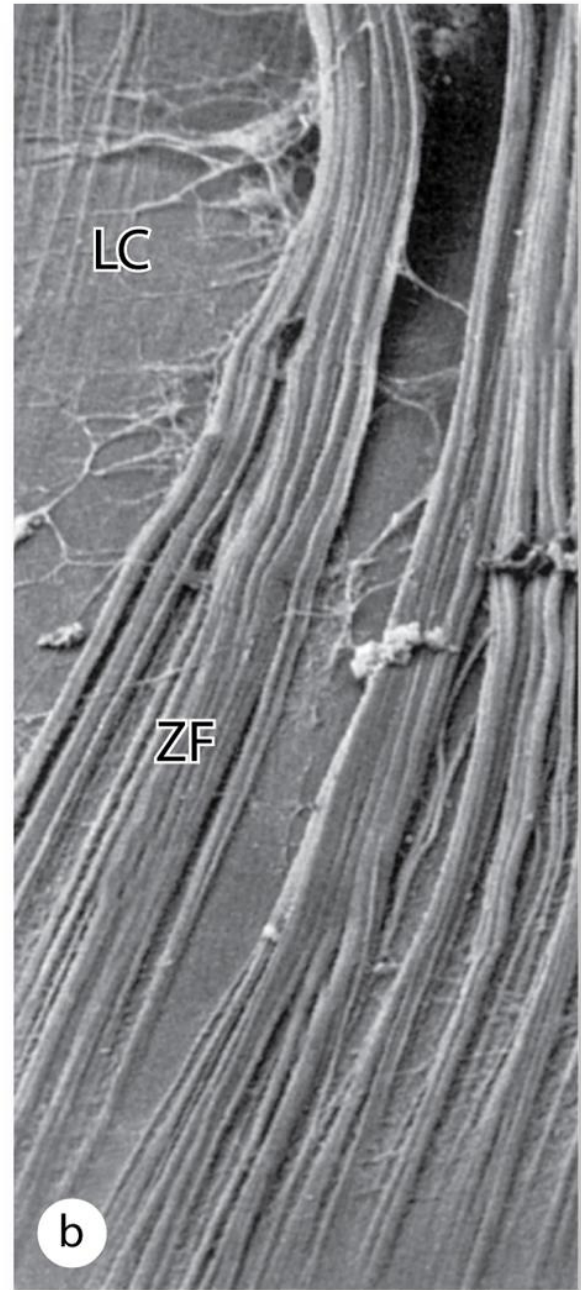
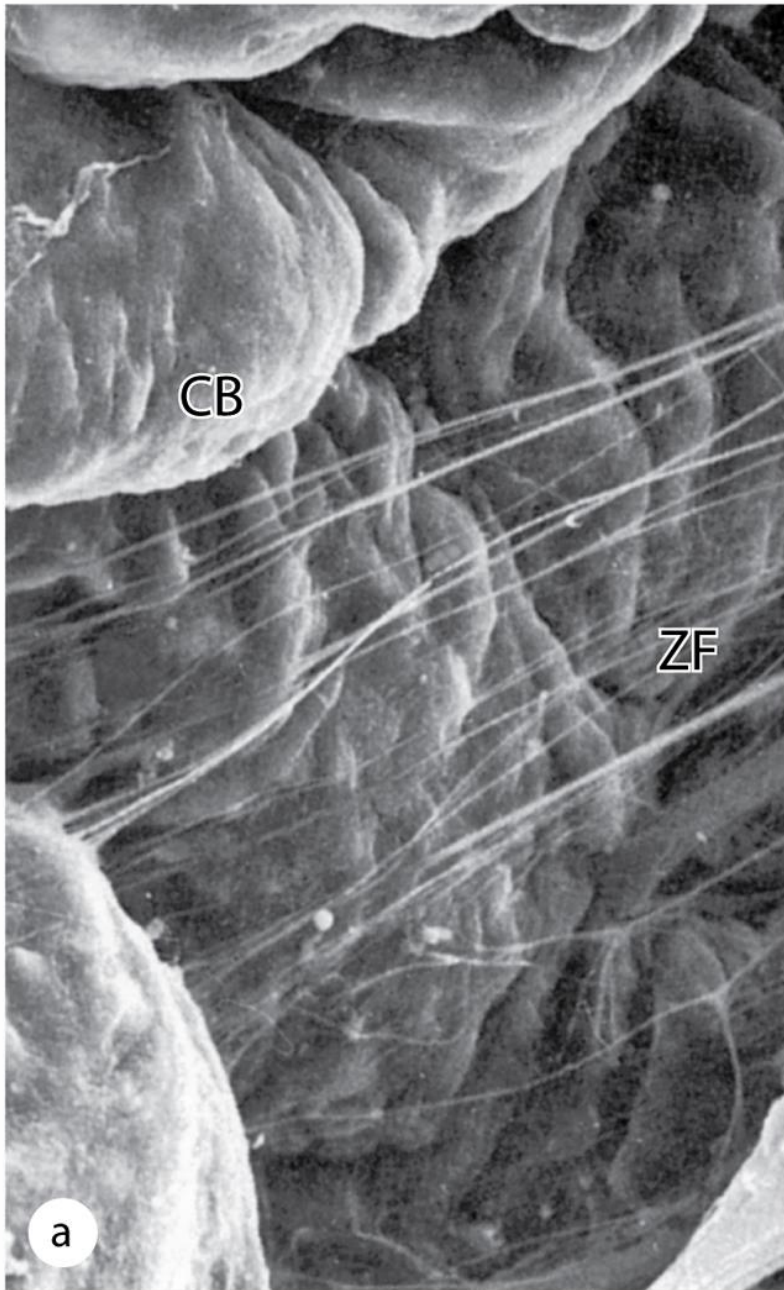
orbiculus ciliaris

corona ciliaris

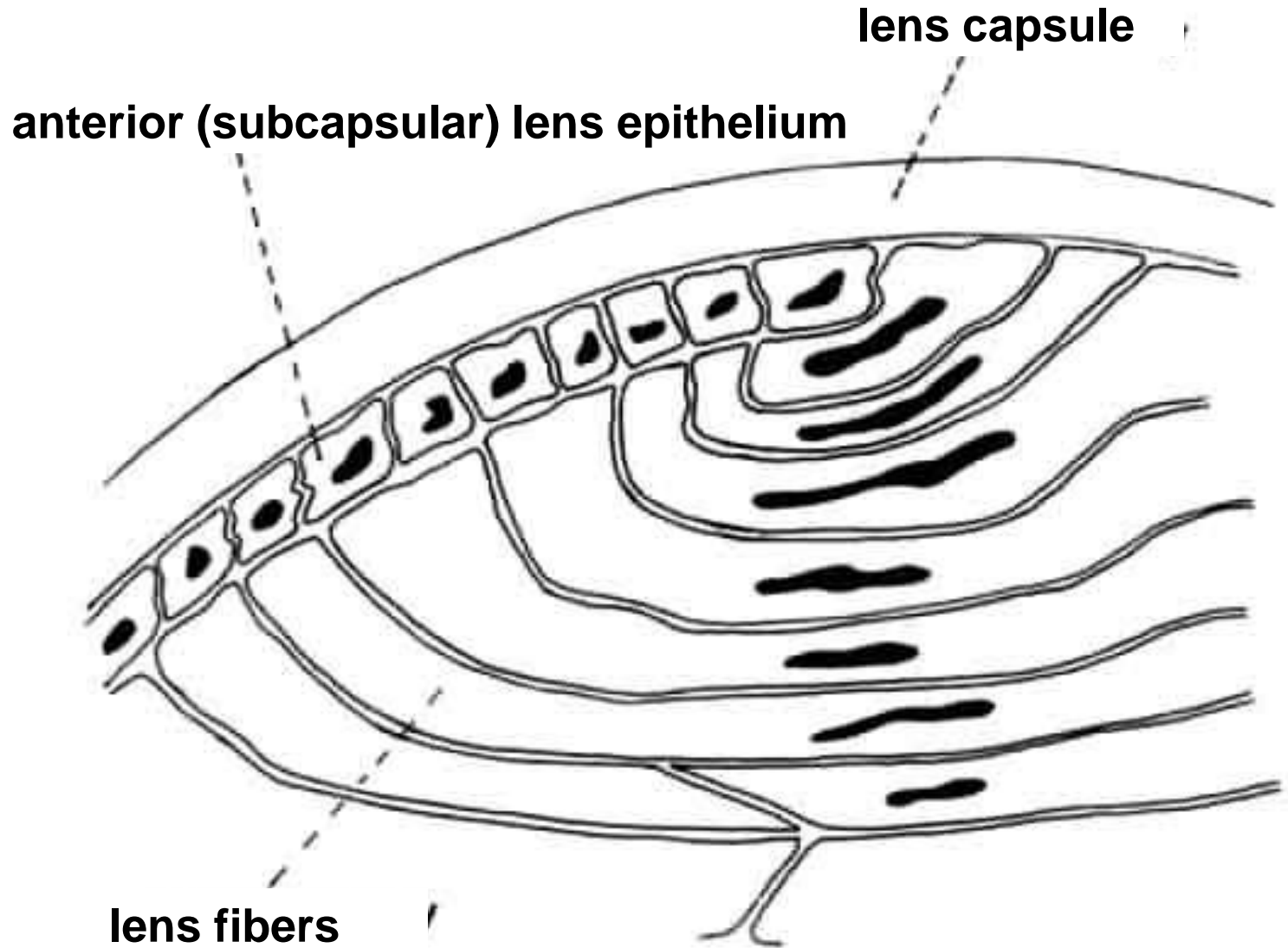
zonula ciliaris Zinni

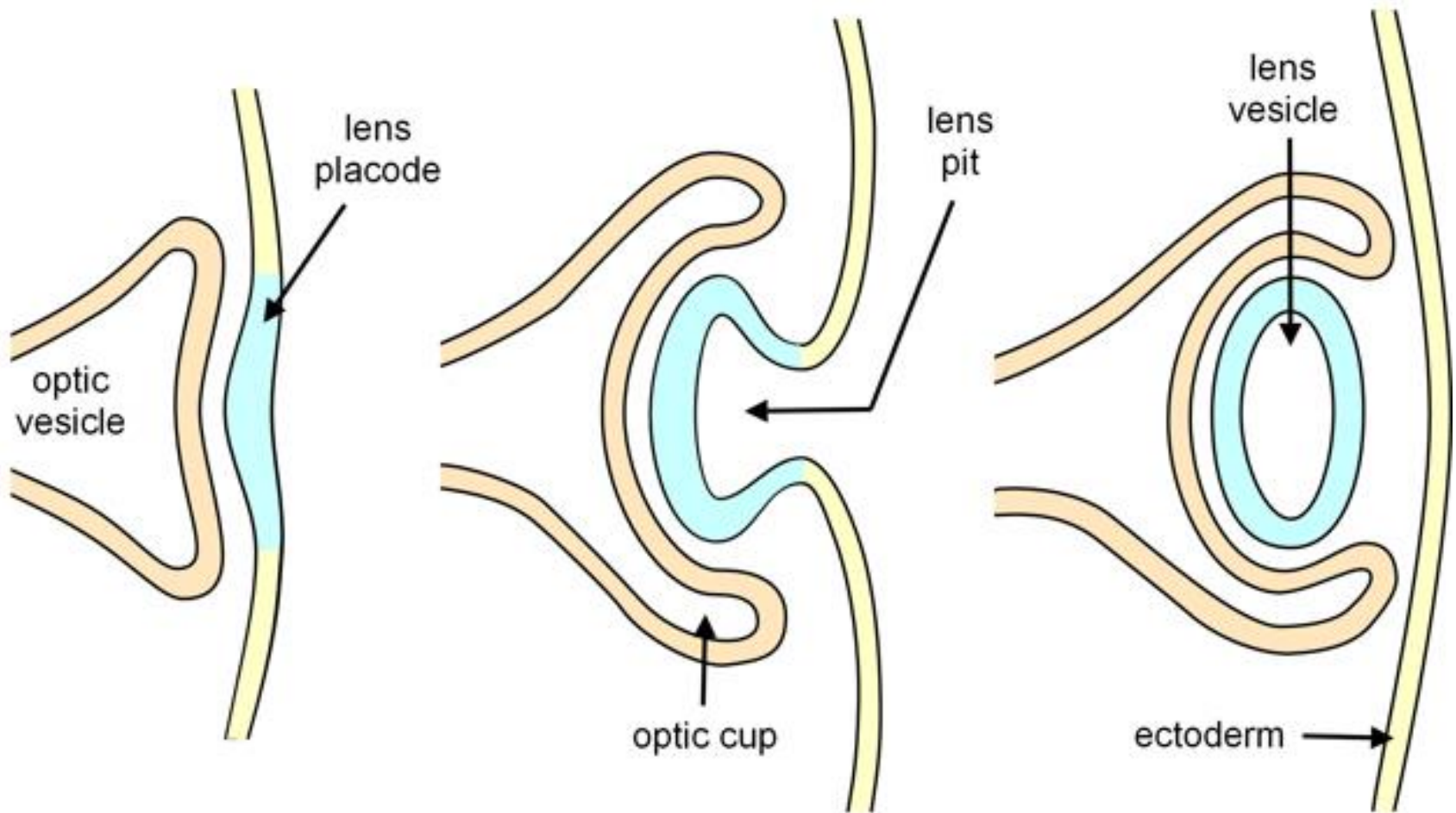
lens





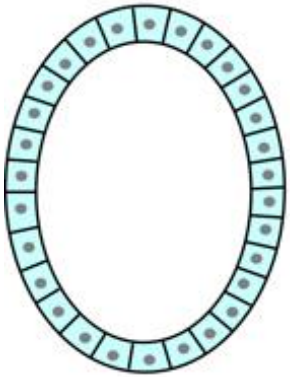
ANTERIOR PART OF THE LENS



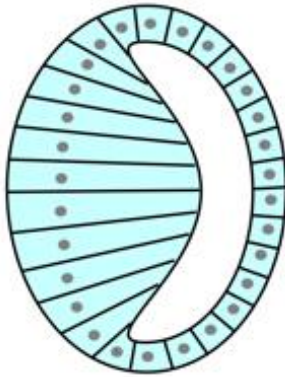


Lens development

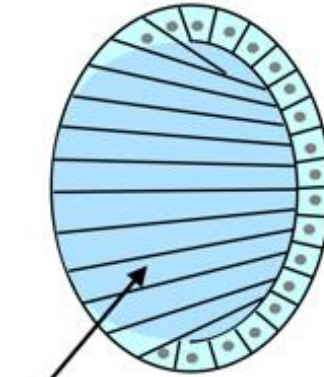
lens vesicle



foetal lens

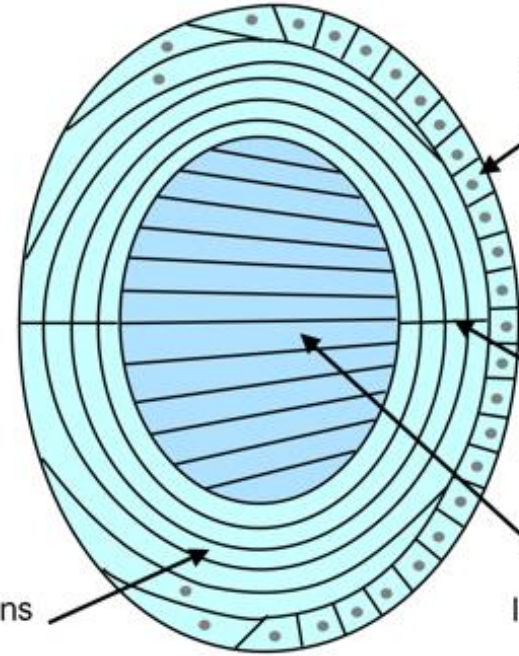


primary lens fibres



secondary lens fibres

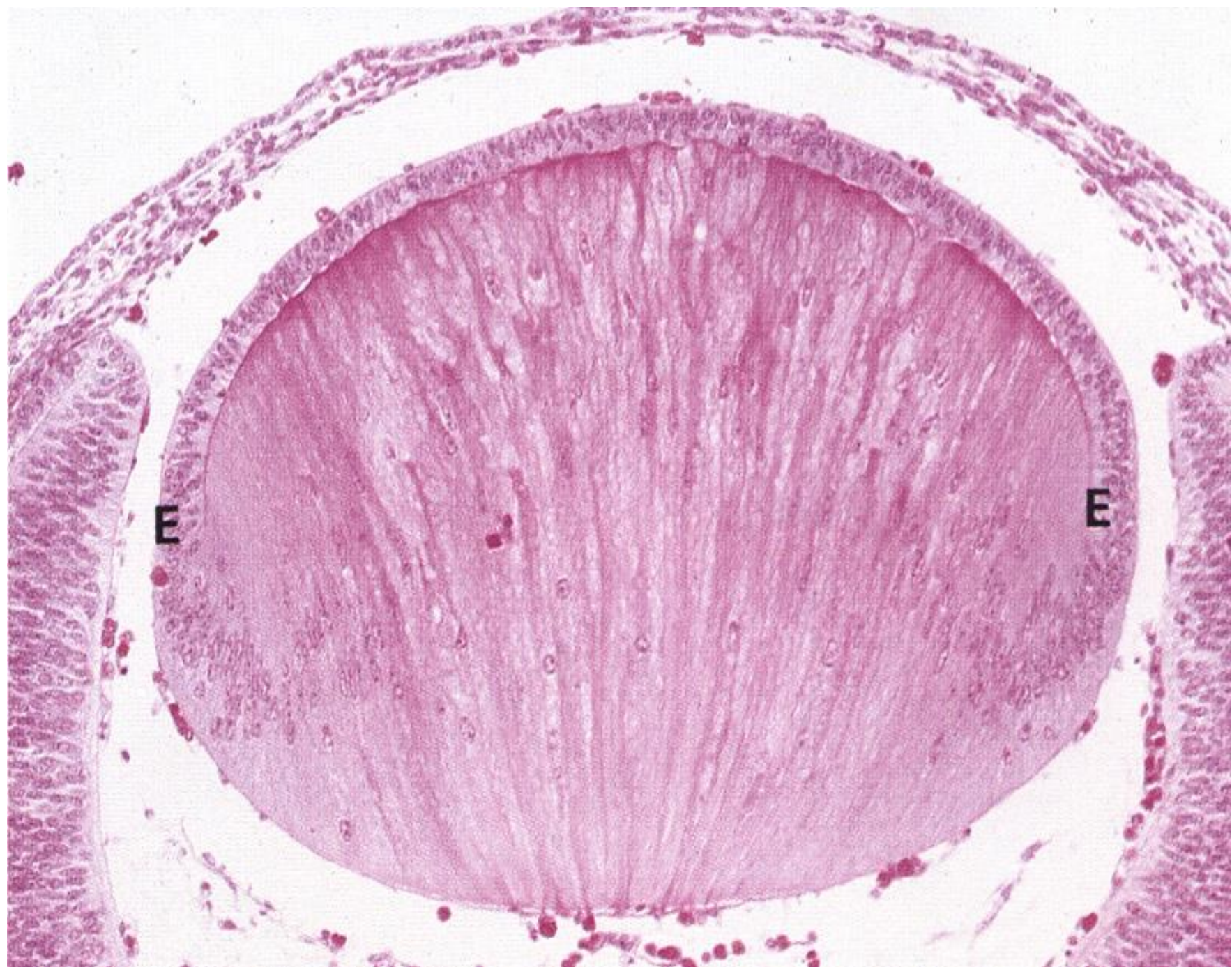
mature lens



epithelium

lens suture

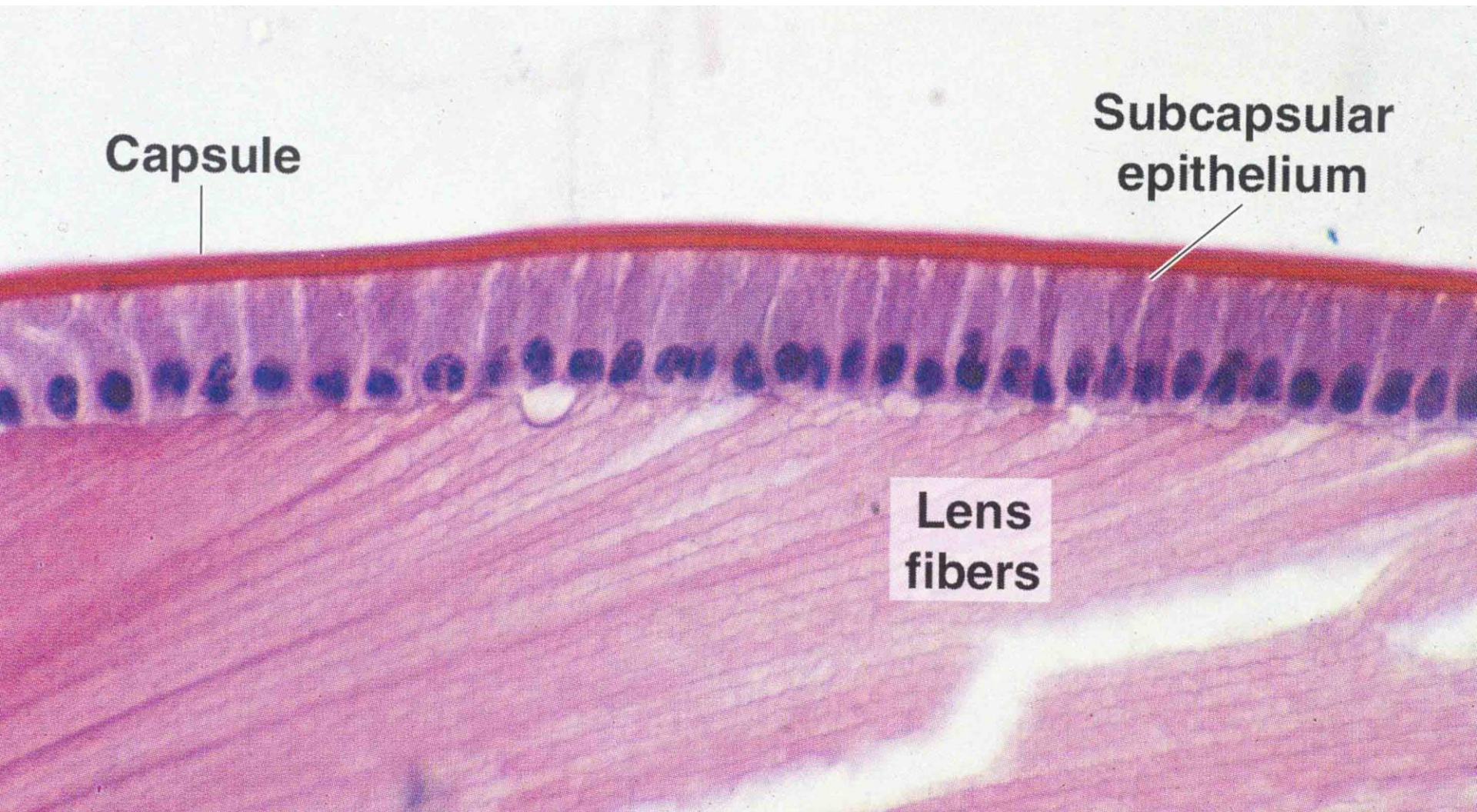
lens nucleus

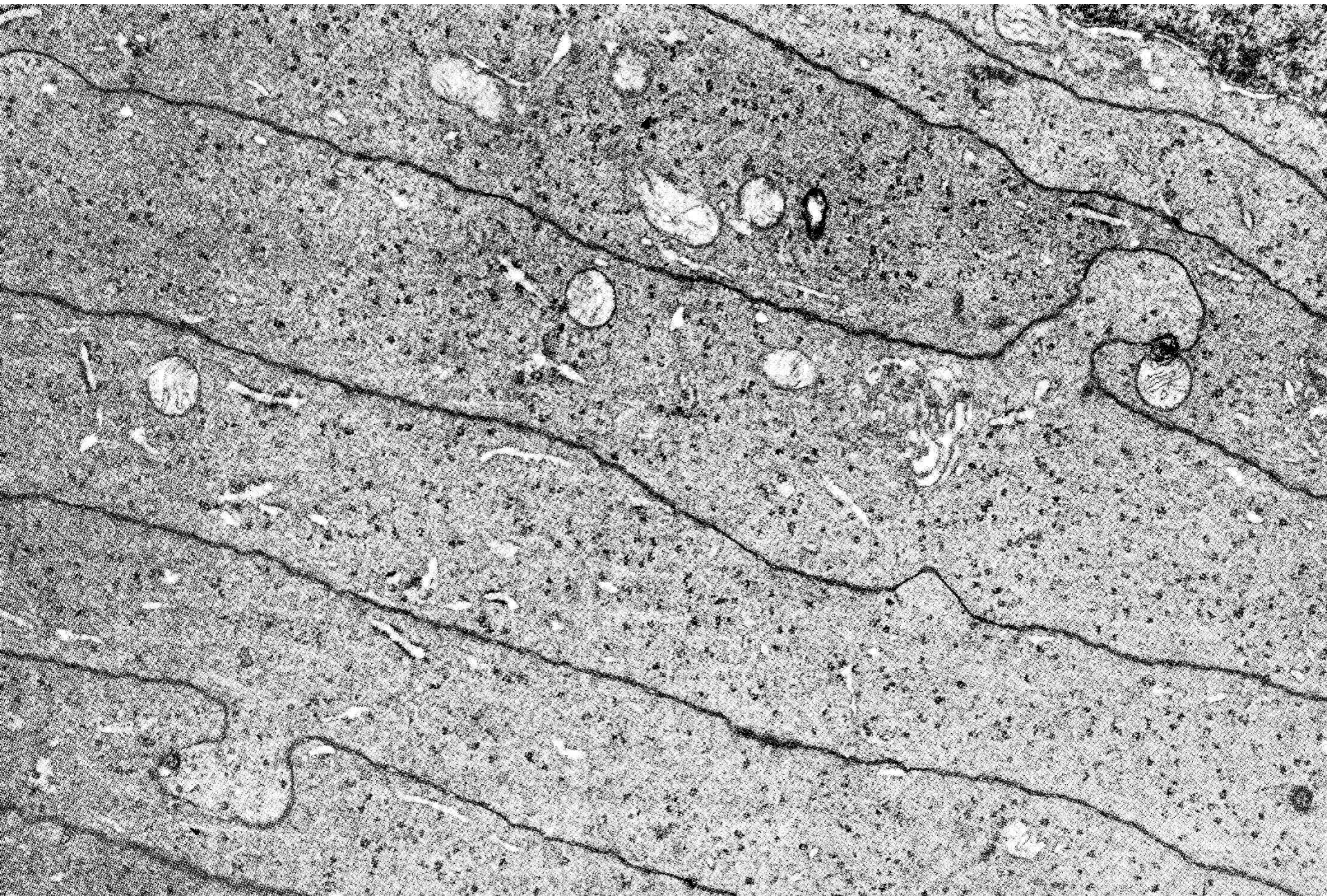


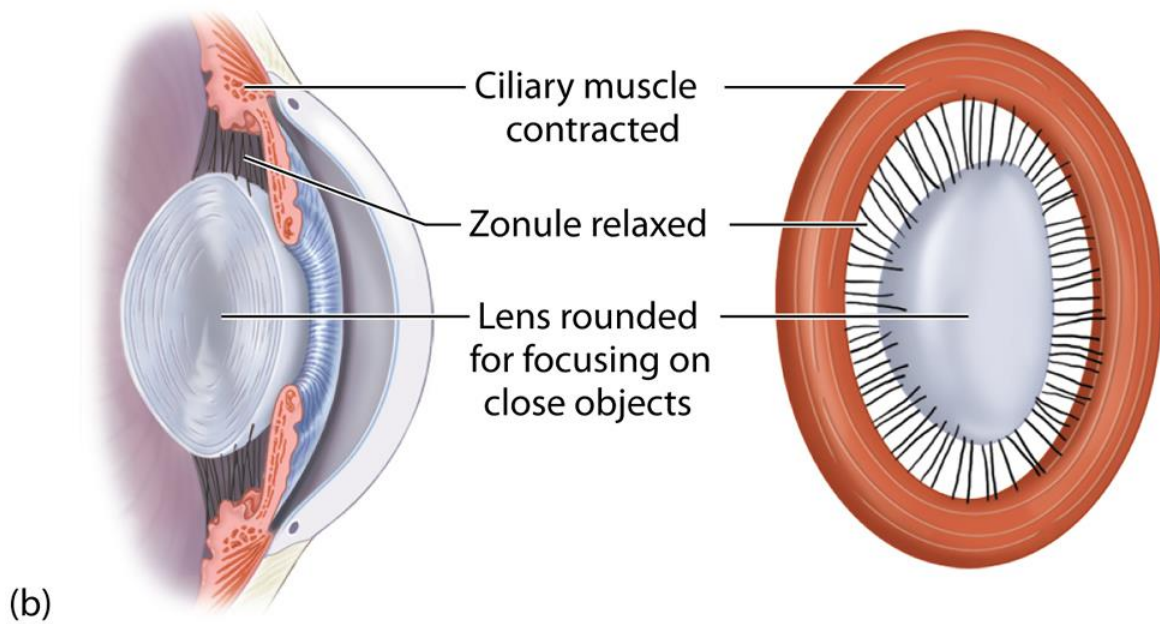
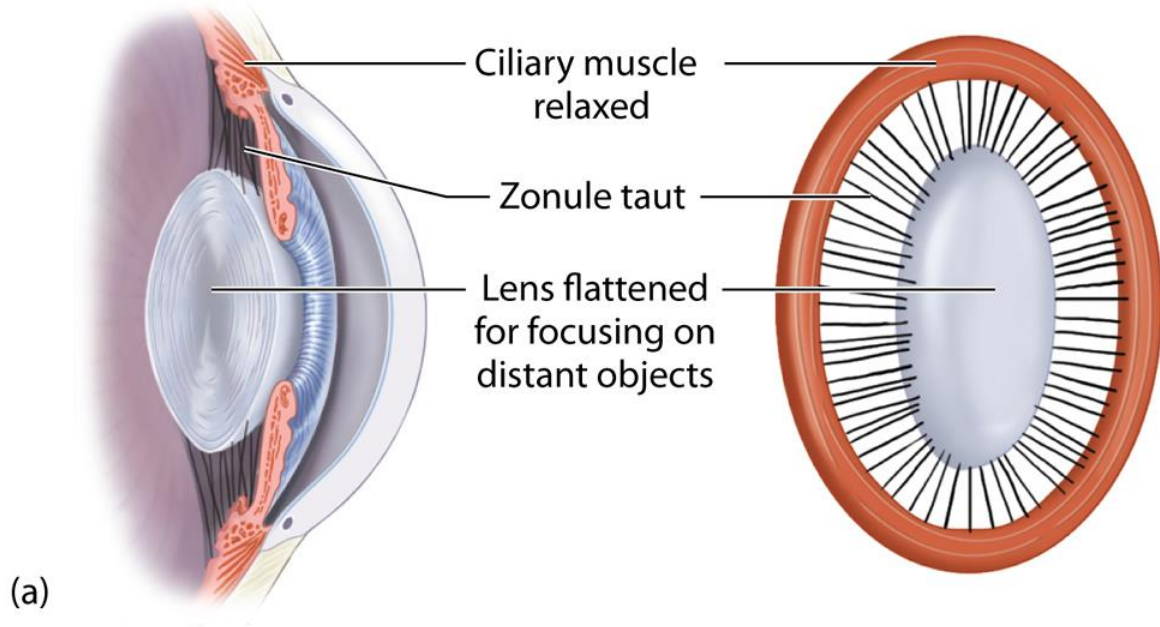
Capsule

**Subcapsular
epithelium**

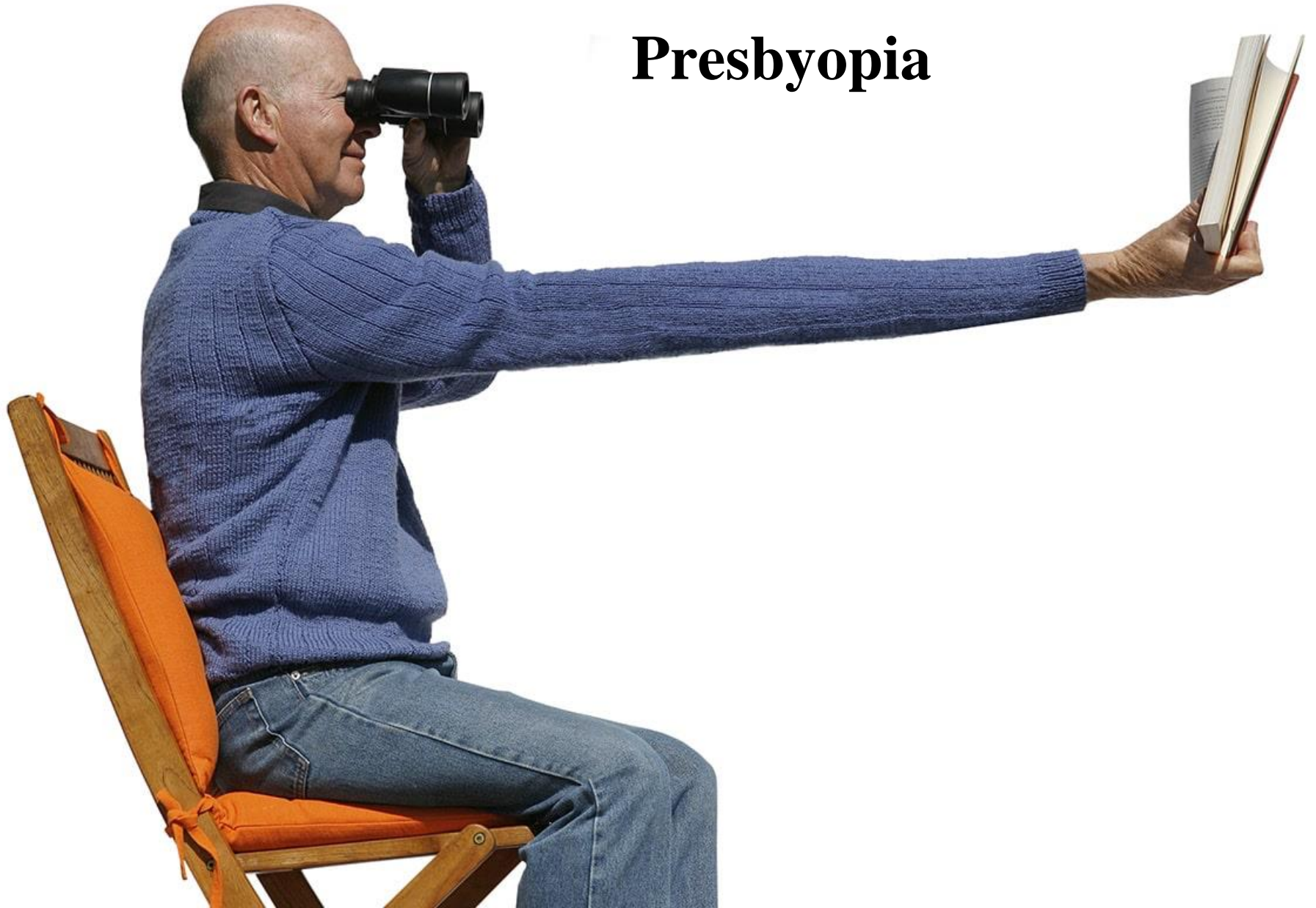
**Lens
fibers**



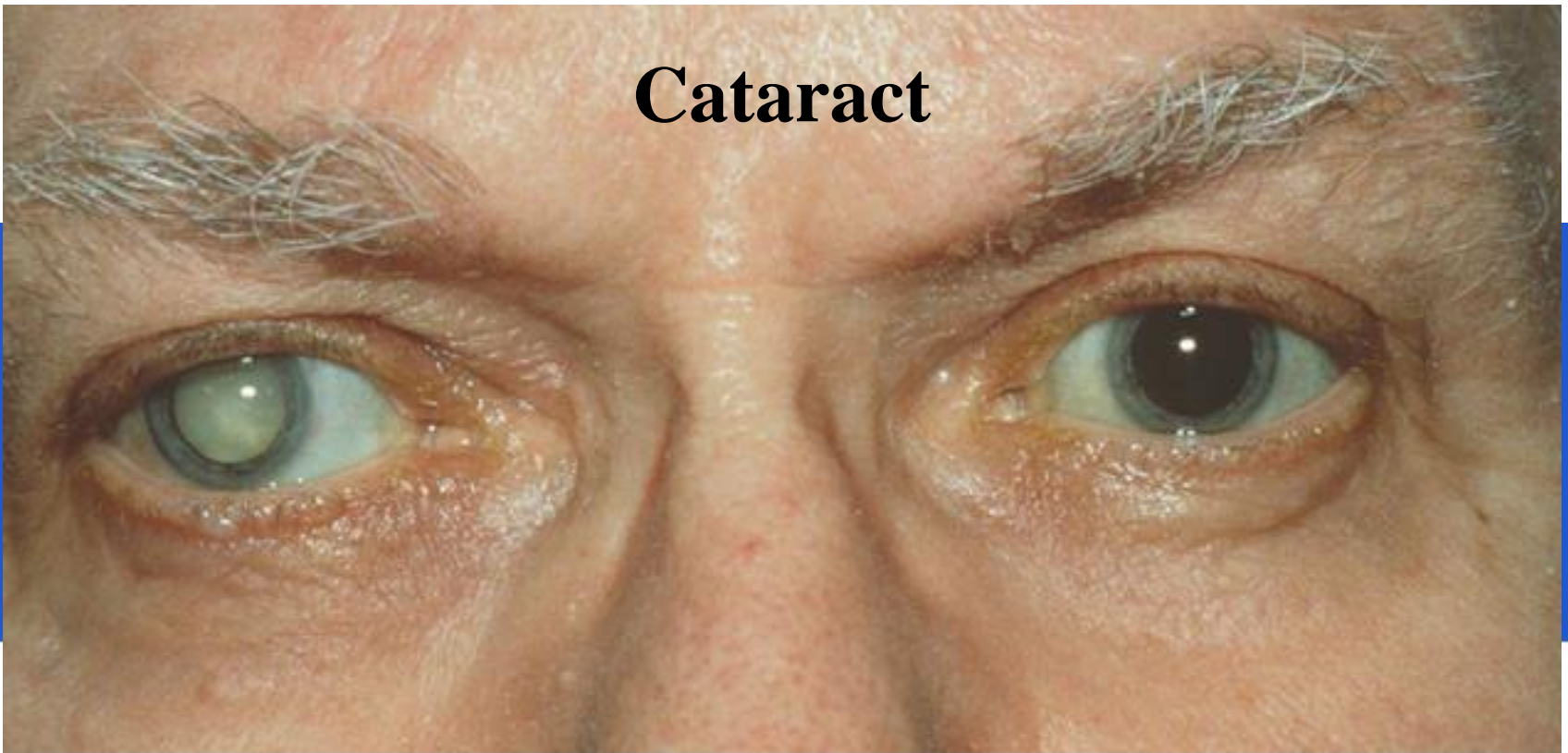




Presbyopia



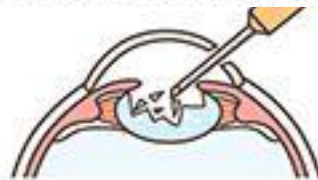
Cataract



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1.
Incision is
made



2.
Emulsification:
breaks up
cloudy lens

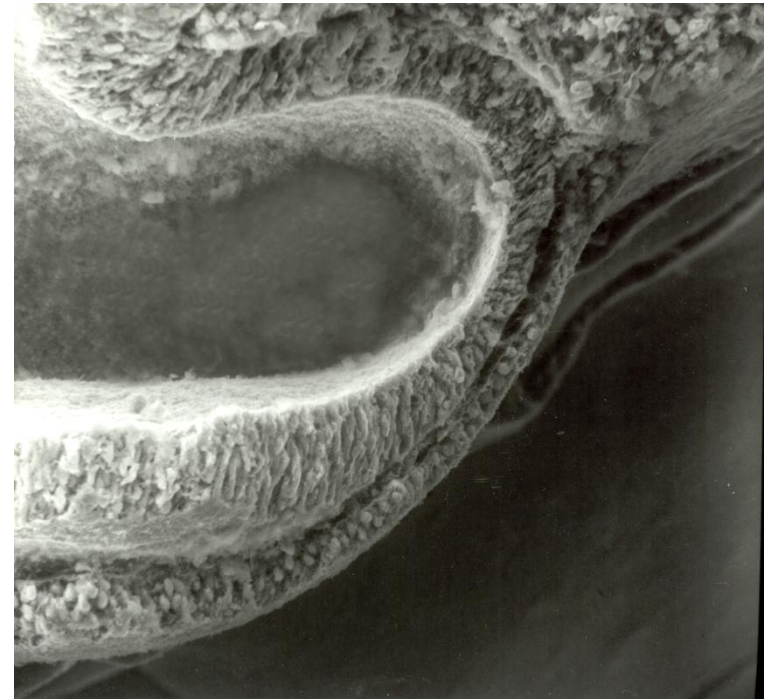
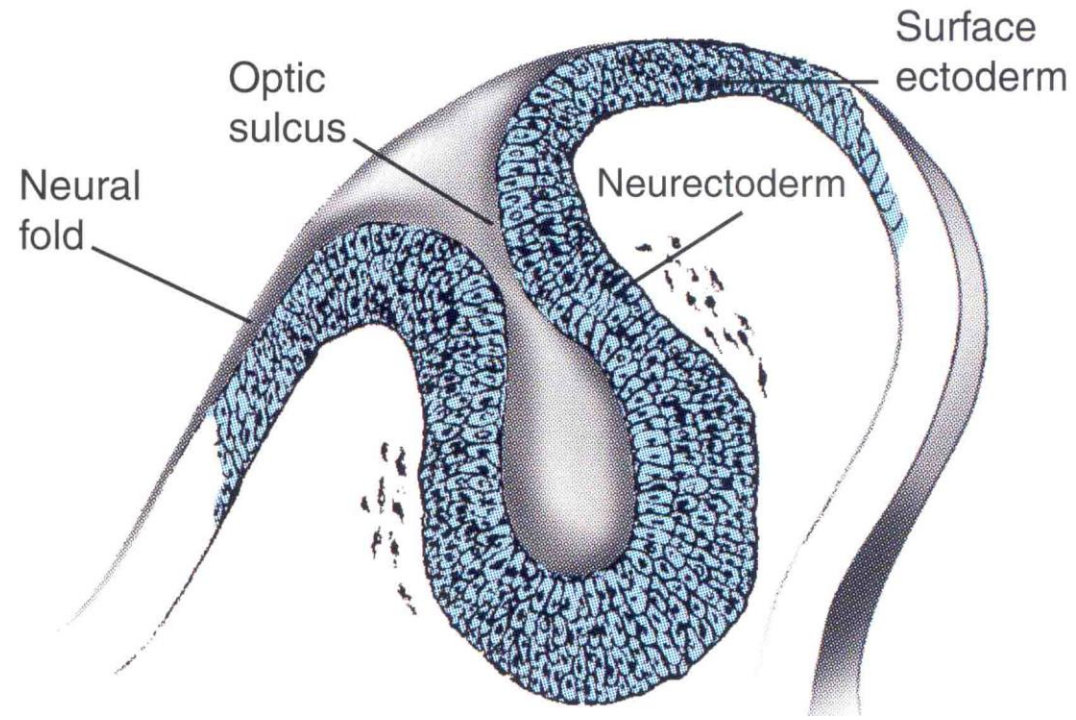
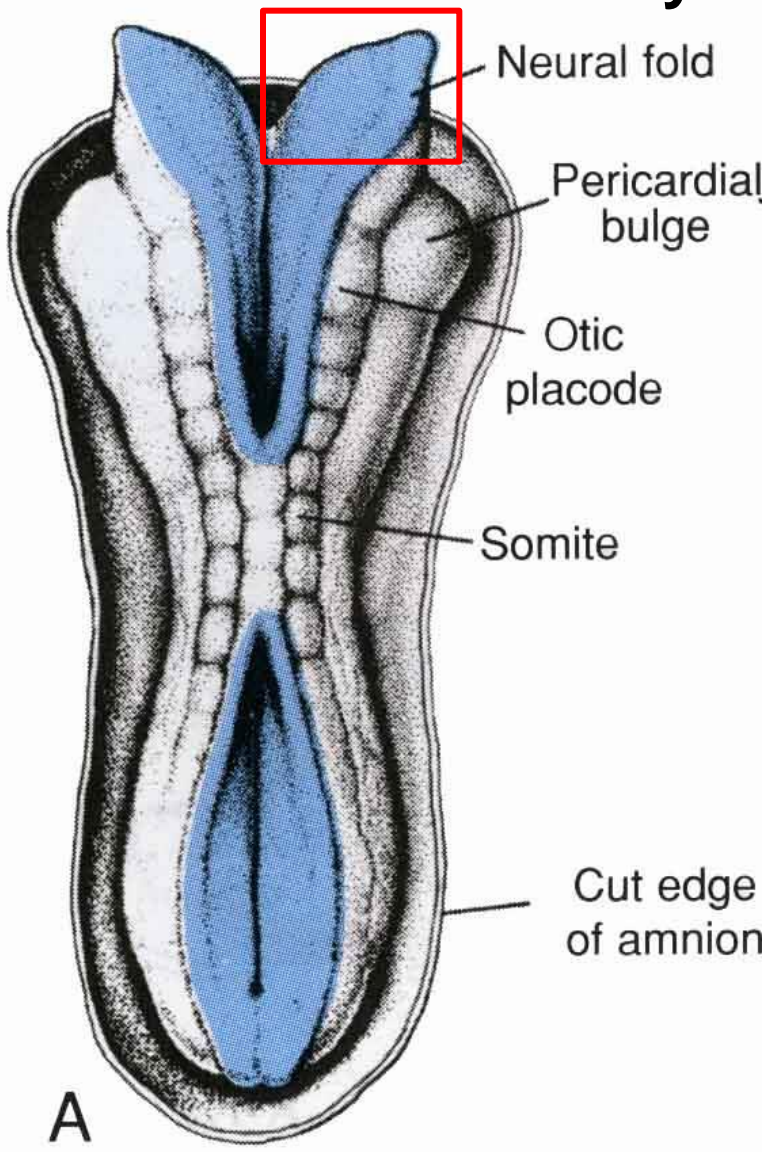


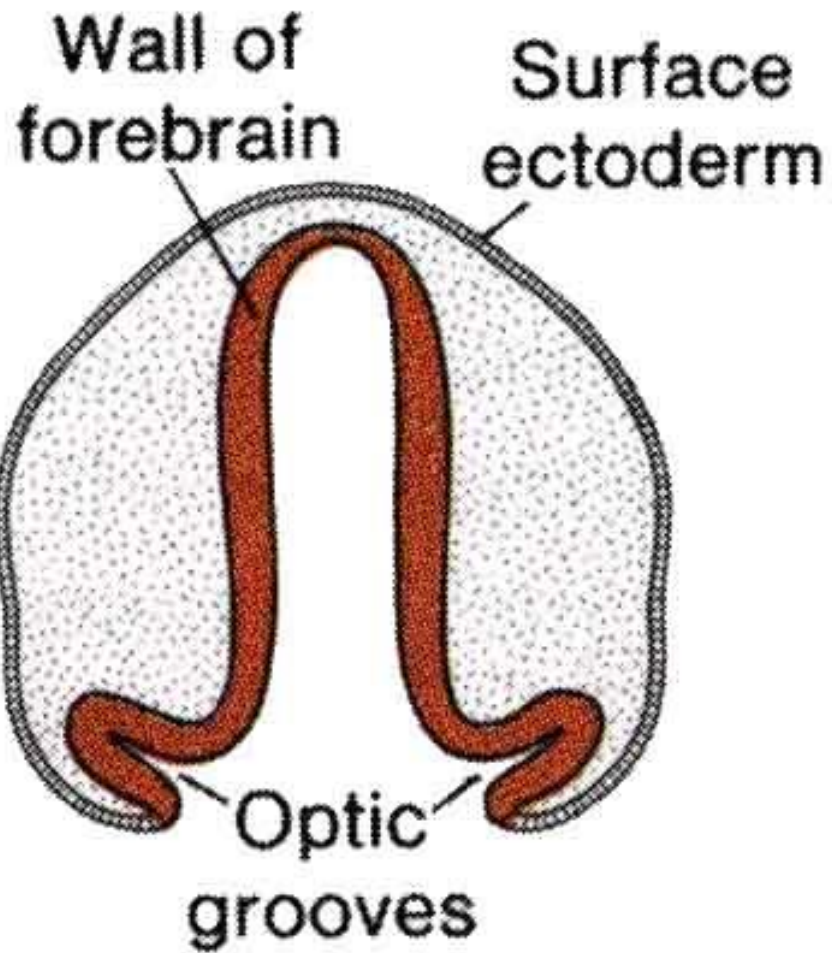
3.
Intraocular lens
is implanted



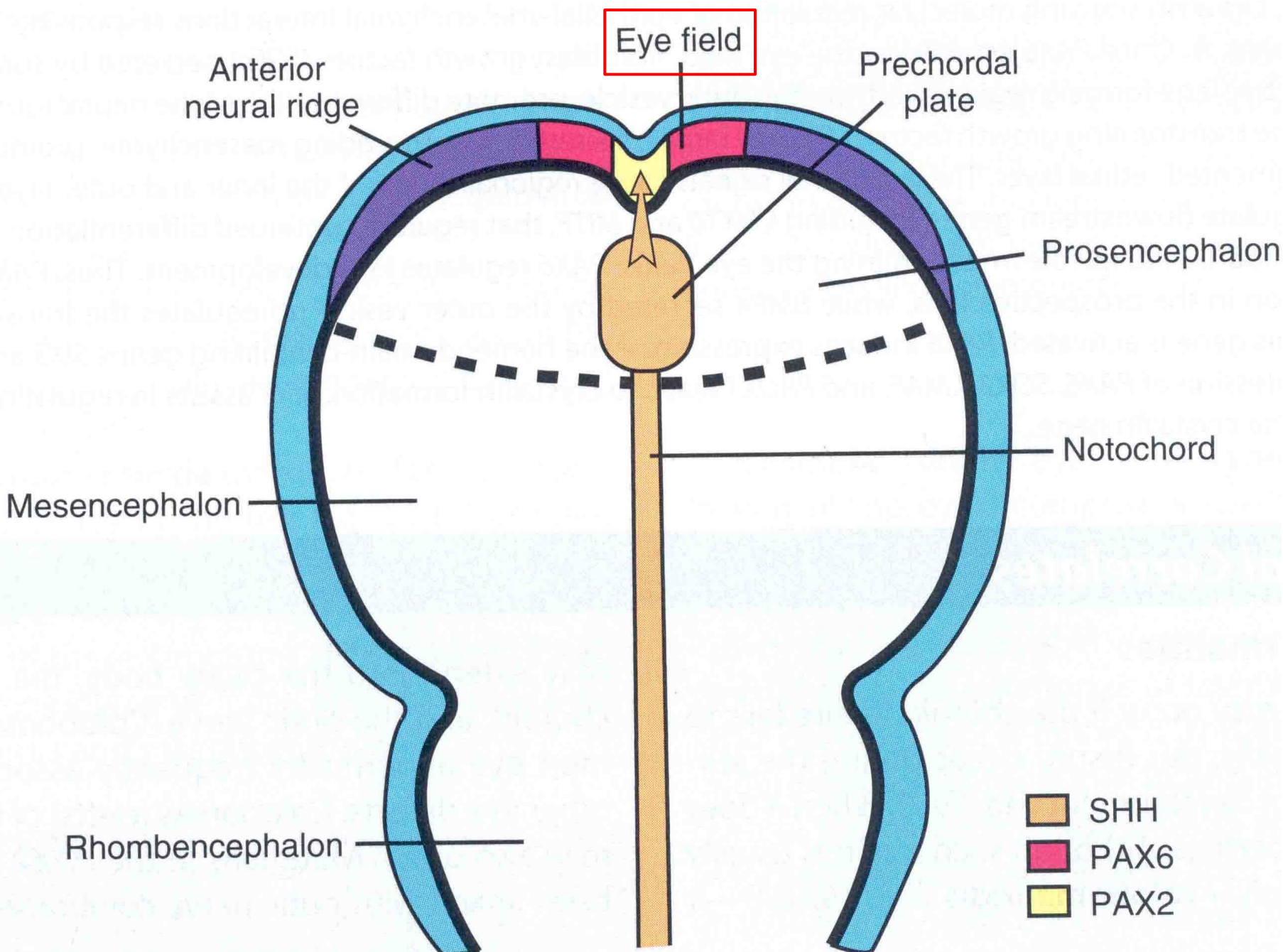
4.
The incision
heals on
its own

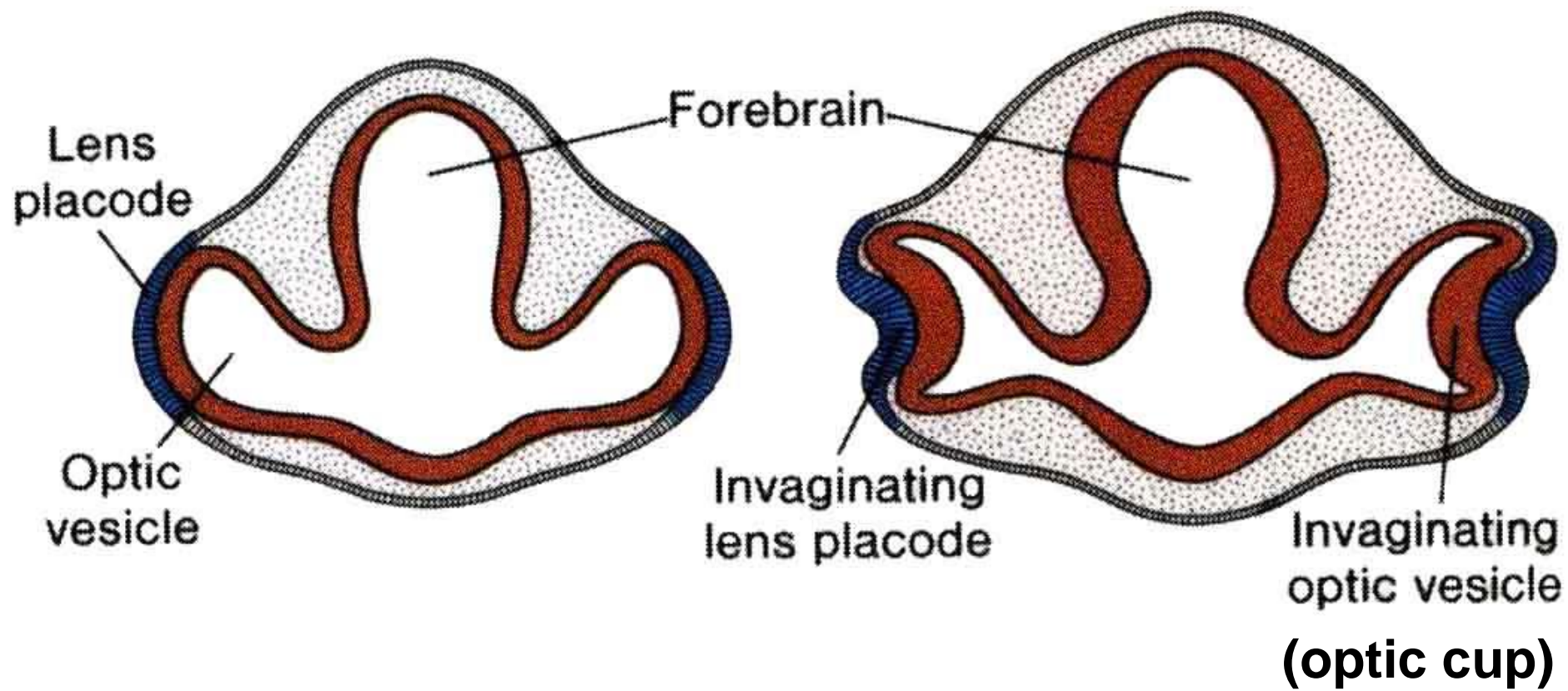
22 days

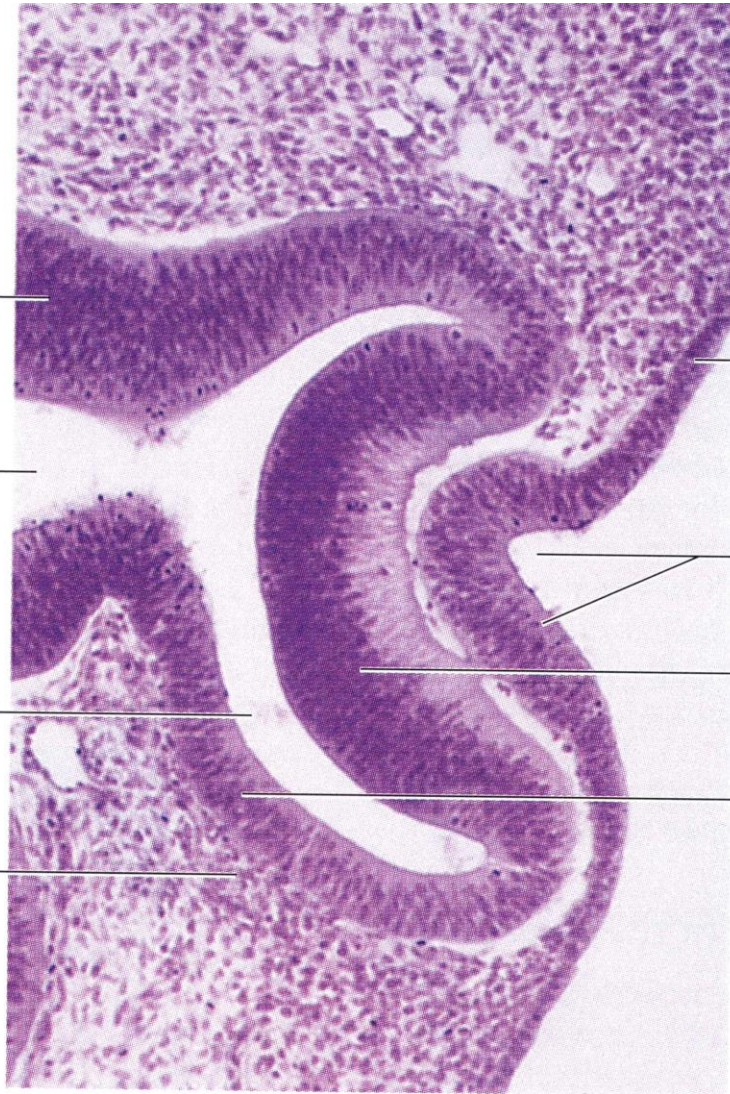












Wall of optic stalk
(continuous with wall
of forebrain)

Cavity of optic
stalk (continuous with
cavity of forebrain)

Intraretinal space

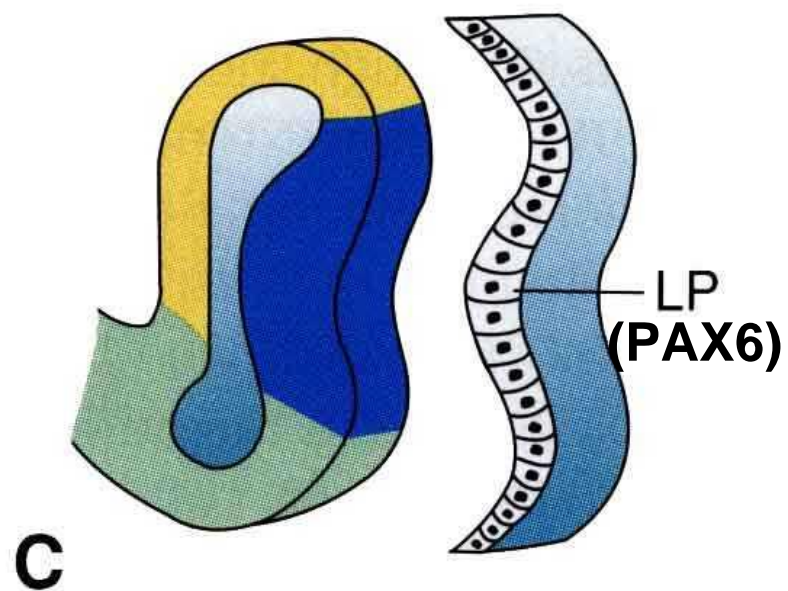
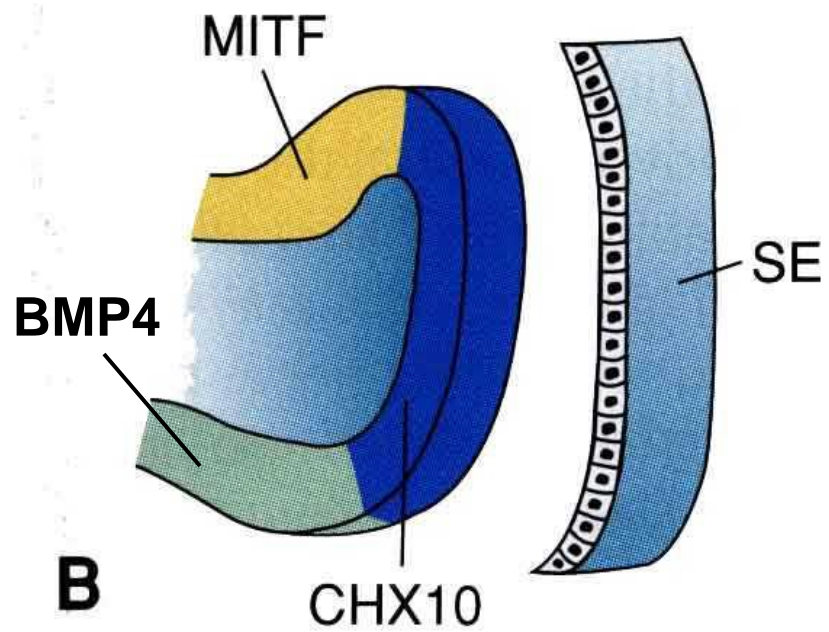
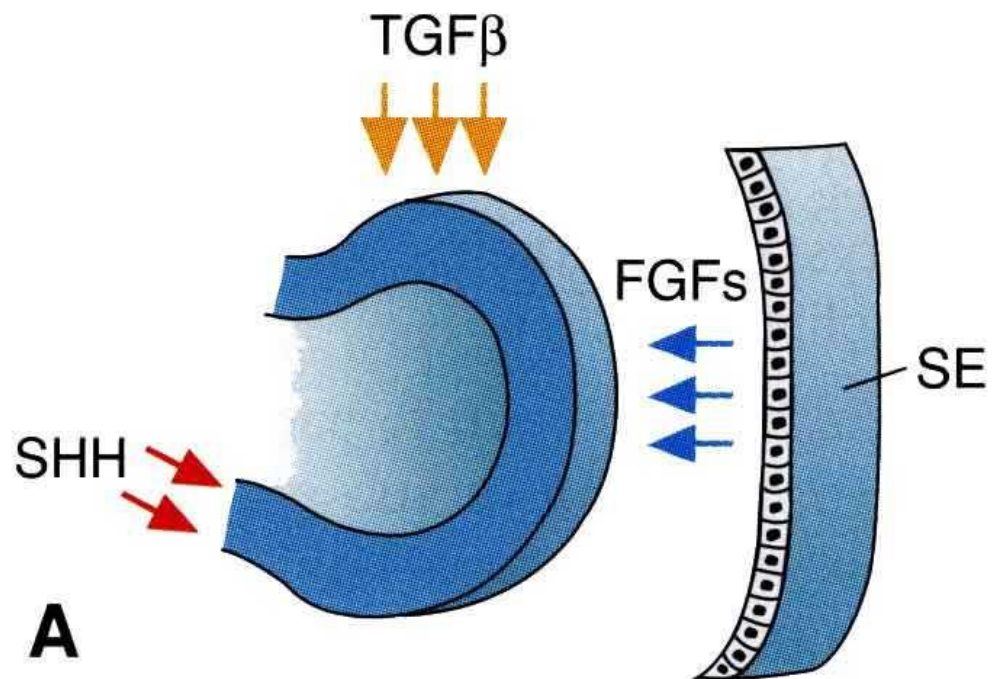
Mesenchyme (primordium
of choroid and sclera)

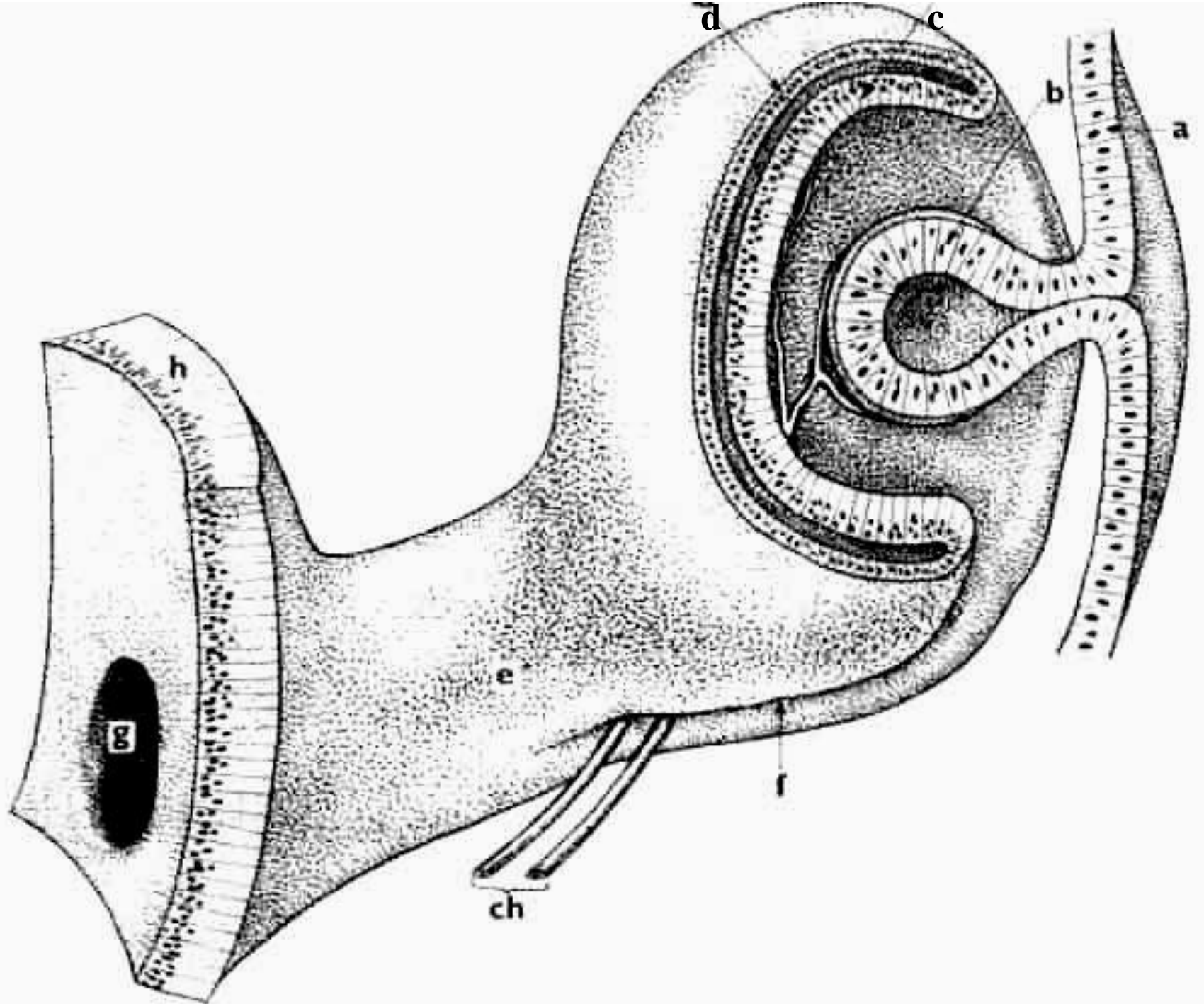
Surface ectoderm

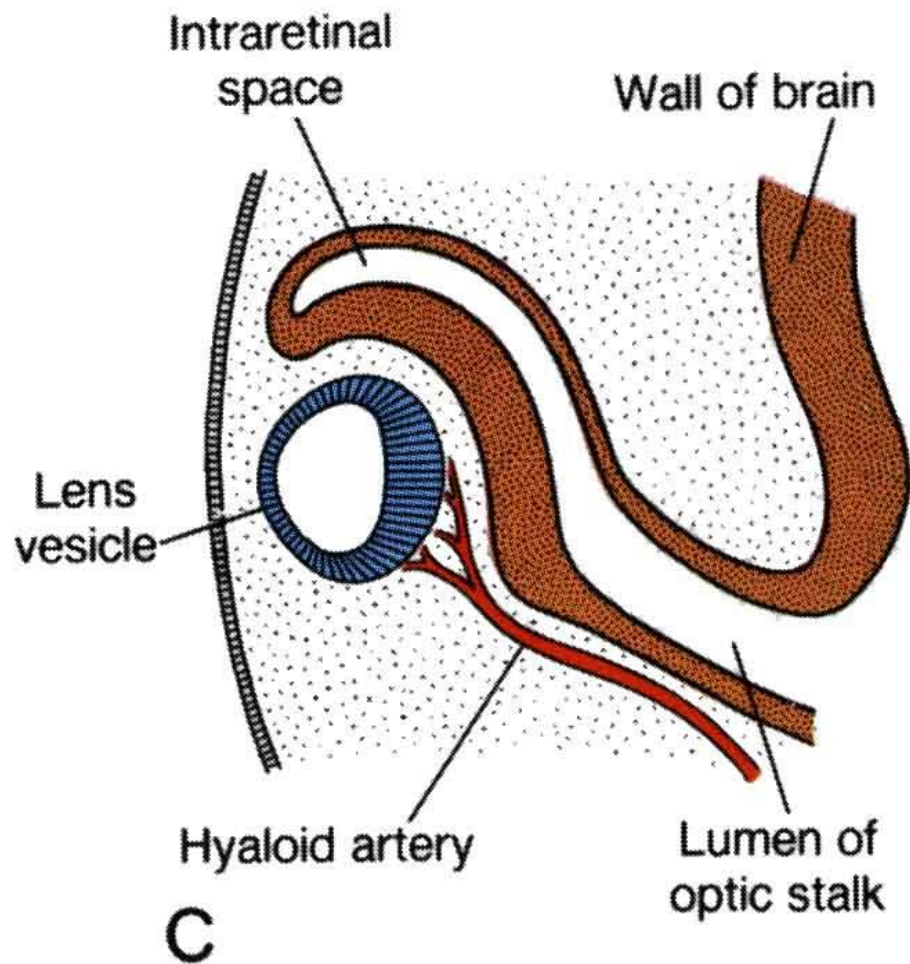
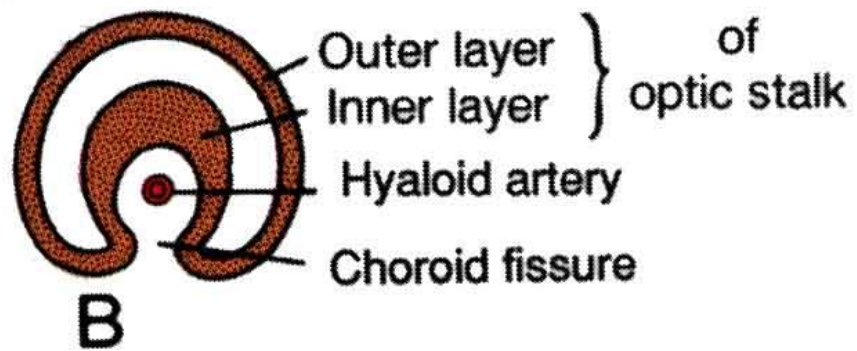
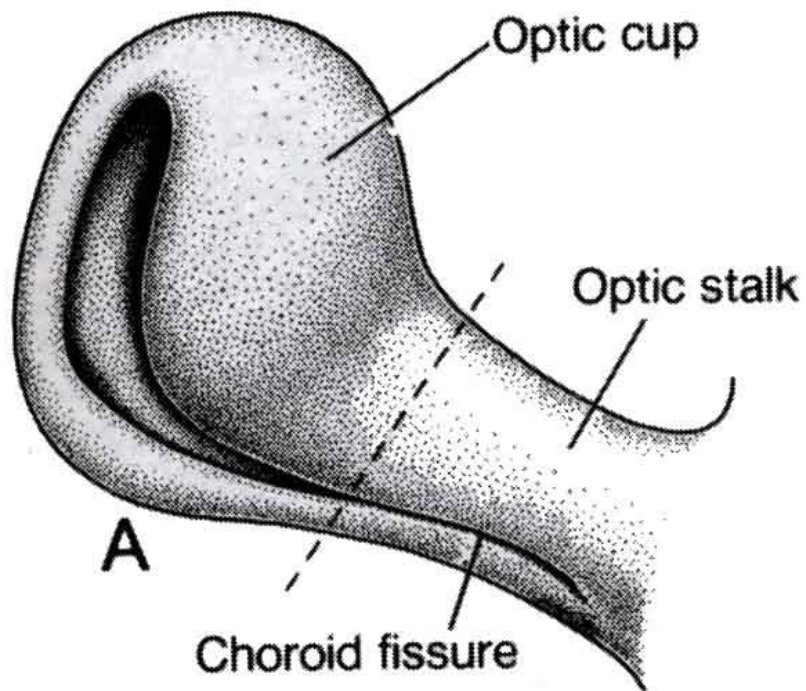
Lens pit
(invaginated lens placode)

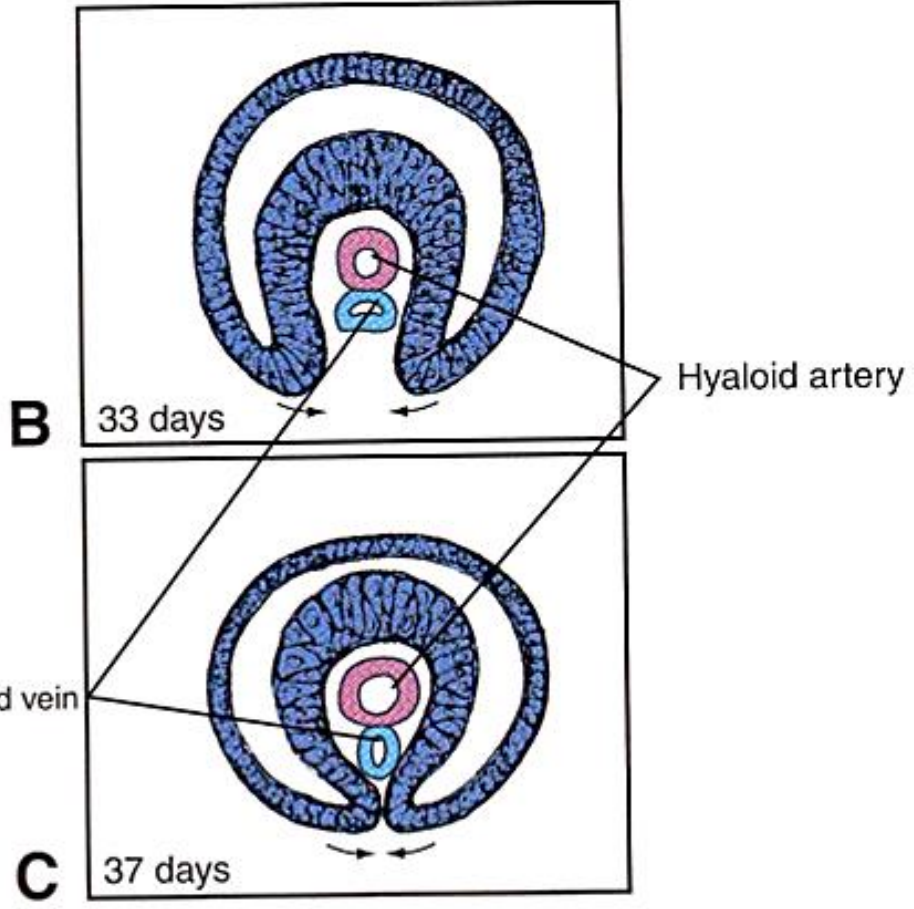
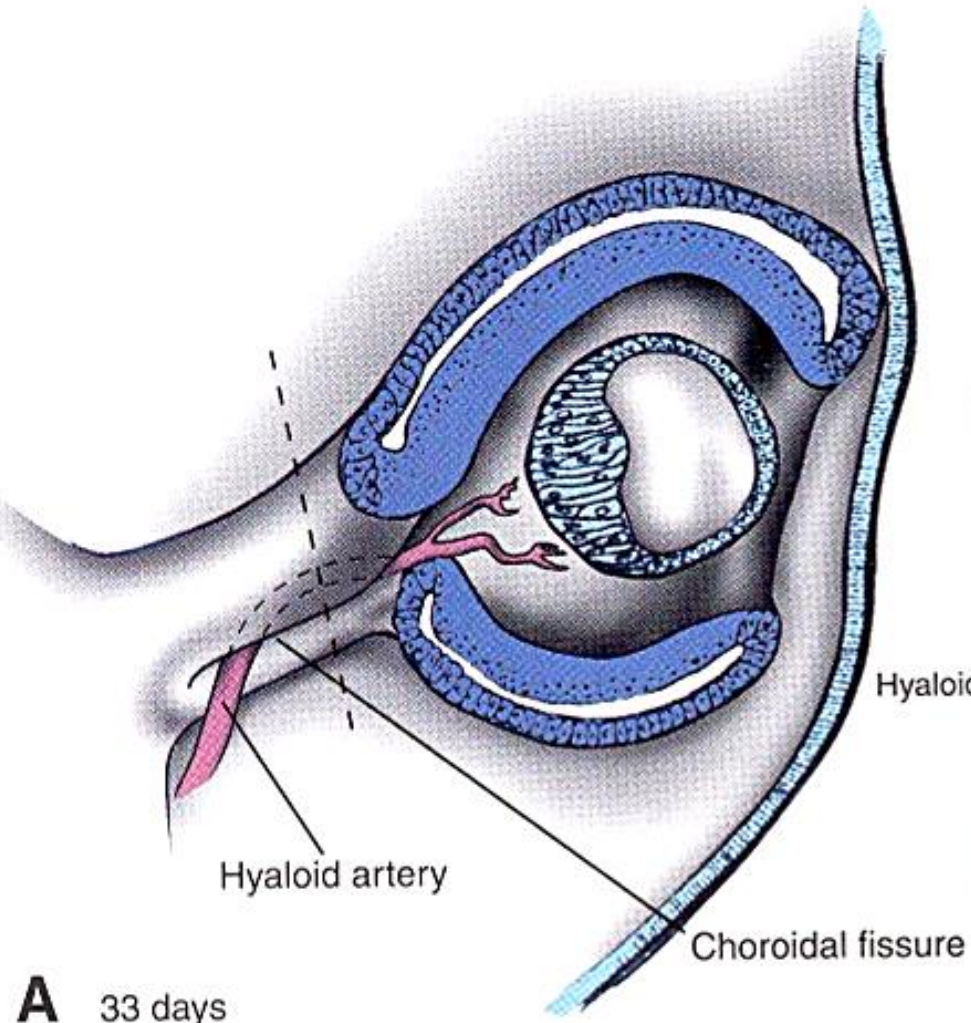
Inner layer of optic cup
(primordium of neural
layer of retina)

Outer layer of optic cup
(primordium of retinal
pigment epithelium)











Optic nerve

Branches of
hyaloid artery

Intraretinal
space

Choroid

Retinal pigment
epithelium

Neural retina

Anterior lens epithelium

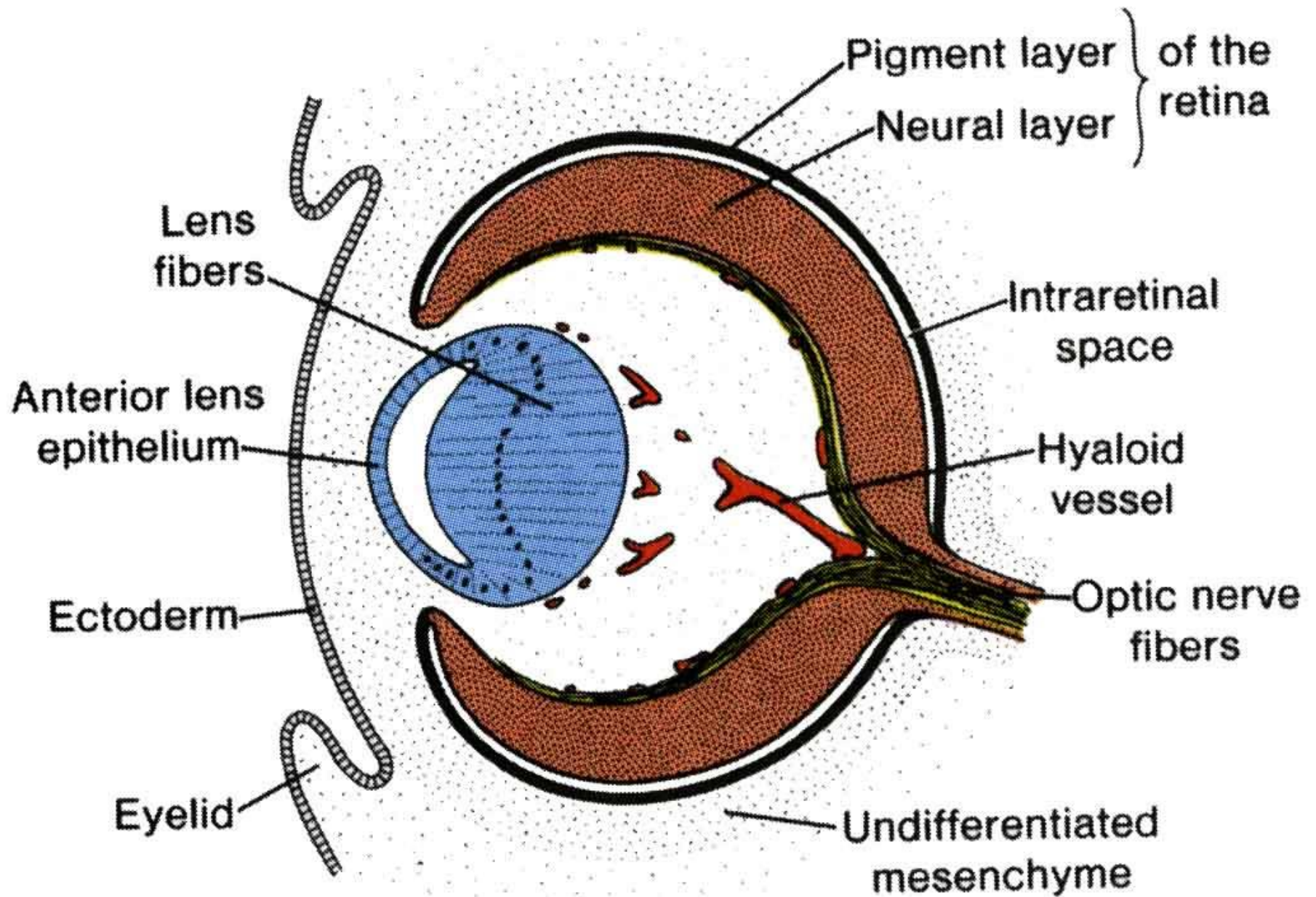
Lens fibers

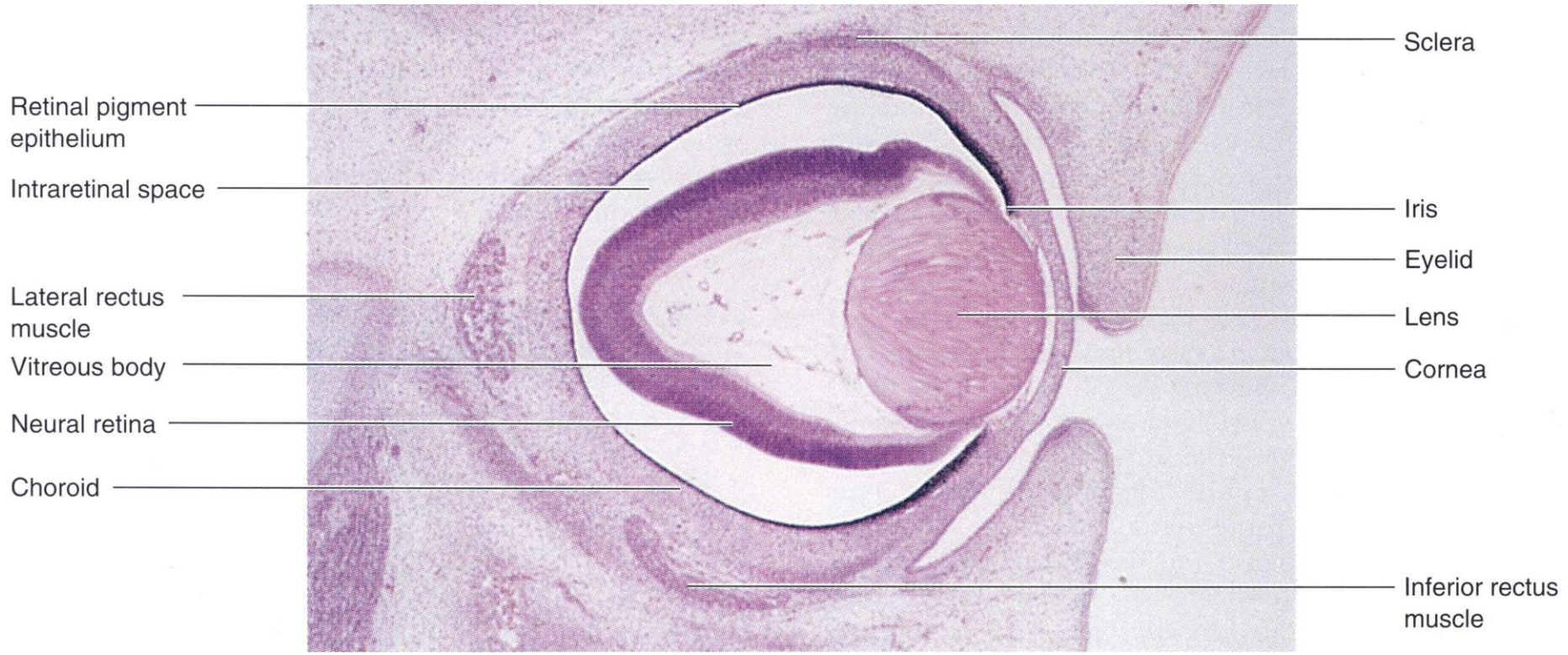
Iris

Vitreous body

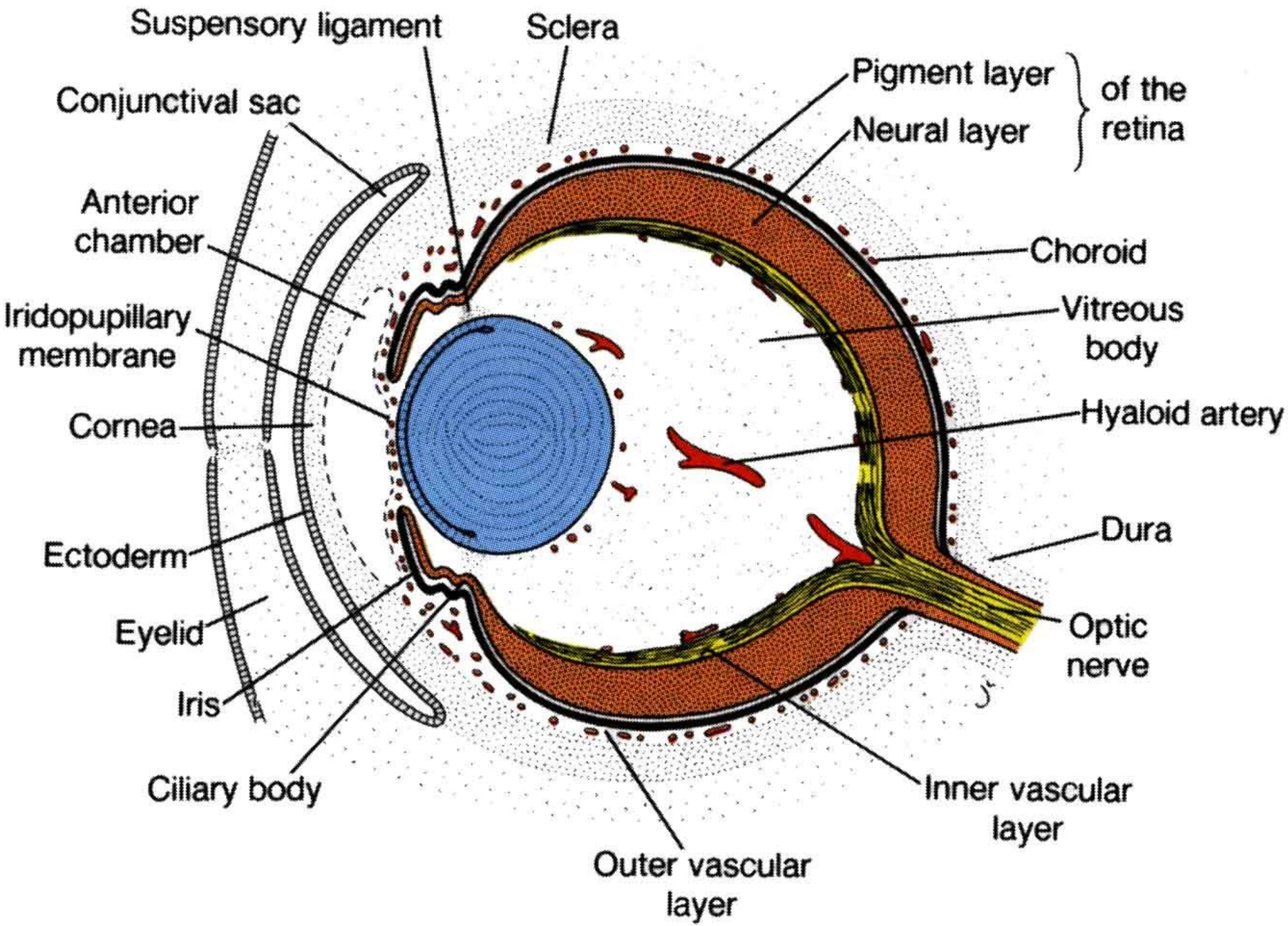
Sclera

44 days





56 days



EYE PARTS: EMBRYONIC SOURCES

Surface
ECTODERM

MESENCHYME

Neural
ECTODERM

LENS

UVEA

SCLERA

RETINA

OPTIC
NERVE

CORNEAL
STROMA

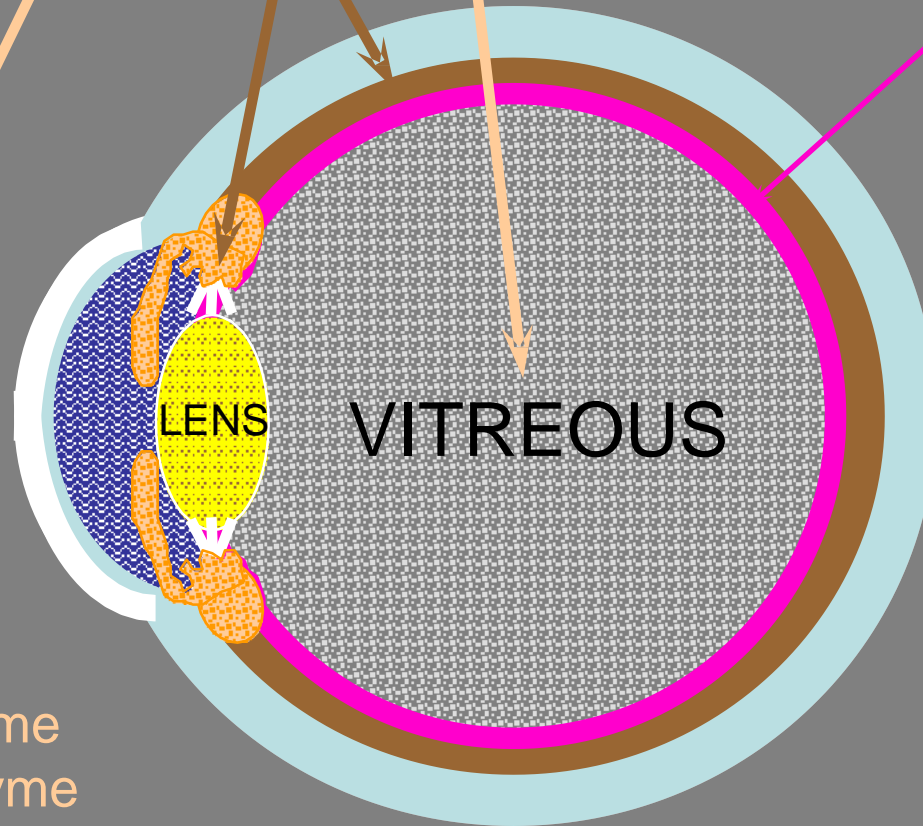
LENS

VITREOUS

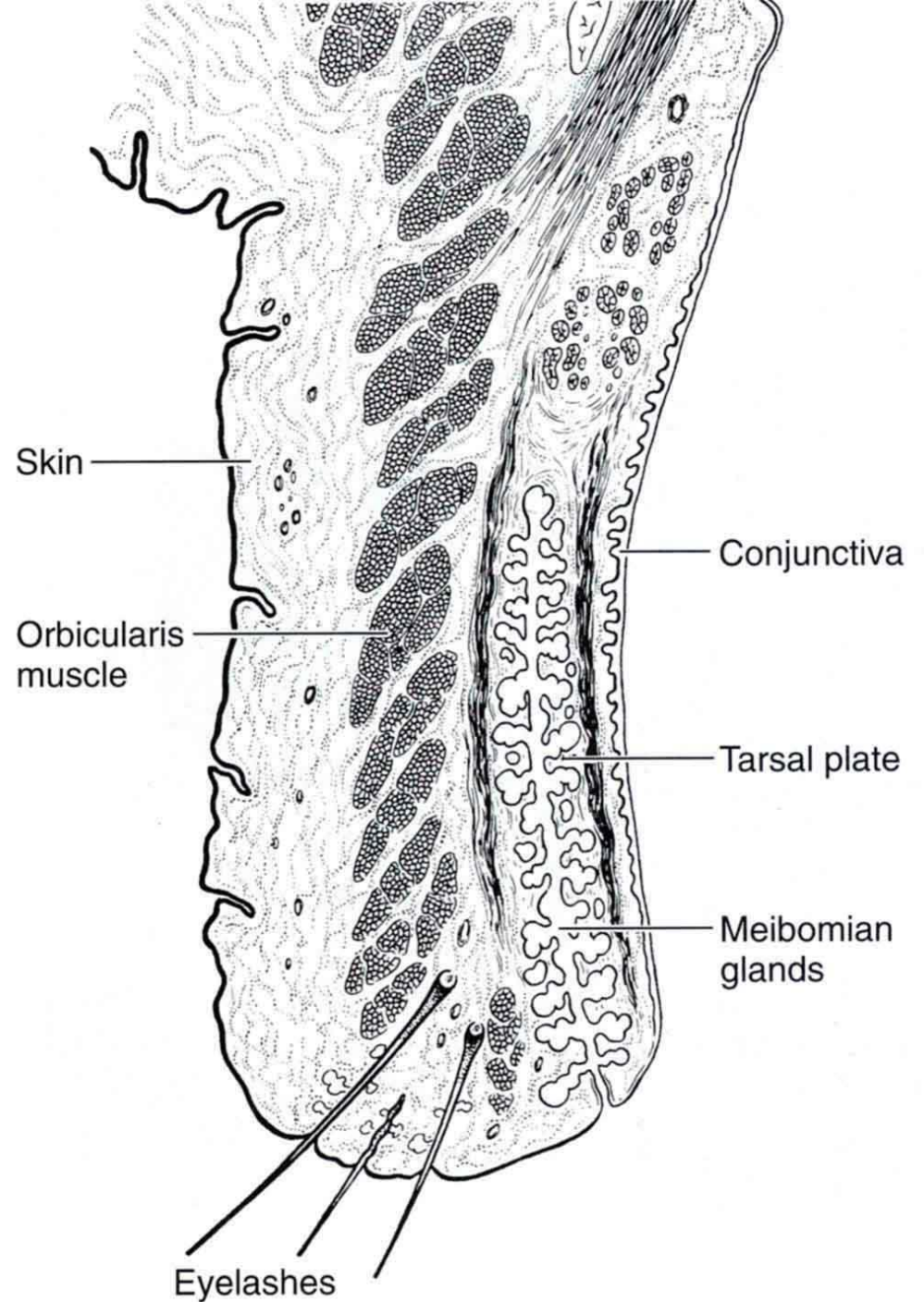
corneal anterior
epithelium

Connective tissue &
muscle (& vessels) come
from cranial mesenchyme

Two ectoderms
drive events
and shaping

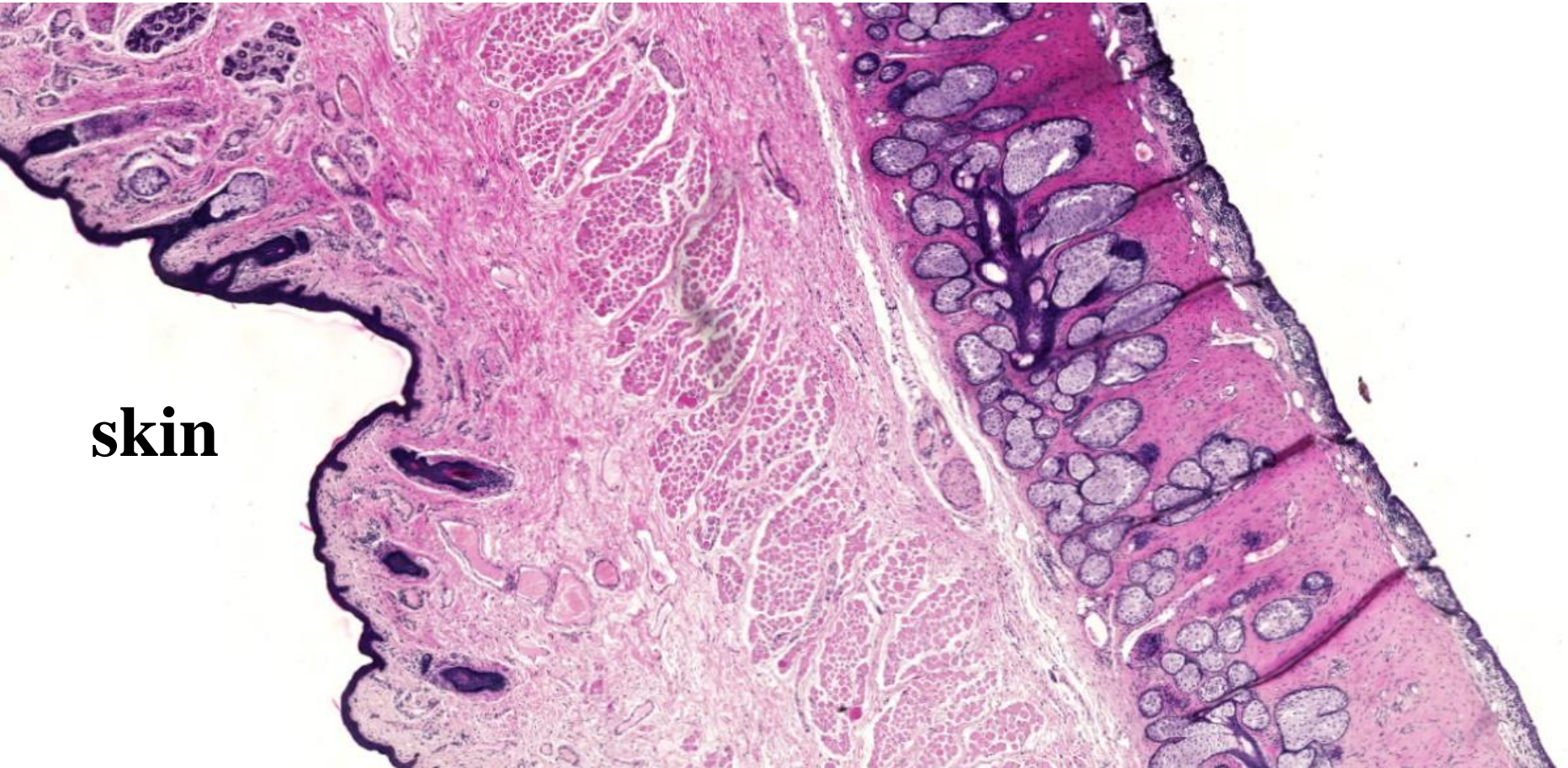


Accessory structures of the eye





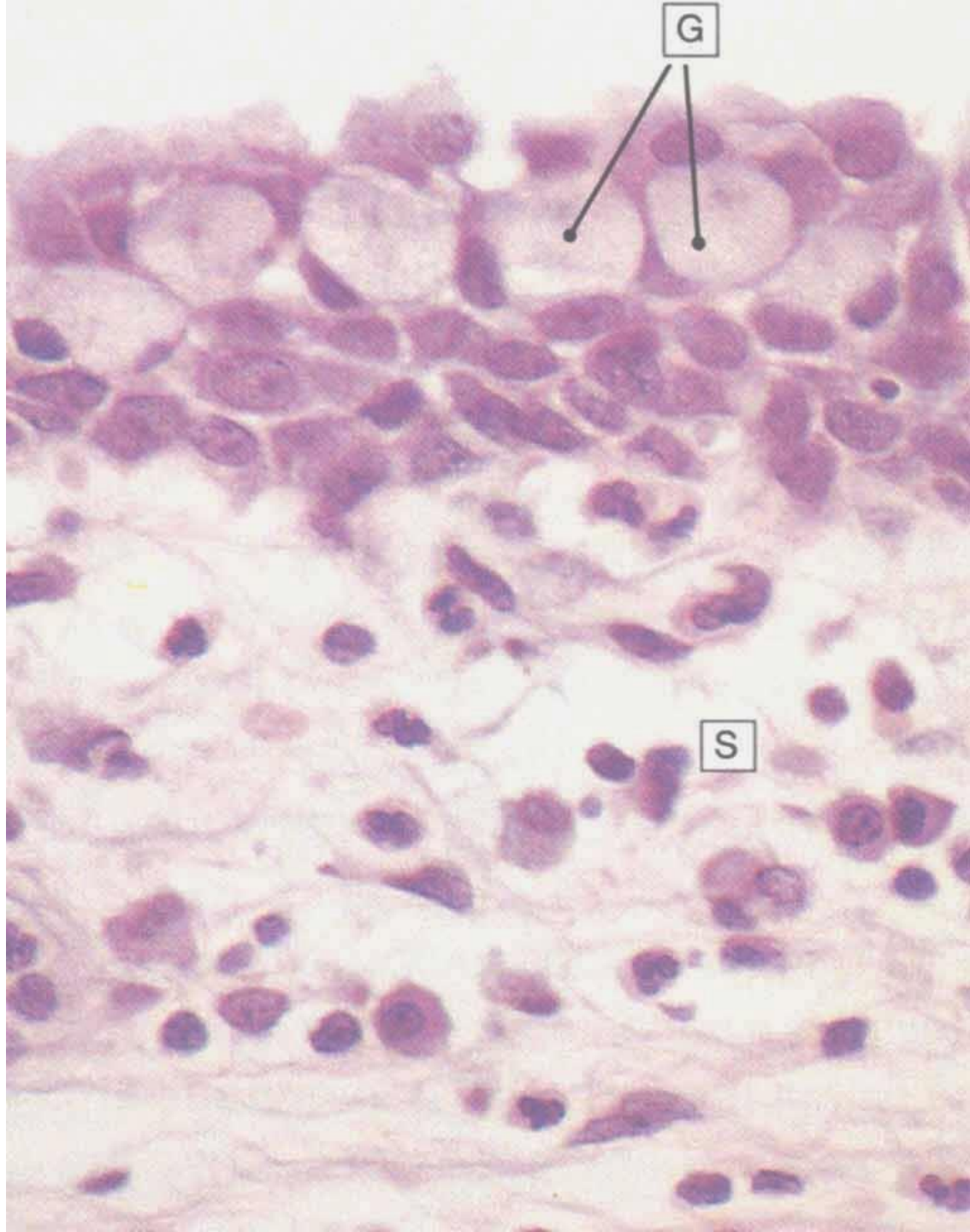
conjunctiva

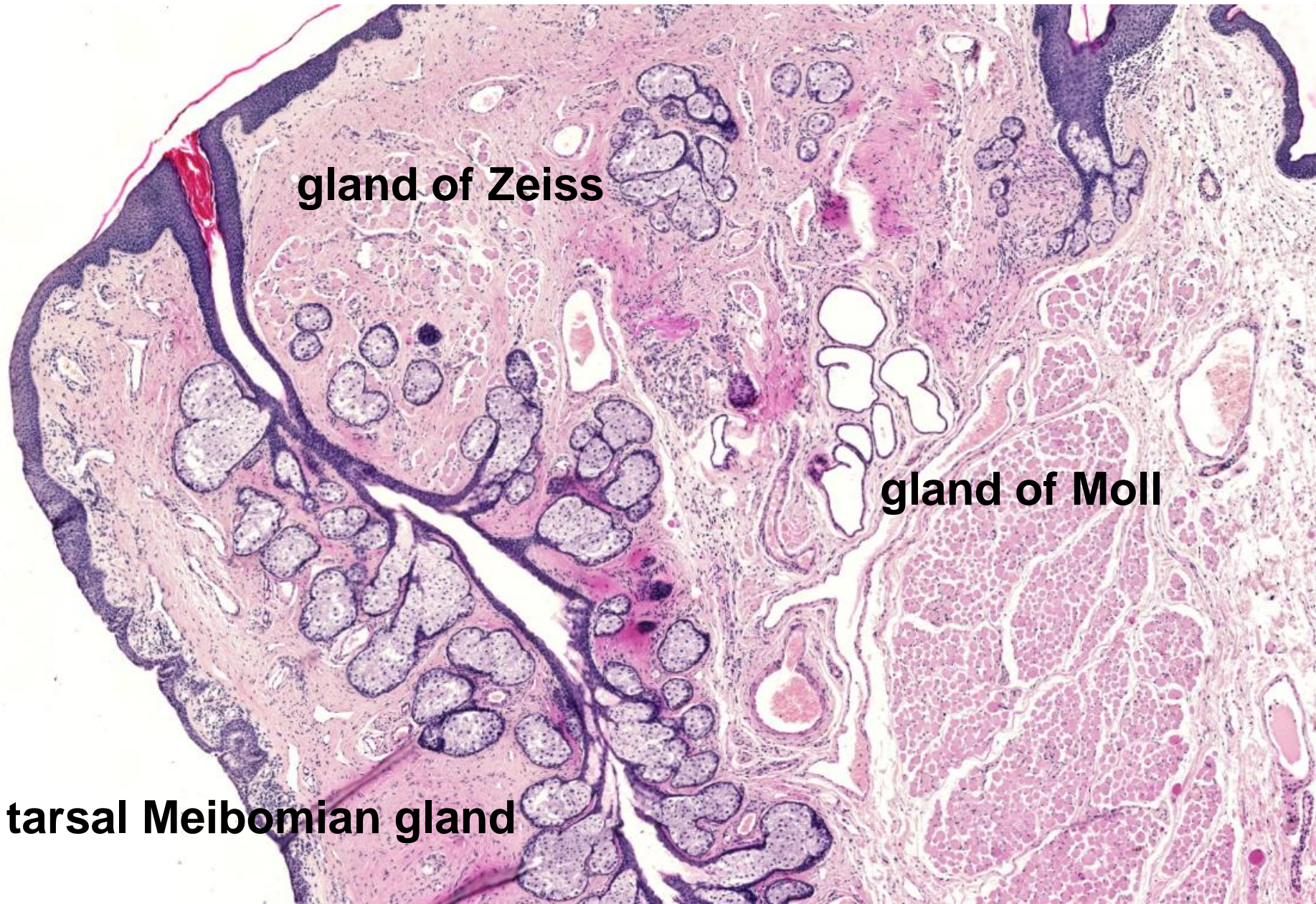


skin

orbicularis oculi muscle

conjunctiva

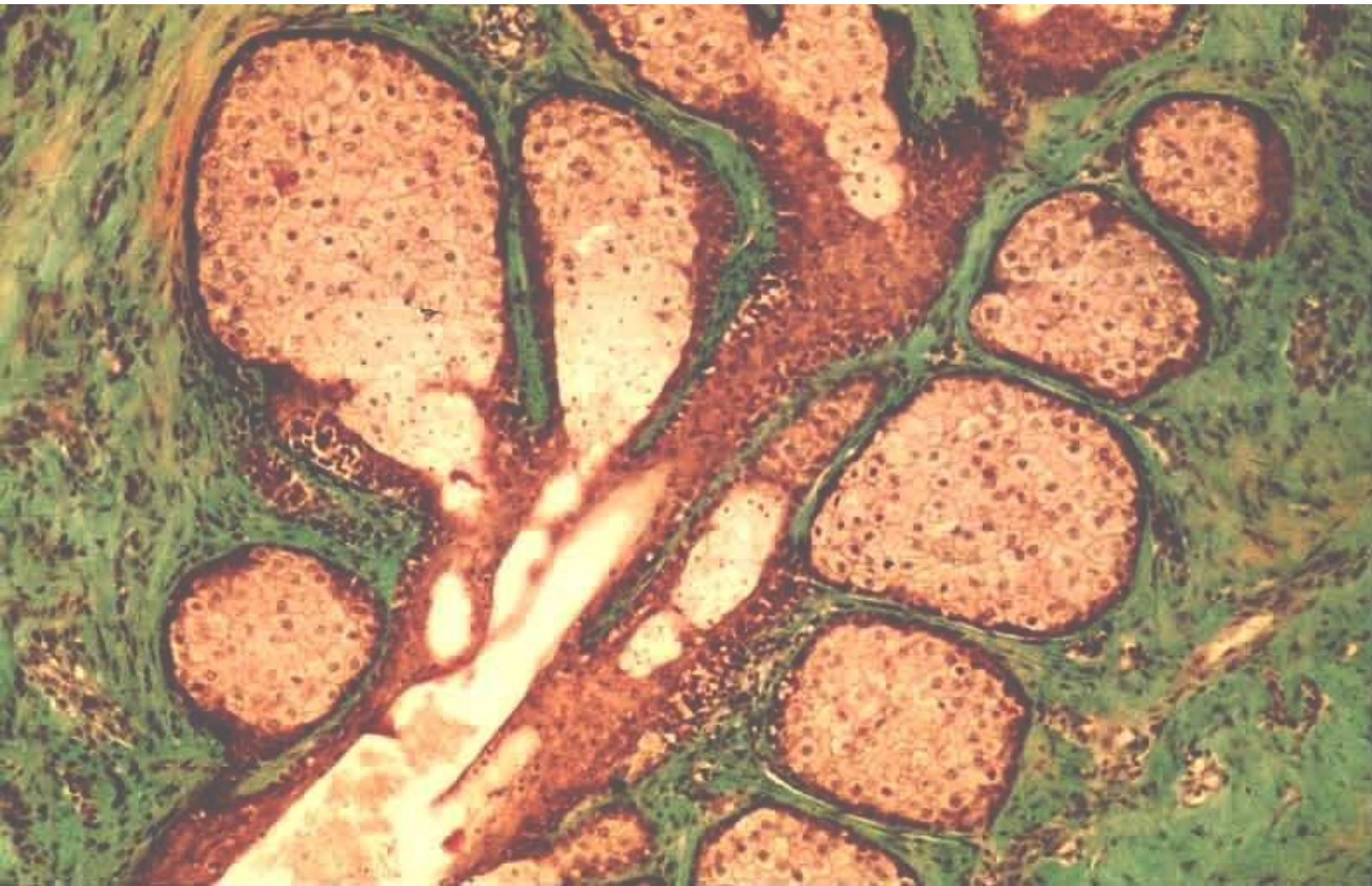




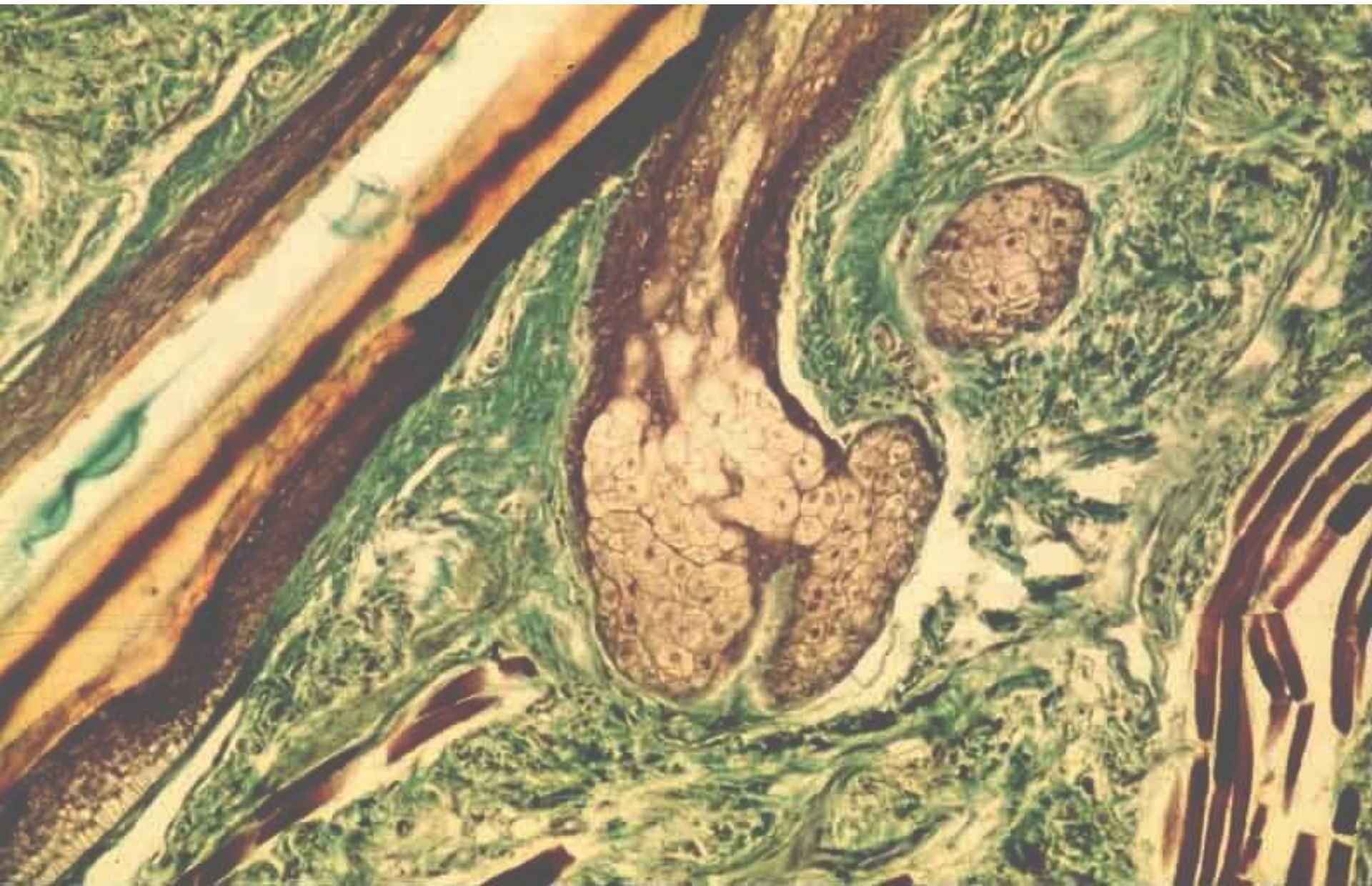
gland of Zeiss

gland of Moll

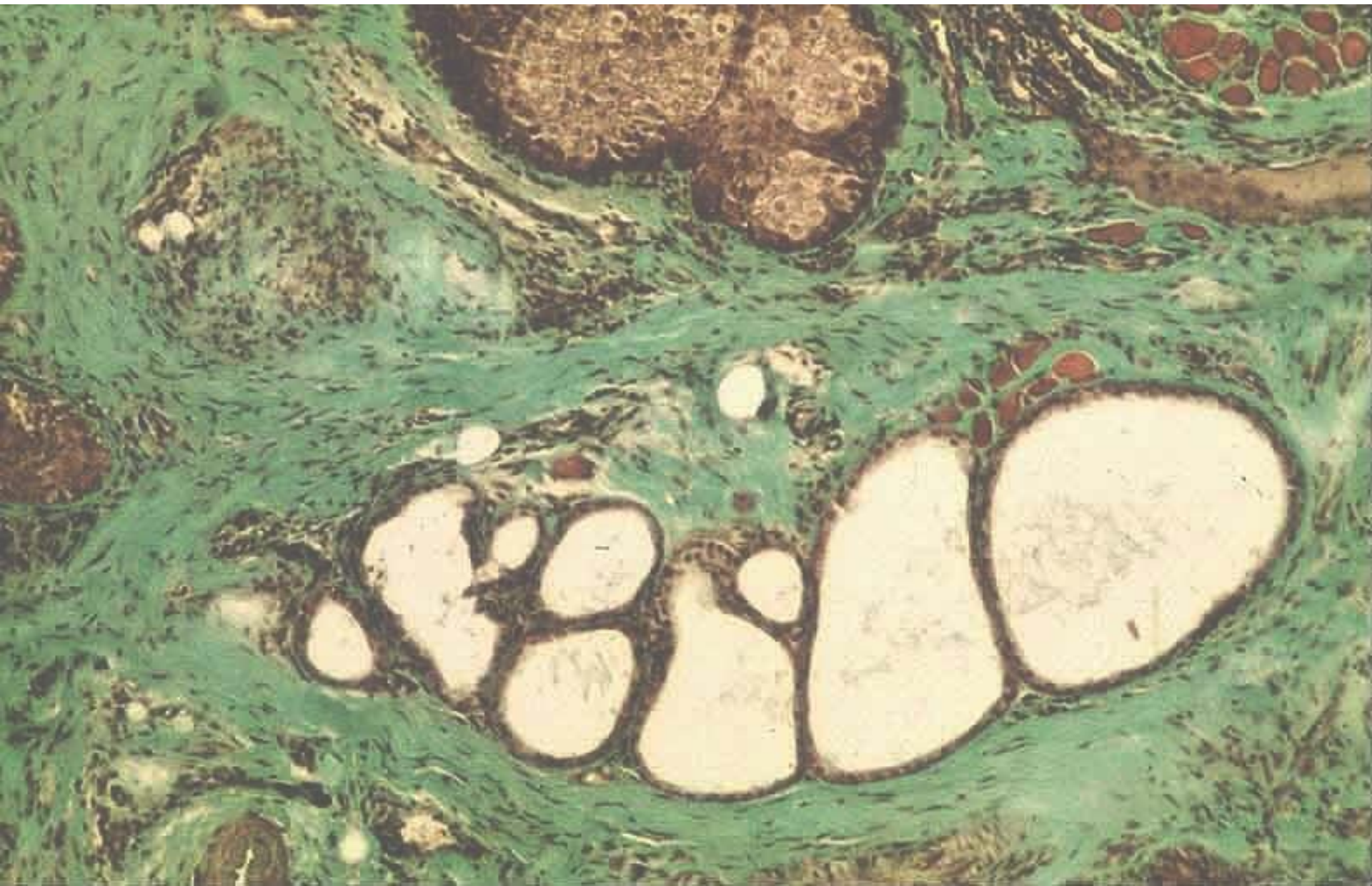
tarsal Meibomian gland



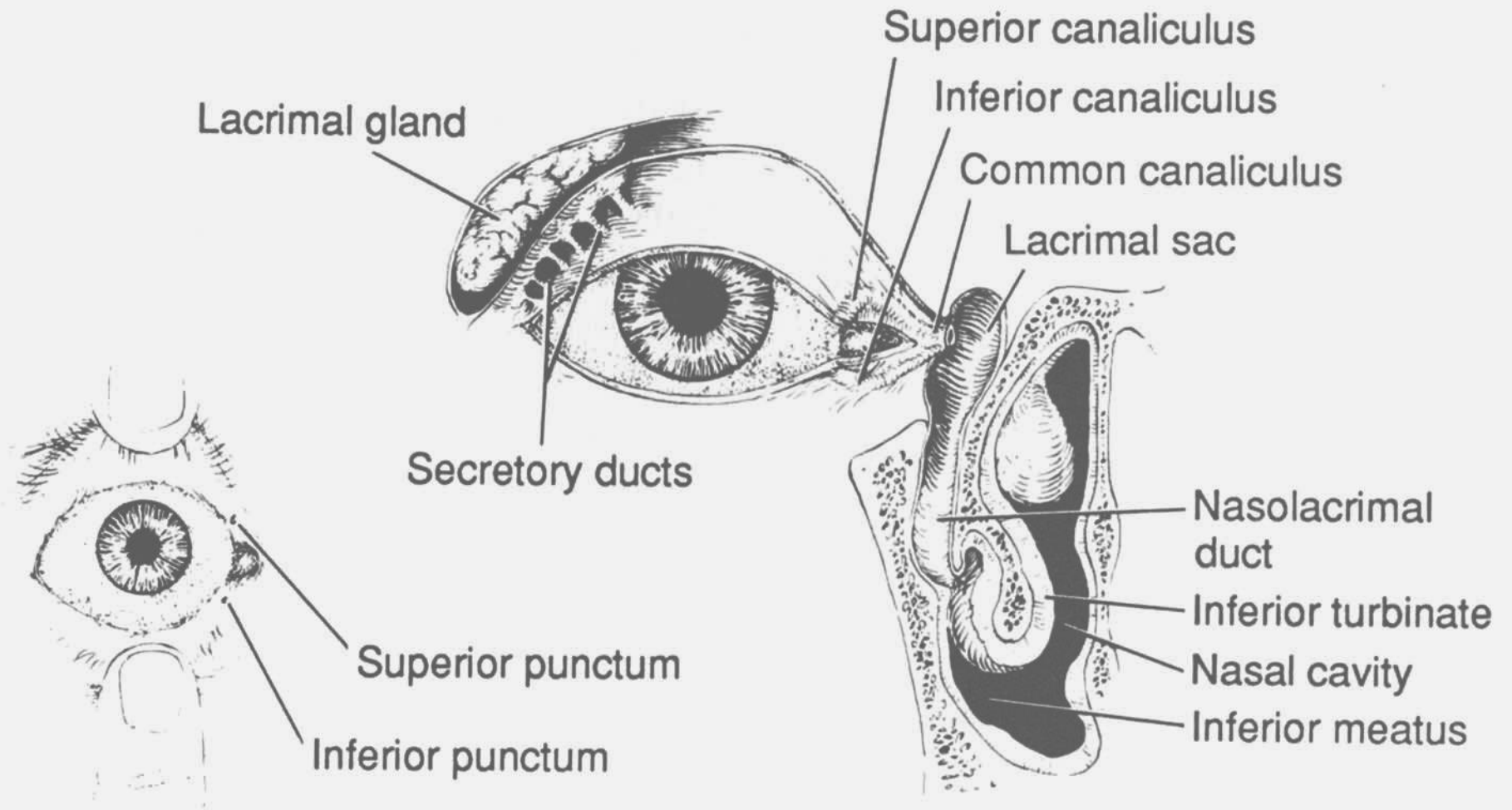
tarsal Meibomian gland

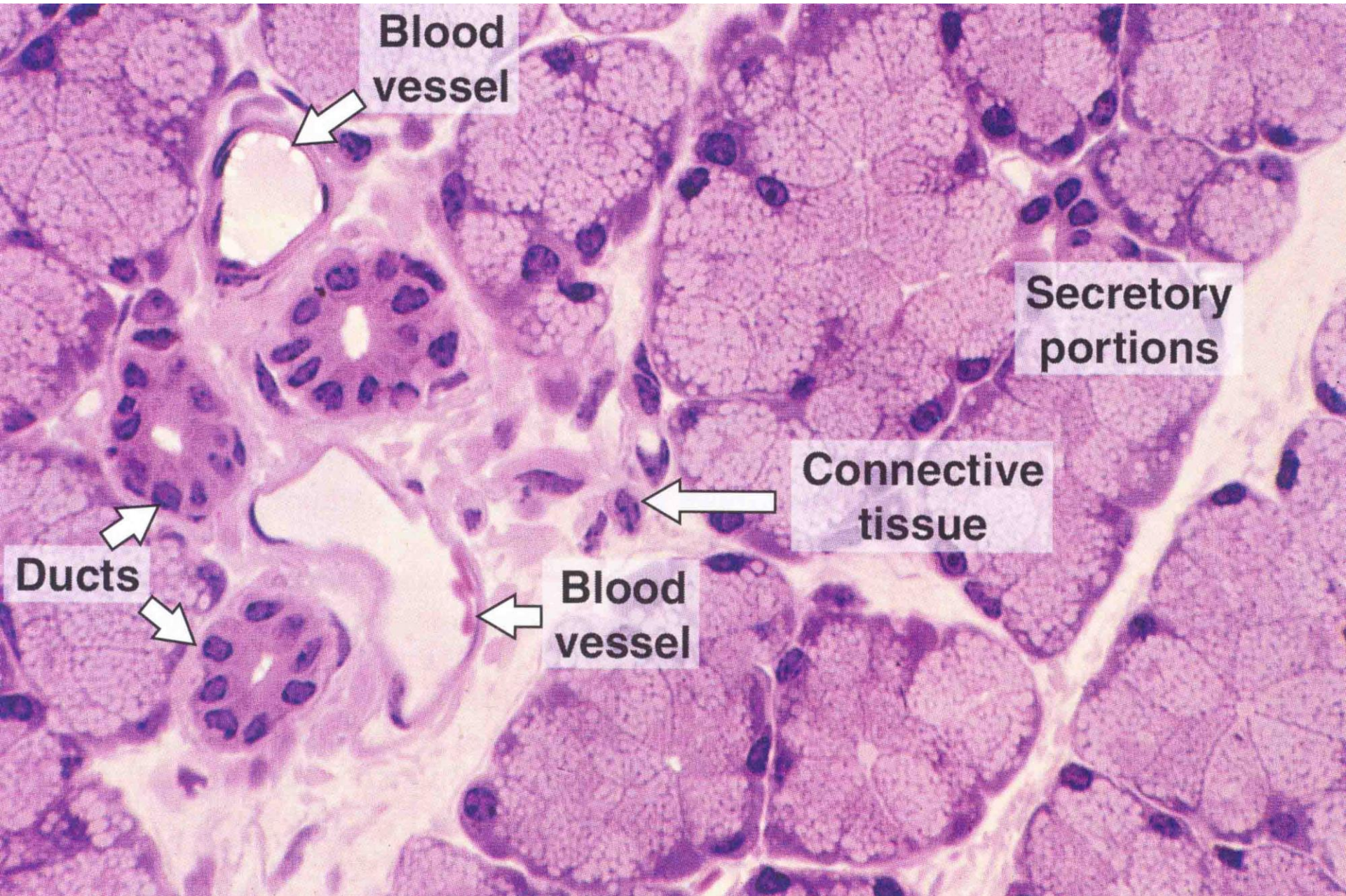


sebaceous glands of eyelashes (gland of Zeiss)



gland of Moll





Blood vessel

Secretory portions

Connective tissue

Ducts

Blood vessel