

Sensory organs

Organs capable of detecting, receiving, processing and transmitting stimuli.

Receptors - structures directly responsible for the detection of a stimulus and for its transformation into the nerve impulses.

Stimuli can be from the external environment (detected by exteroceptors) or from internal structures (interoceptors)

Receptors of sensory organs

functional classification

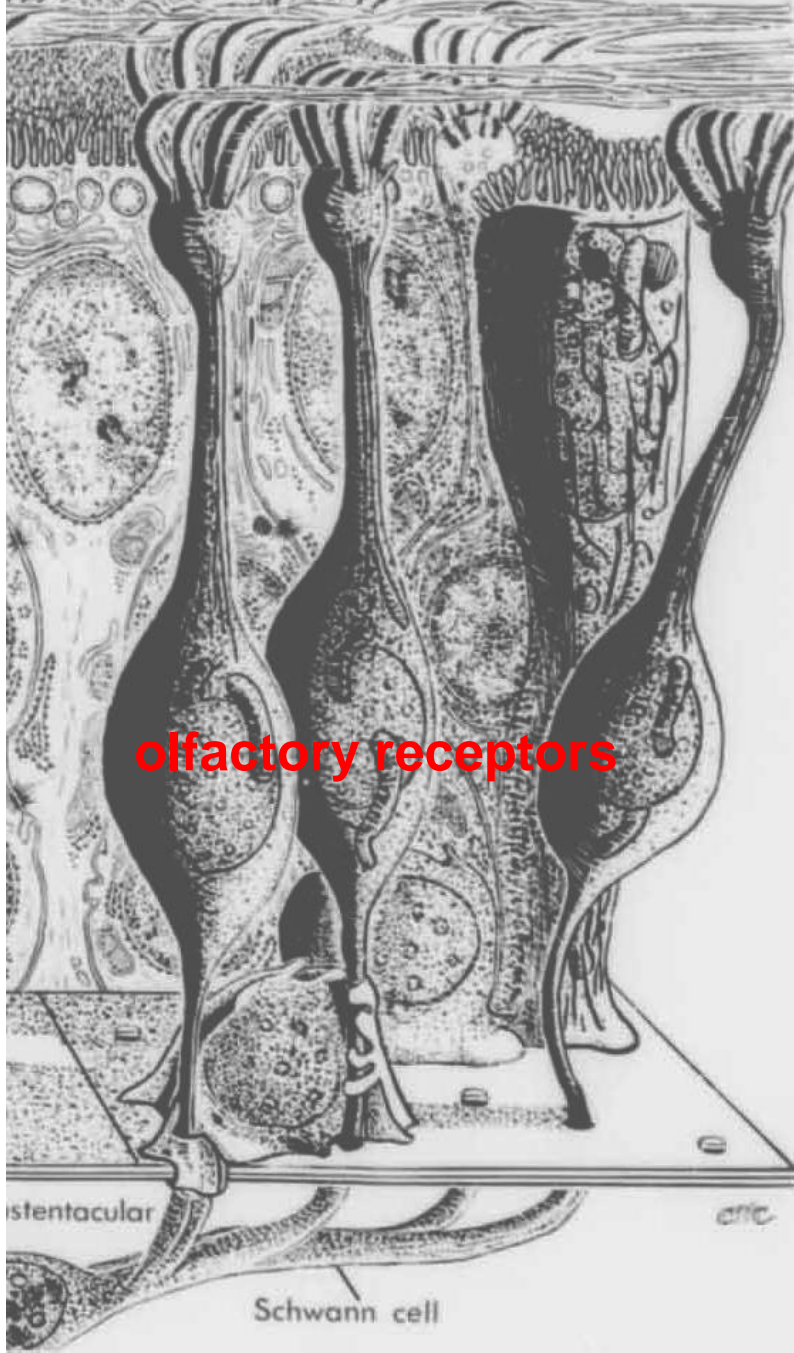
- 1/ photoreceptors – light
- 2/ chemoreceptors – taste, smell, concentration of substances in body fluids
- 3/ mechanoreceptors
 - a/ audioreceptors – sound waves
 - b/ proprioceptors – position in space
 - c/ other mechanoreceptors – pressure, touch, vibrations
- 4/ thermoreceptors – temperature
-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

Receptors of sensory organs

morphological classification

- 1/ primary receptors – neurons
 - a) whole modified neurons (olfactory, visual)
 - b) peripheral endings of afferent neuron axons
 - encapsulated
 - free
- 2/ secondary receptors – epithelial cells
 - must be synaptic connected with peripheral axonal branches or with dendrites (n. VIII) of afferent neurons

1a/ primary receptor cells

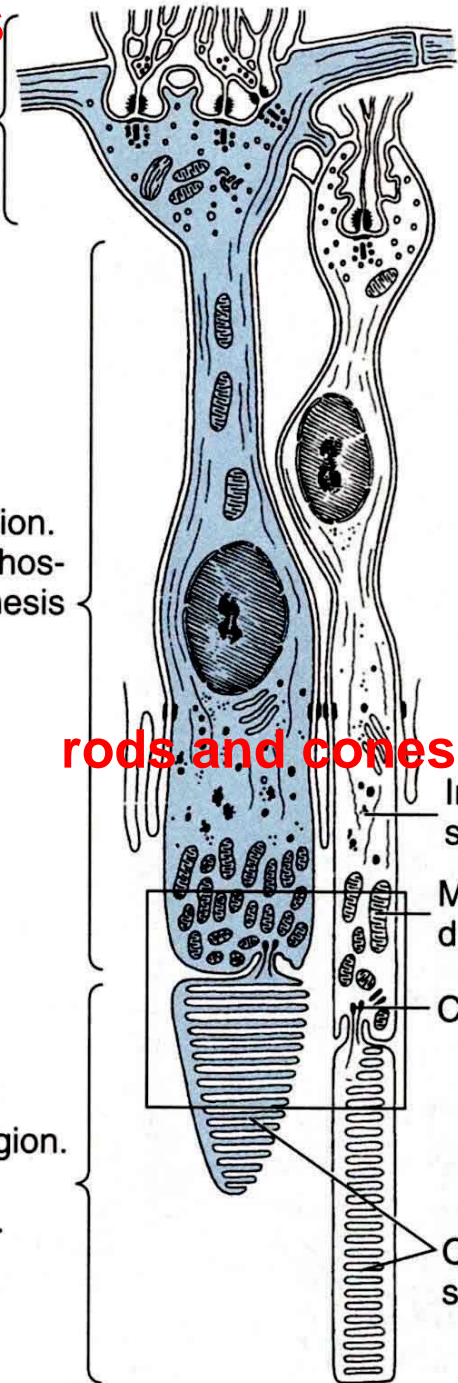


olfactory receptors

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

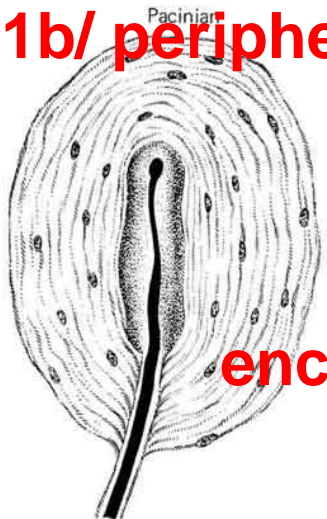
Inner segment

Mitochondria

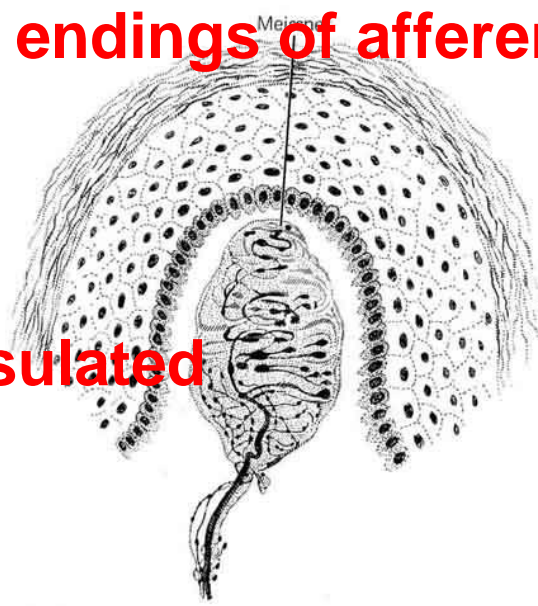
Cilium

Outer segments

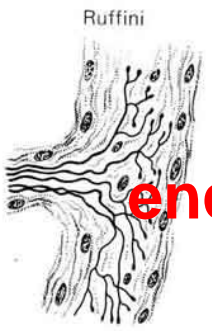
1b/ peripheral endings of afferent neurons



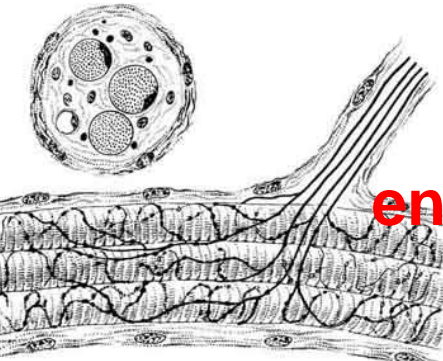
encapsulated



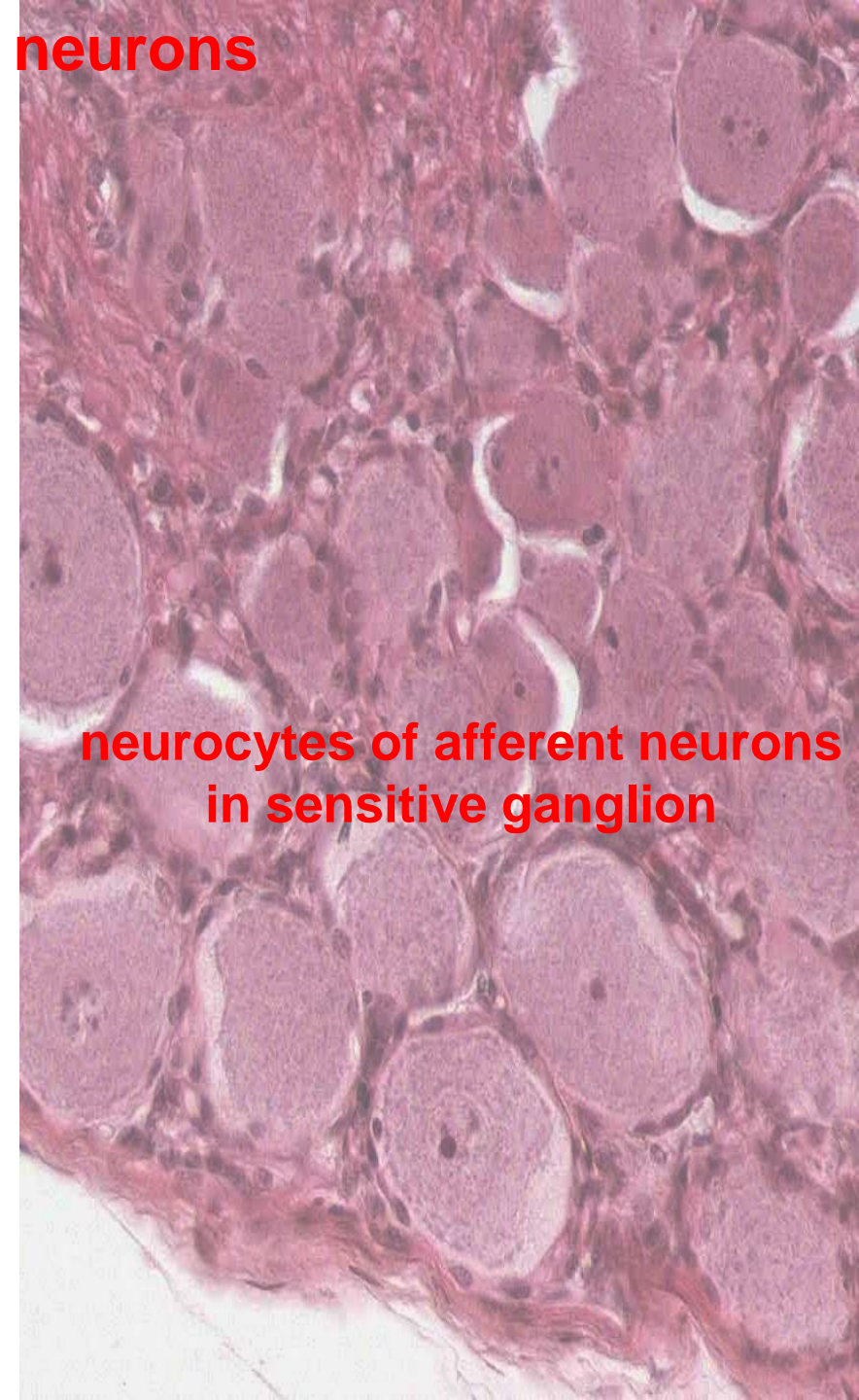
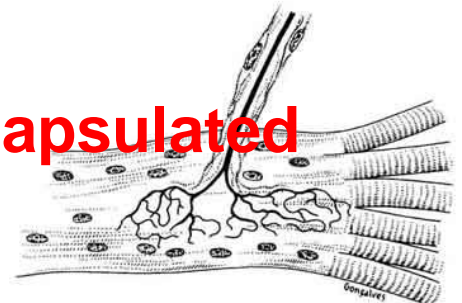
free

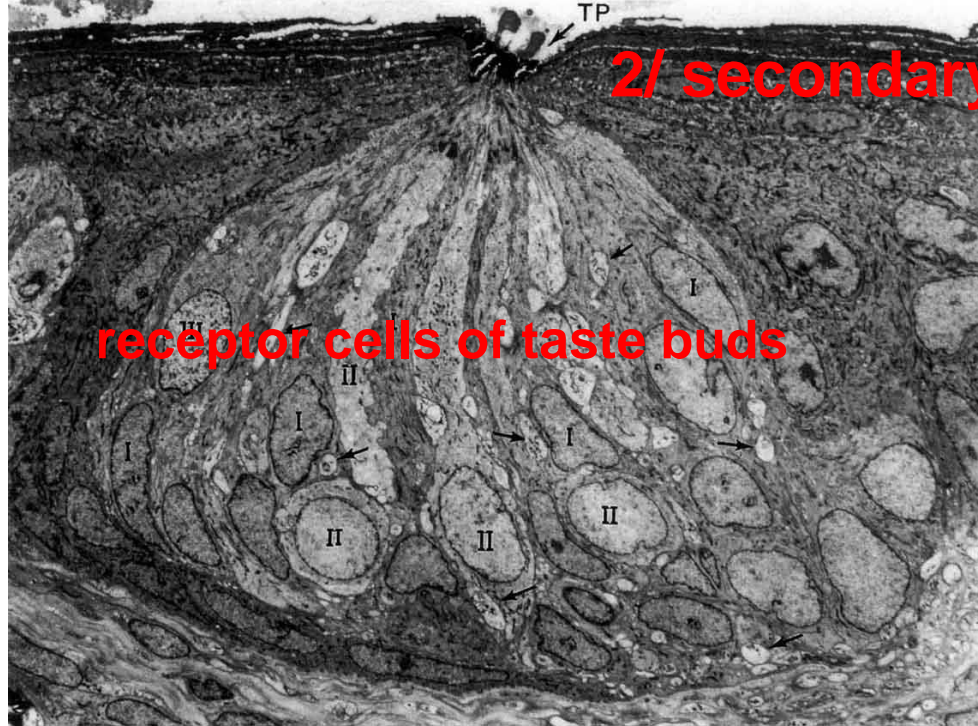


encapsulated

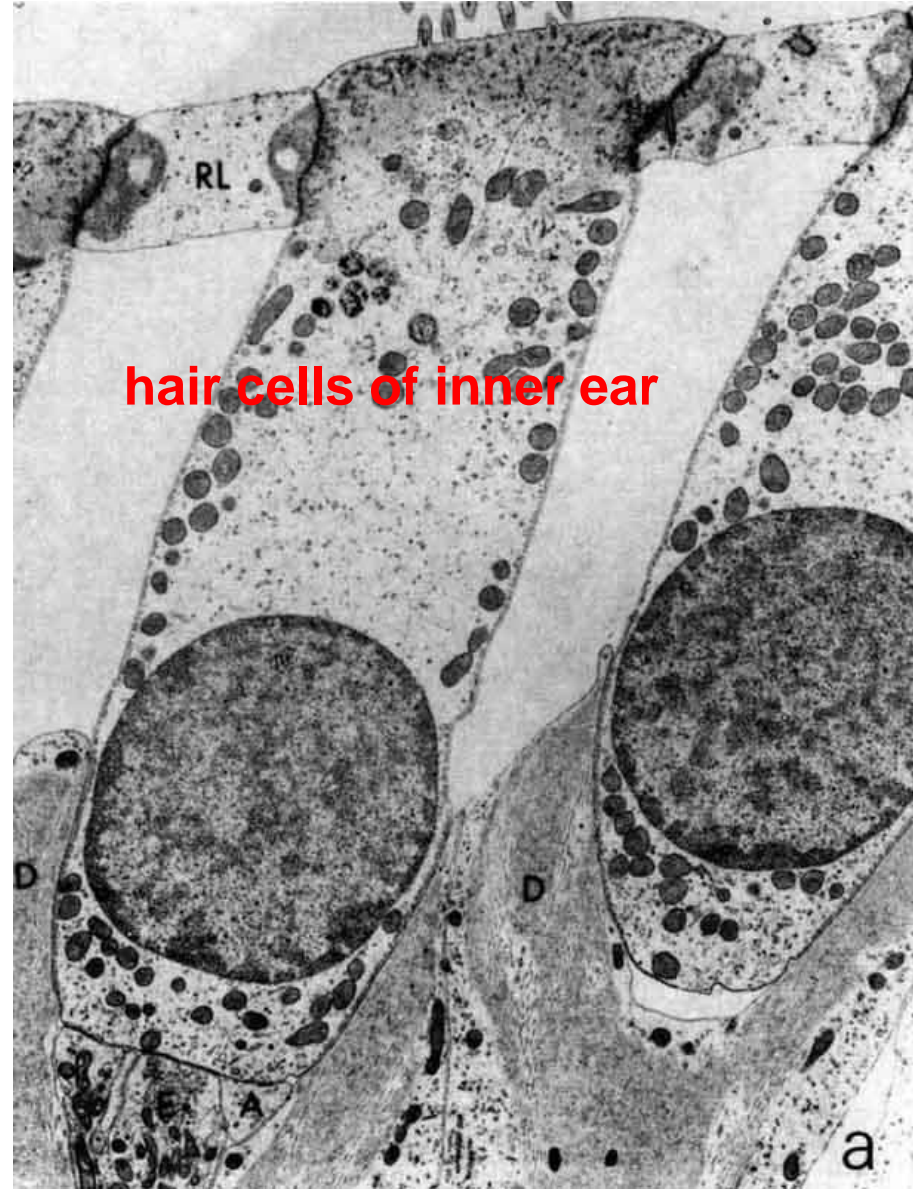


encapsulated

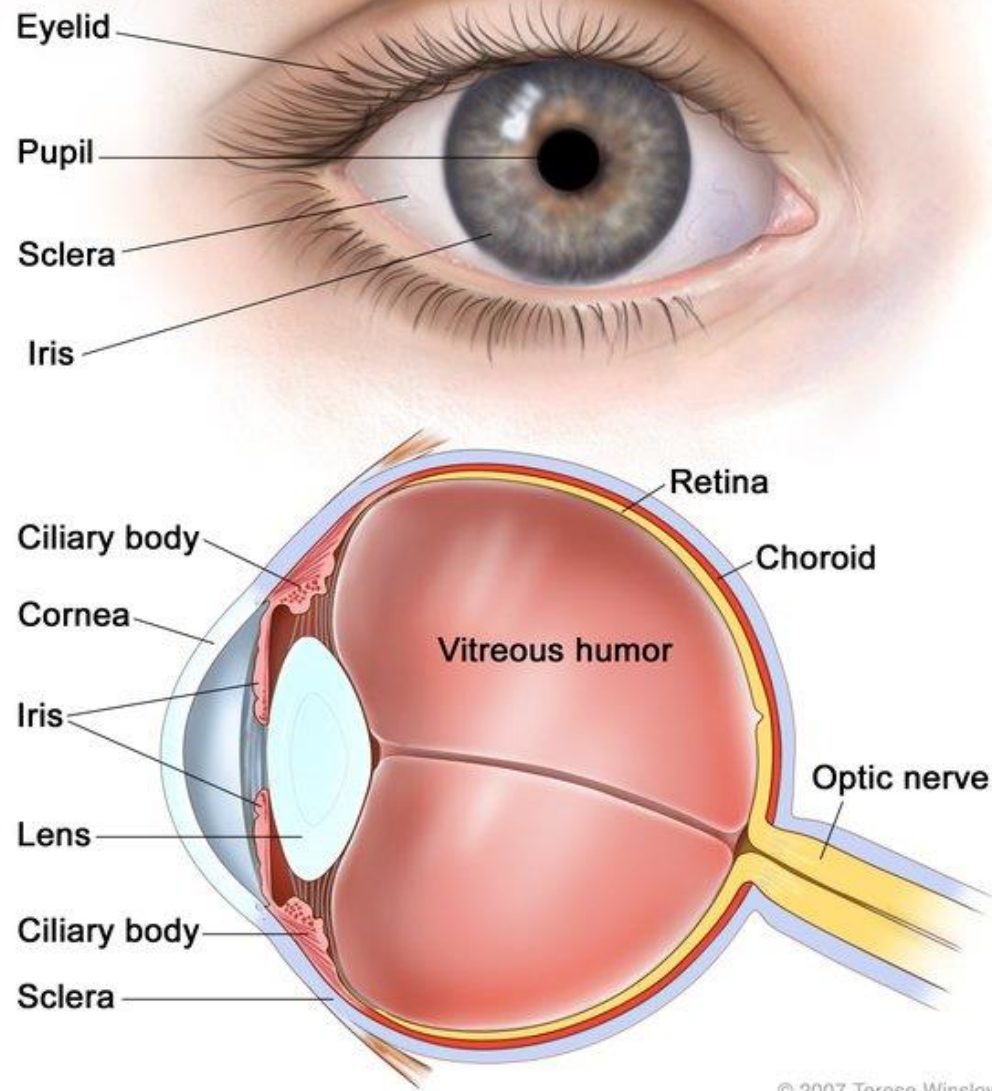




2/ secondary receptor cells



Sense organs I – vision (photoreceptors)



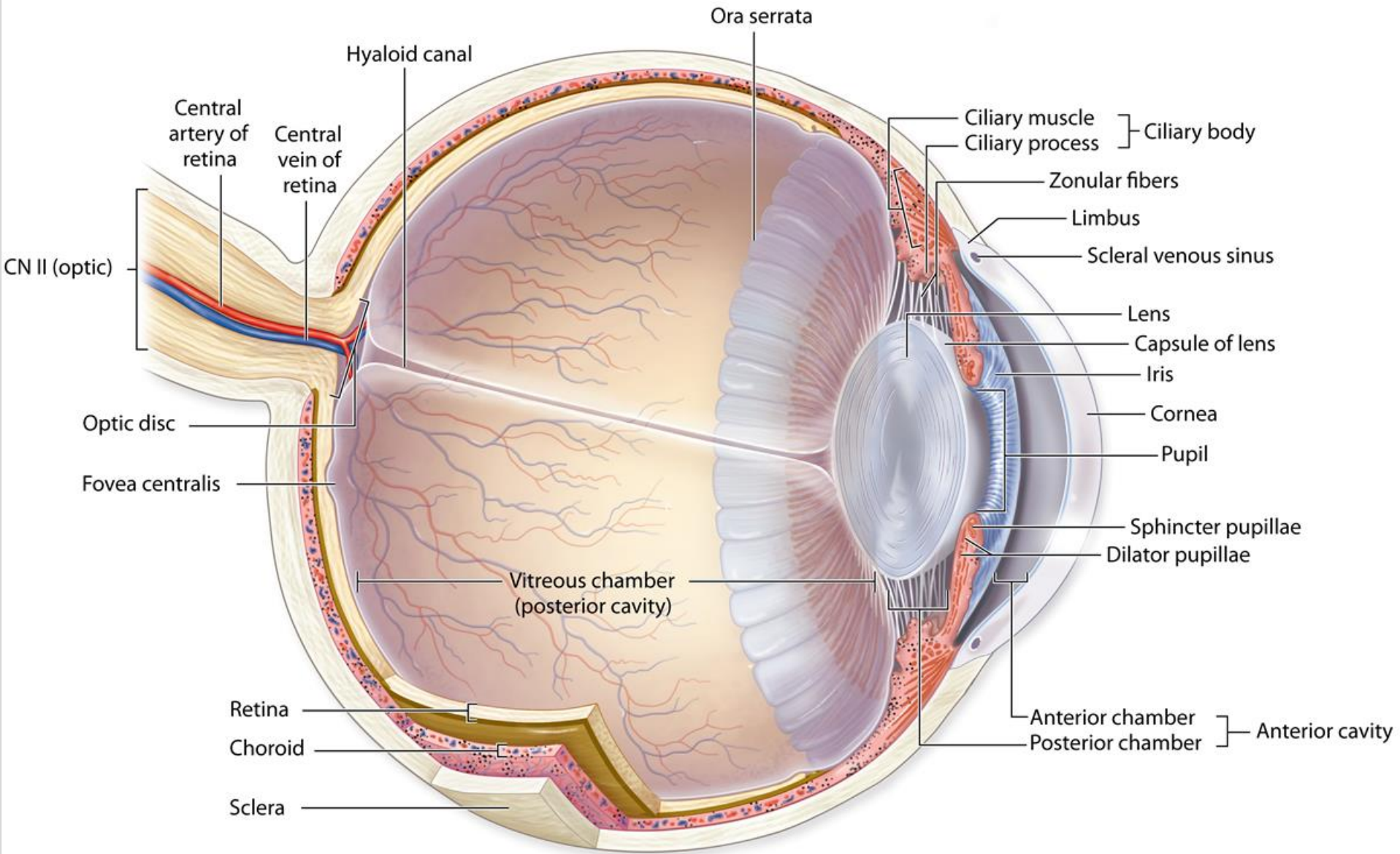
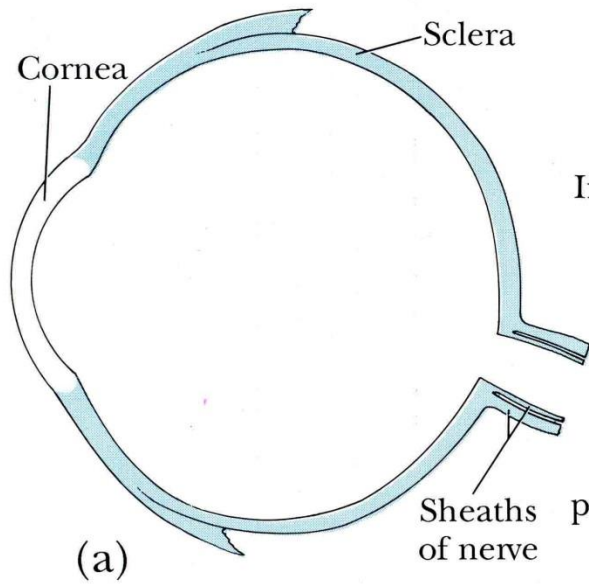
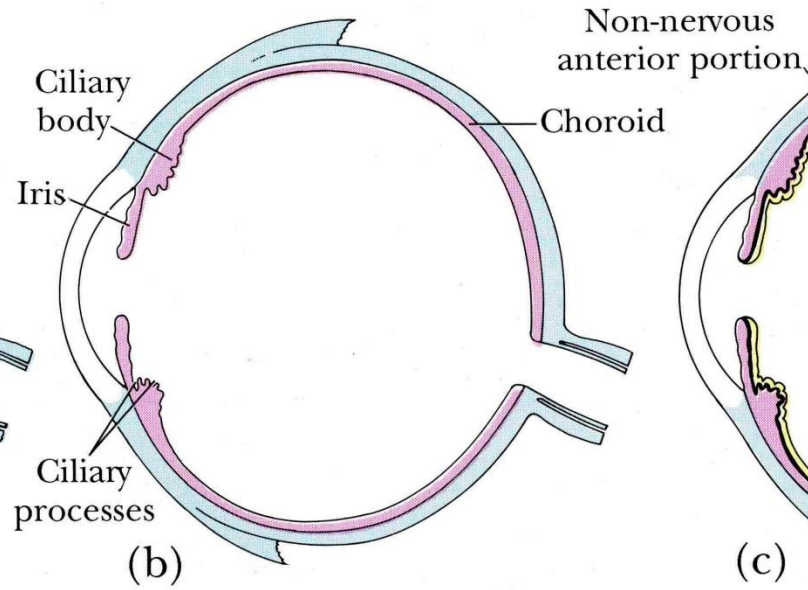


Figure 23-1

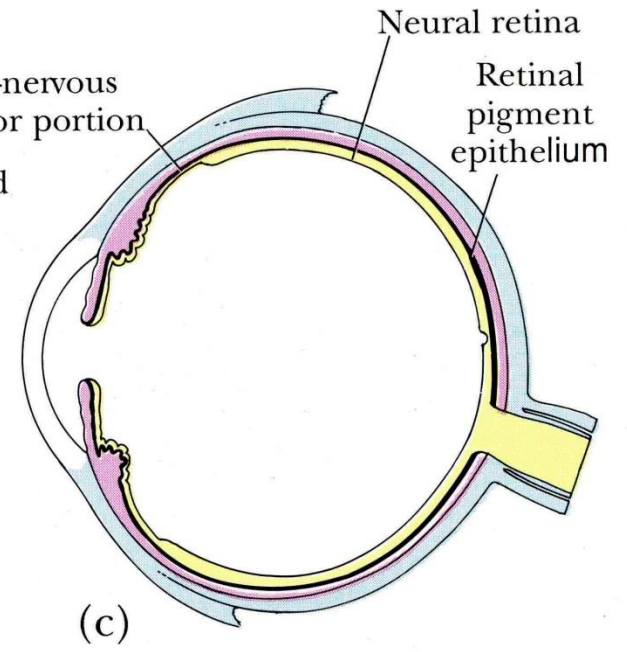
tunica fibrosa



tunica vasculosa

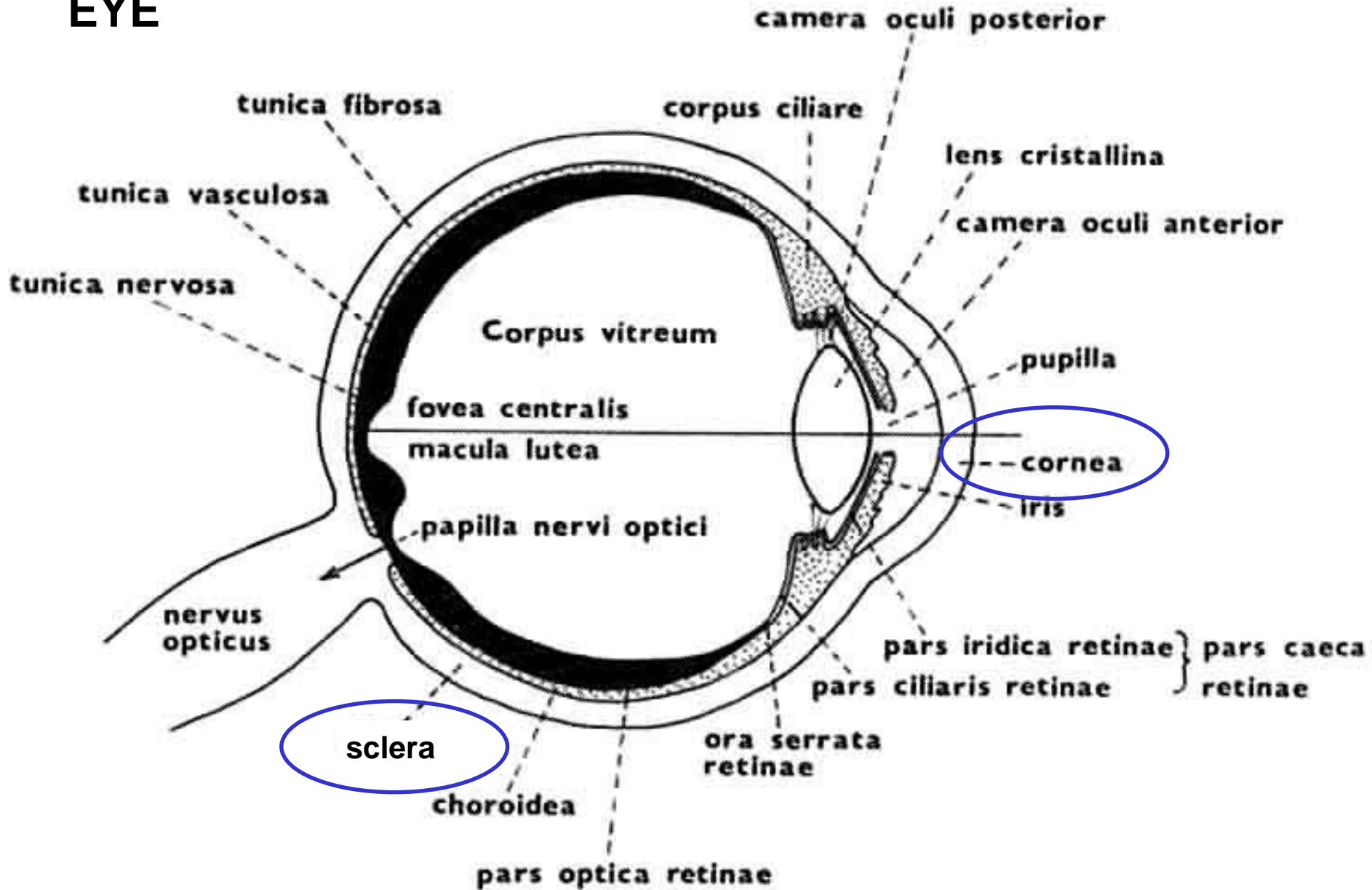


tunica nervosa



Tunica fibrosa (cornea and sclera)

EYE

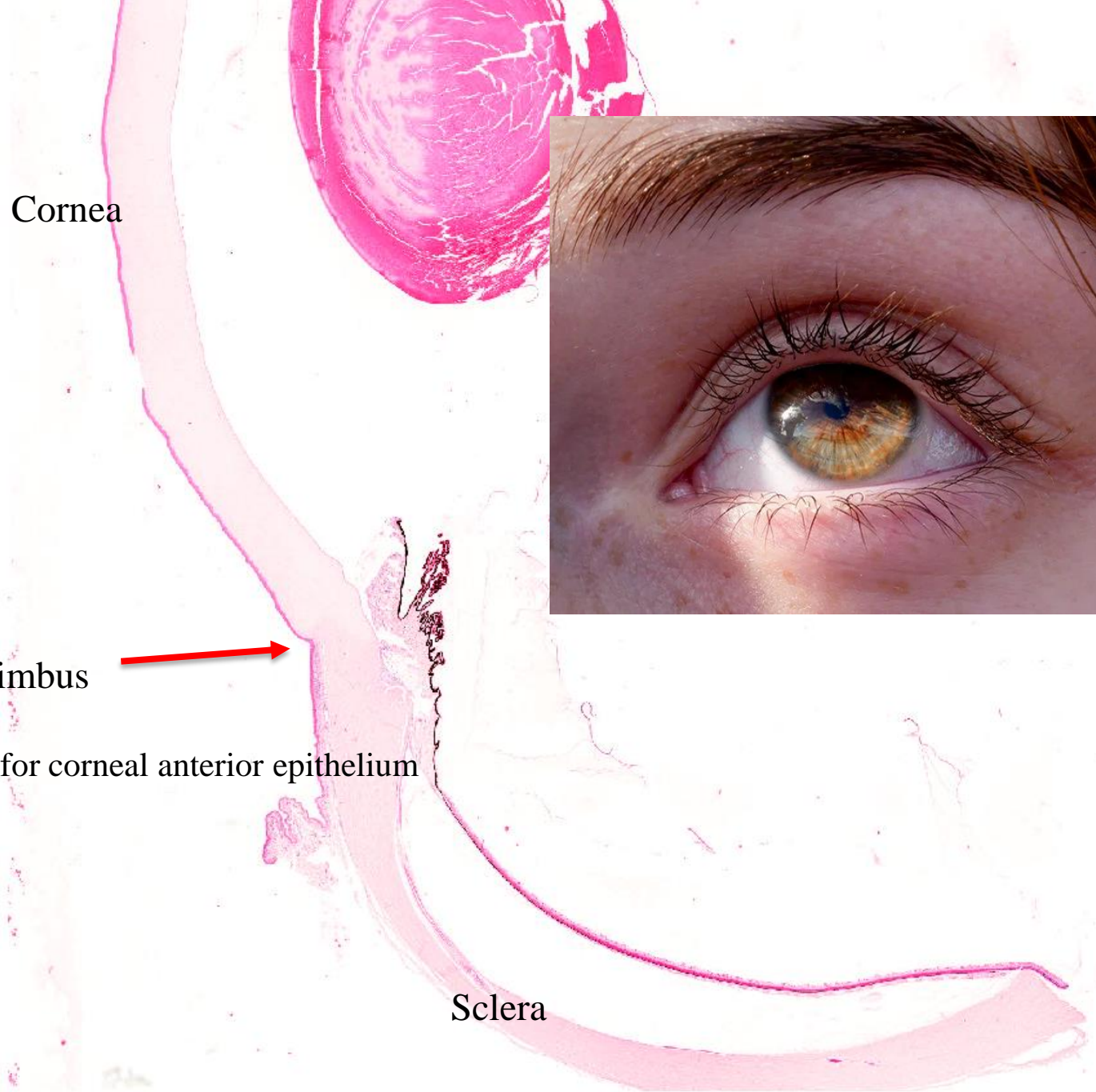


Cornea

Limbus

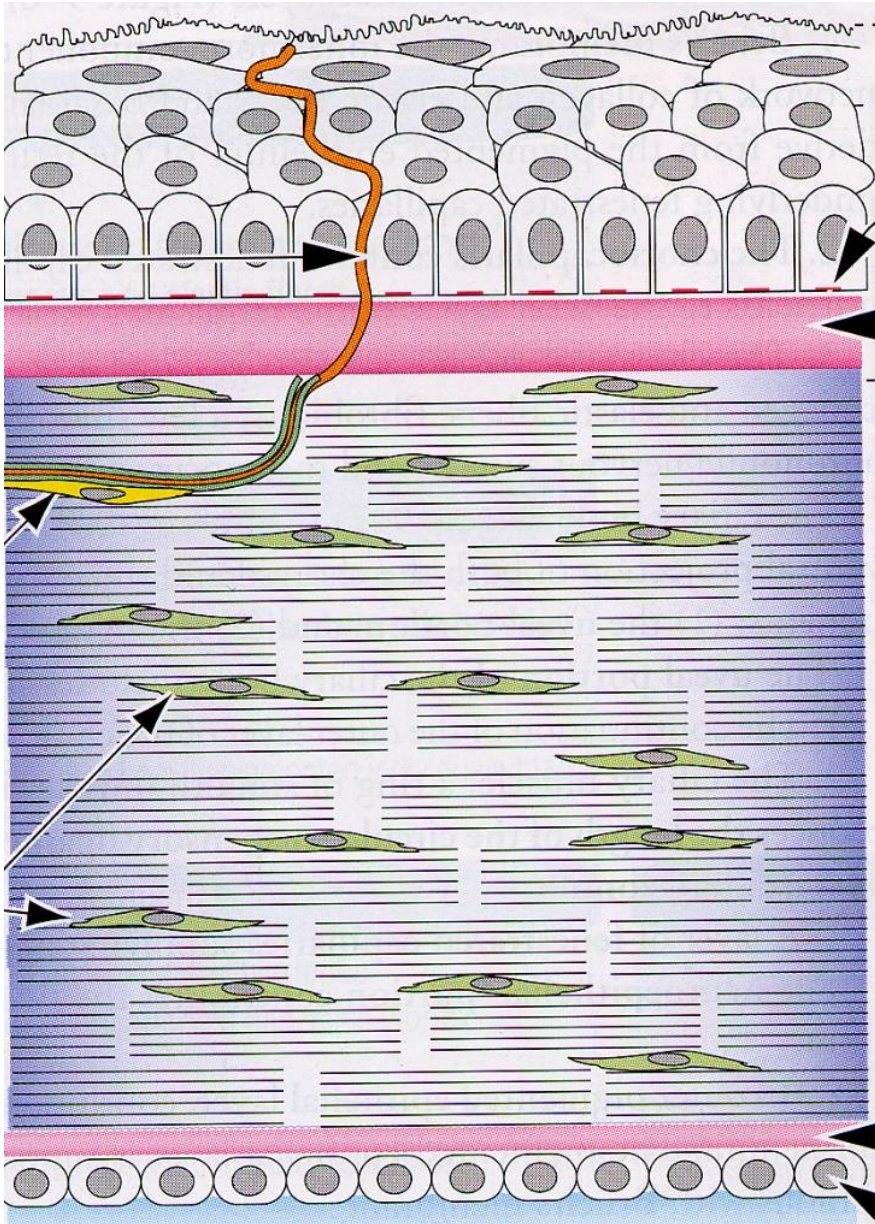
Reserve cells for corneal anterior epithelium

Sclera



Cornea

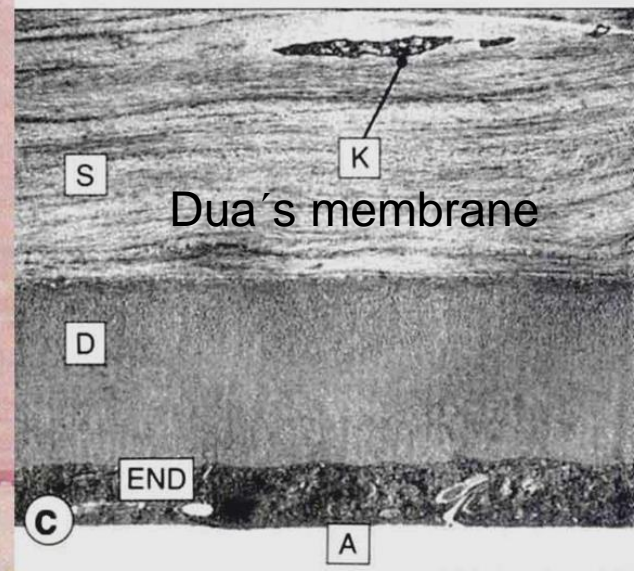
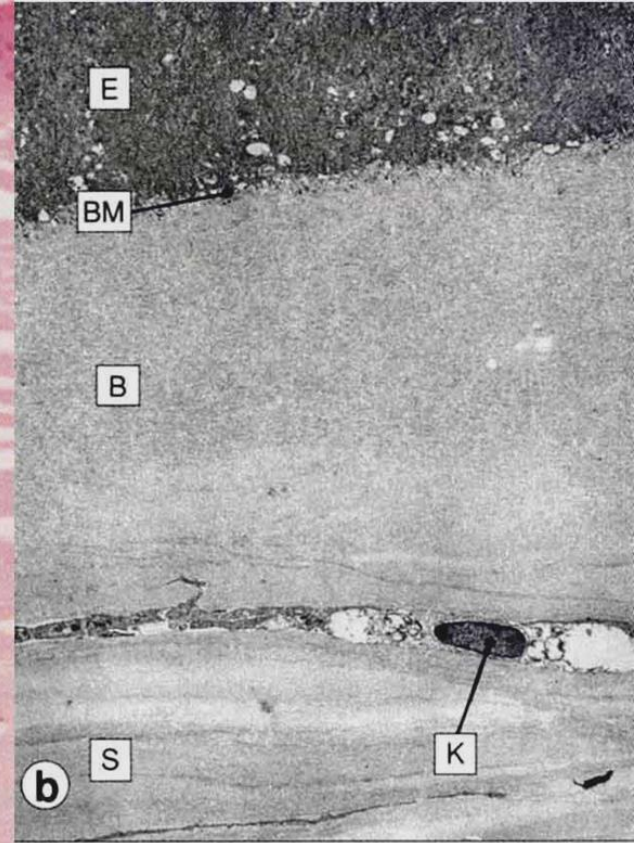
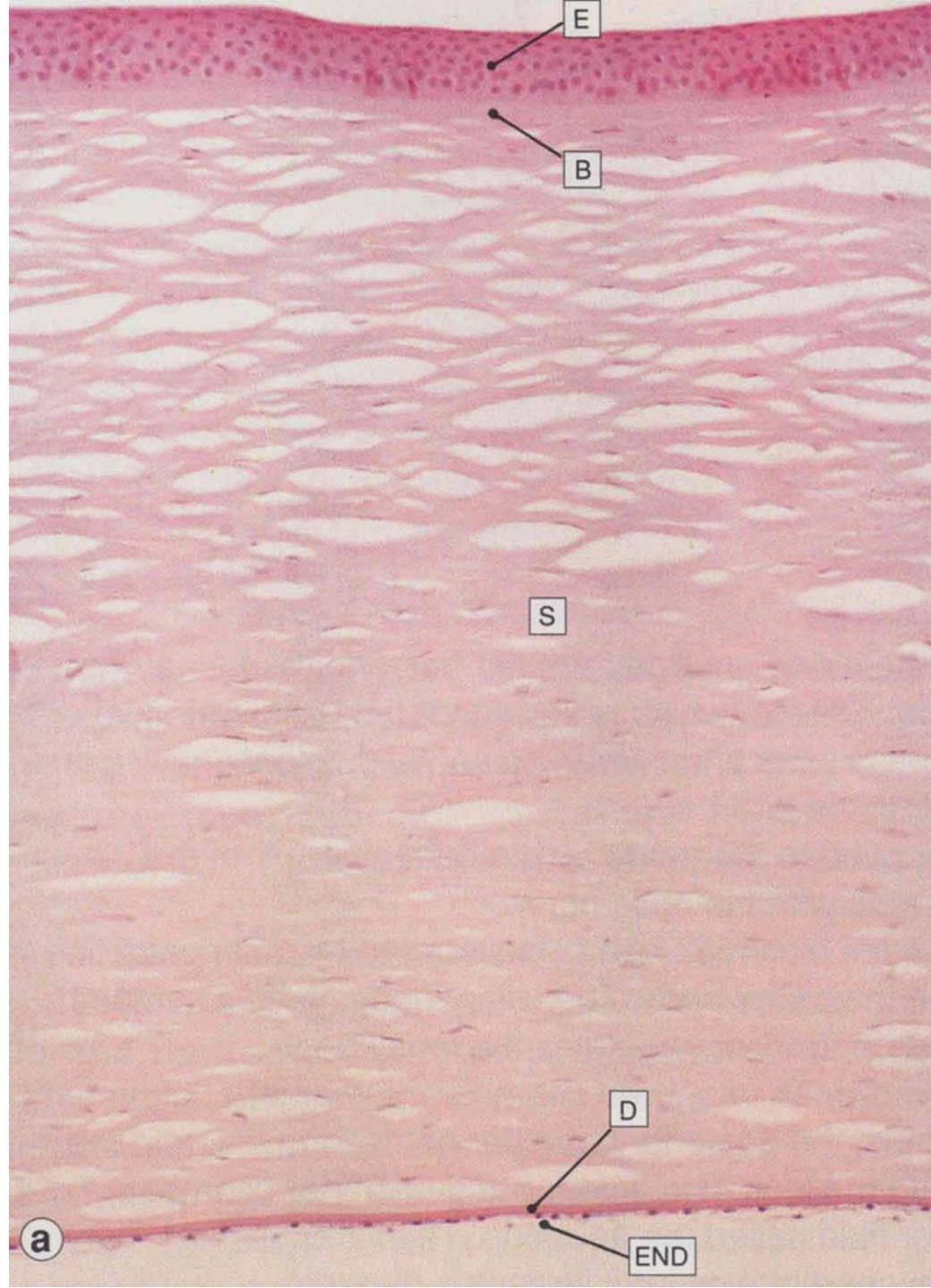
- **5 layers**
- Anterior epithelium
 - ***Stratified squamous nonkerat.***
- Lamina limitans anterior
 - ***Bowman's membrane***
- Substantia propria corneae
 - ***Dense regular connective tissue***
- Lamina limitans posterior
 - ***Descemet's membrane***
- Posterior epithelium
 - ***Simple squamous (endothelium)***

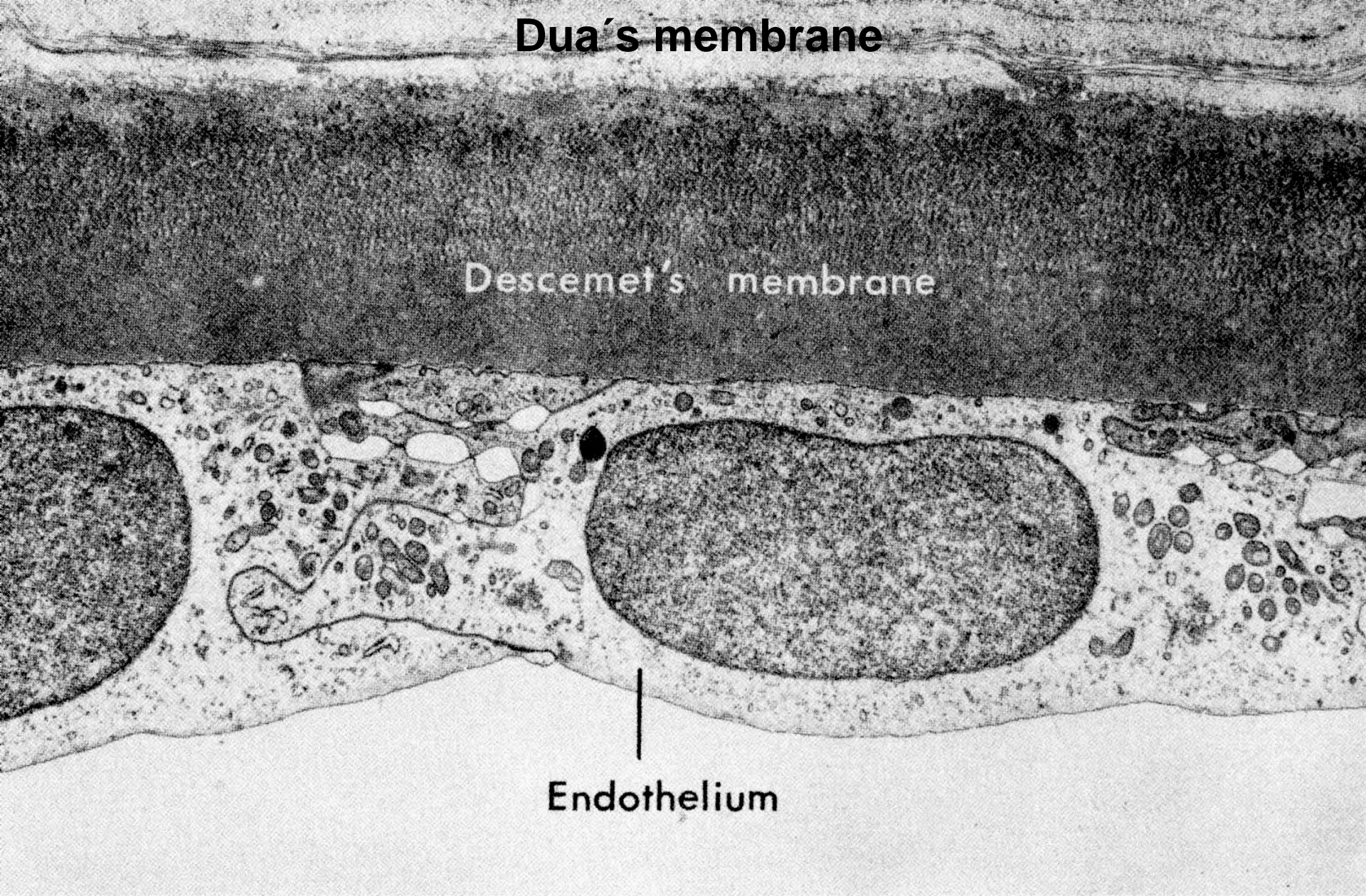


- Epithelial cell- 7 days
- sensory nerve endings
- Stroma – avascular
- nutrition- diffusion from anterior chamber

keratocytes

Fibroblast-like cells





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 μm



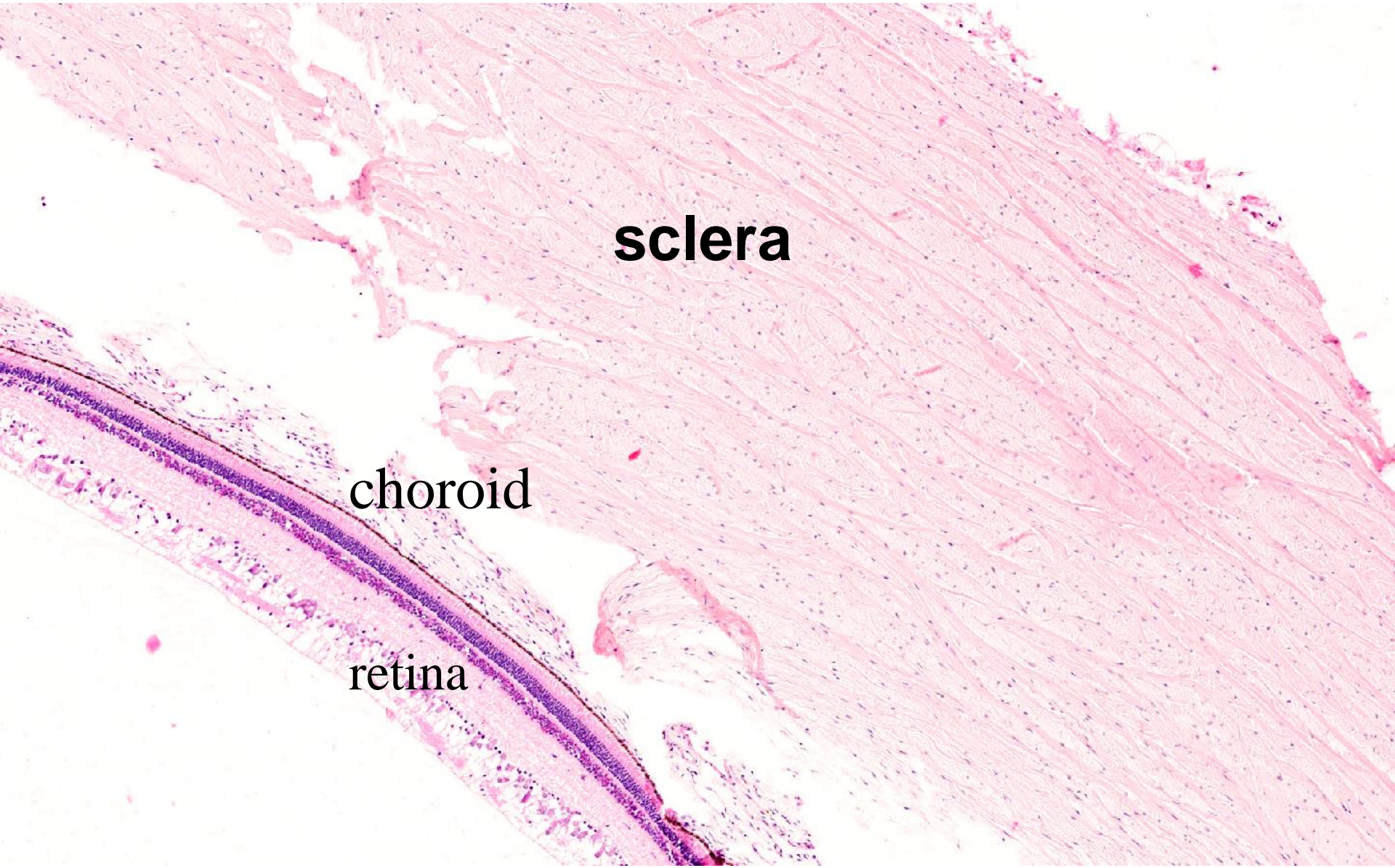
A histological section of the eye wall, stained with hematoxylin and eosin (H&E). The image shows the outer layers of the eye. On the left, a thin layer of conjunctiva is visible, characterized by stratified columnar epithelium and a lamina propria mucosae. A red arrow points to this layer. To the right of the conjunctiva is the thick, dense sclera, composed of dense irregular connective tissue. The sclera is shown as a broad, pink-stained band. On the far right, the inner layers of the eye are visible, including the choroid and the retina, which shows a complex, multi-layered structure with various cell types and pigments.

Conjunctiva

- Stratified columnar epithelium + lamina propria mucosae

Sclera

Dense irregular connective tissue



sclera

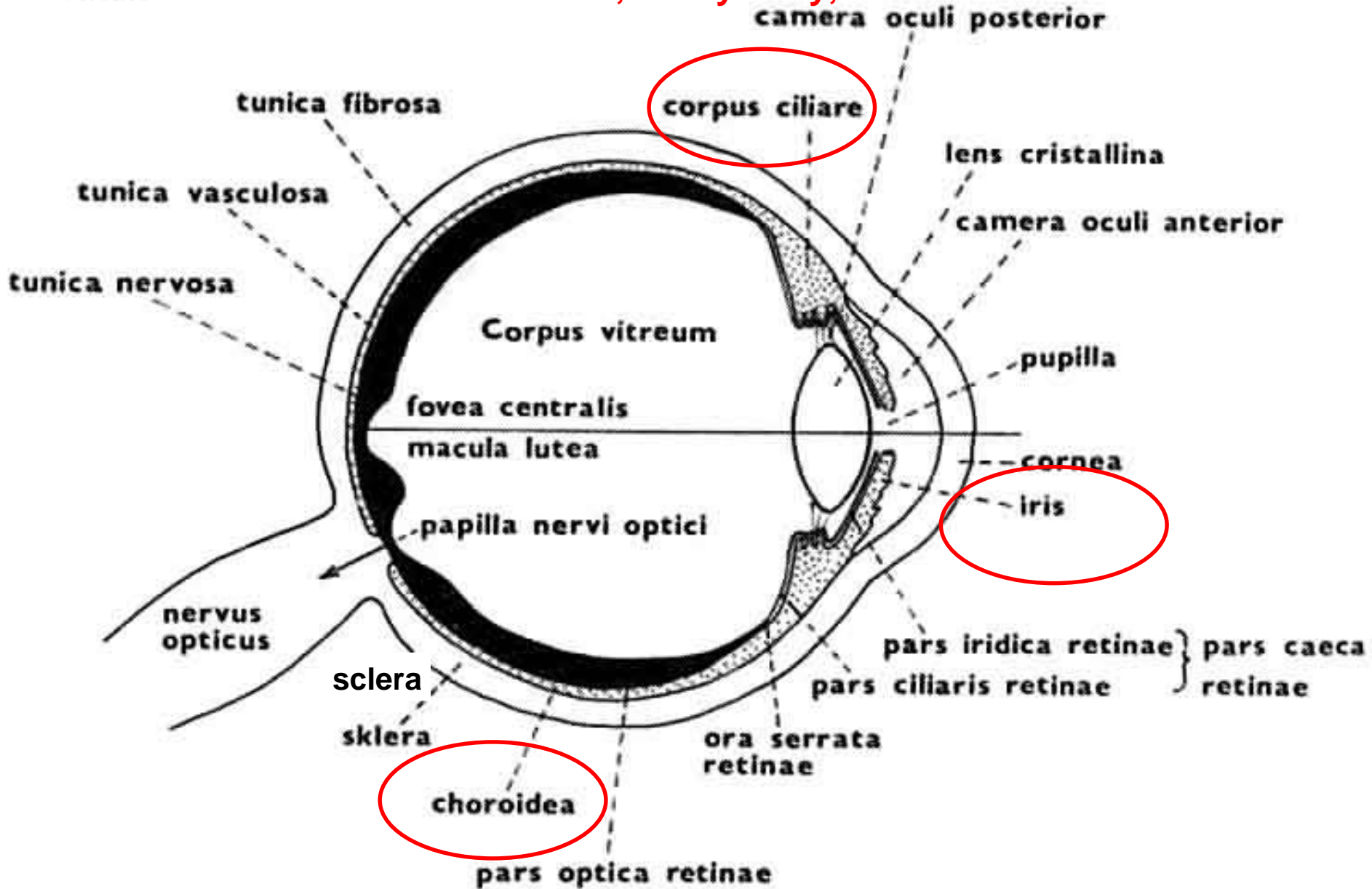
choroid

retina

Tunica vasculosa (vascular layer, uvea)

EYE

choroid, ciliary body, iris



Tunica vasculosa (media)

Choroid

- lamina suprachoroidea

• lamina (zona) vasculosa (choroid stroma)

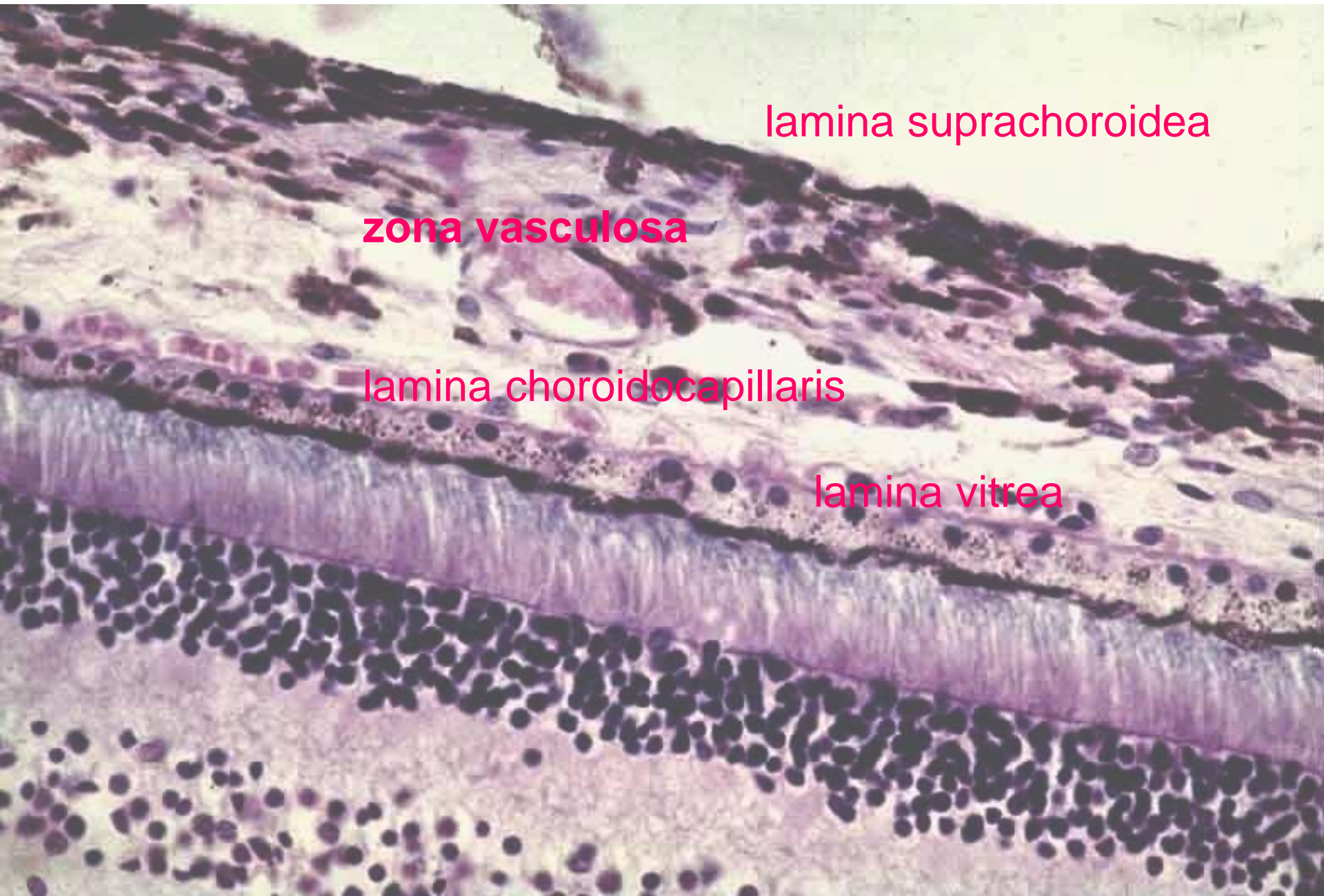
• – vessels, loose connective tissue, smooth muscle cells, nerves

• lamina choroidocapillaris

– capillaries

lamina vitrea = *Bruch's membrane*

- – BL of pigmented retinal epithelium, collagen and elastic fibres, BL of capillaries



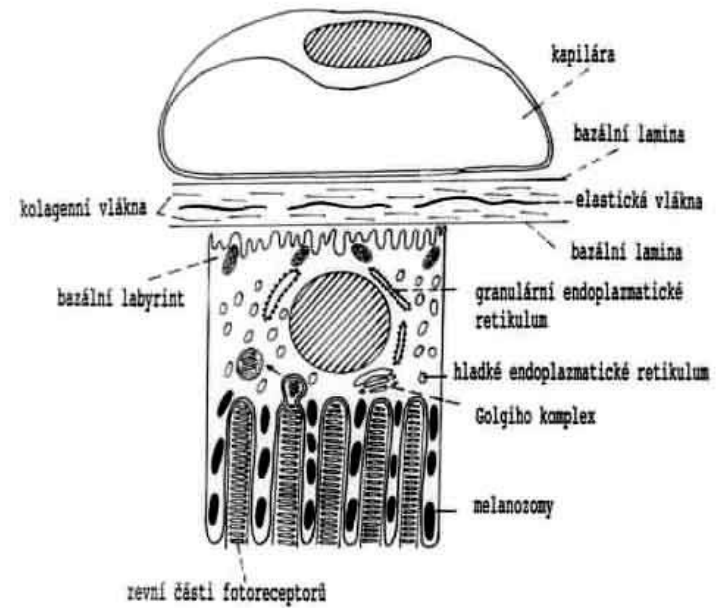
lamina suprachoroidea

zona vasculosa

lamina choroidocapillaris

lamina vitrea

lamina vasculosa



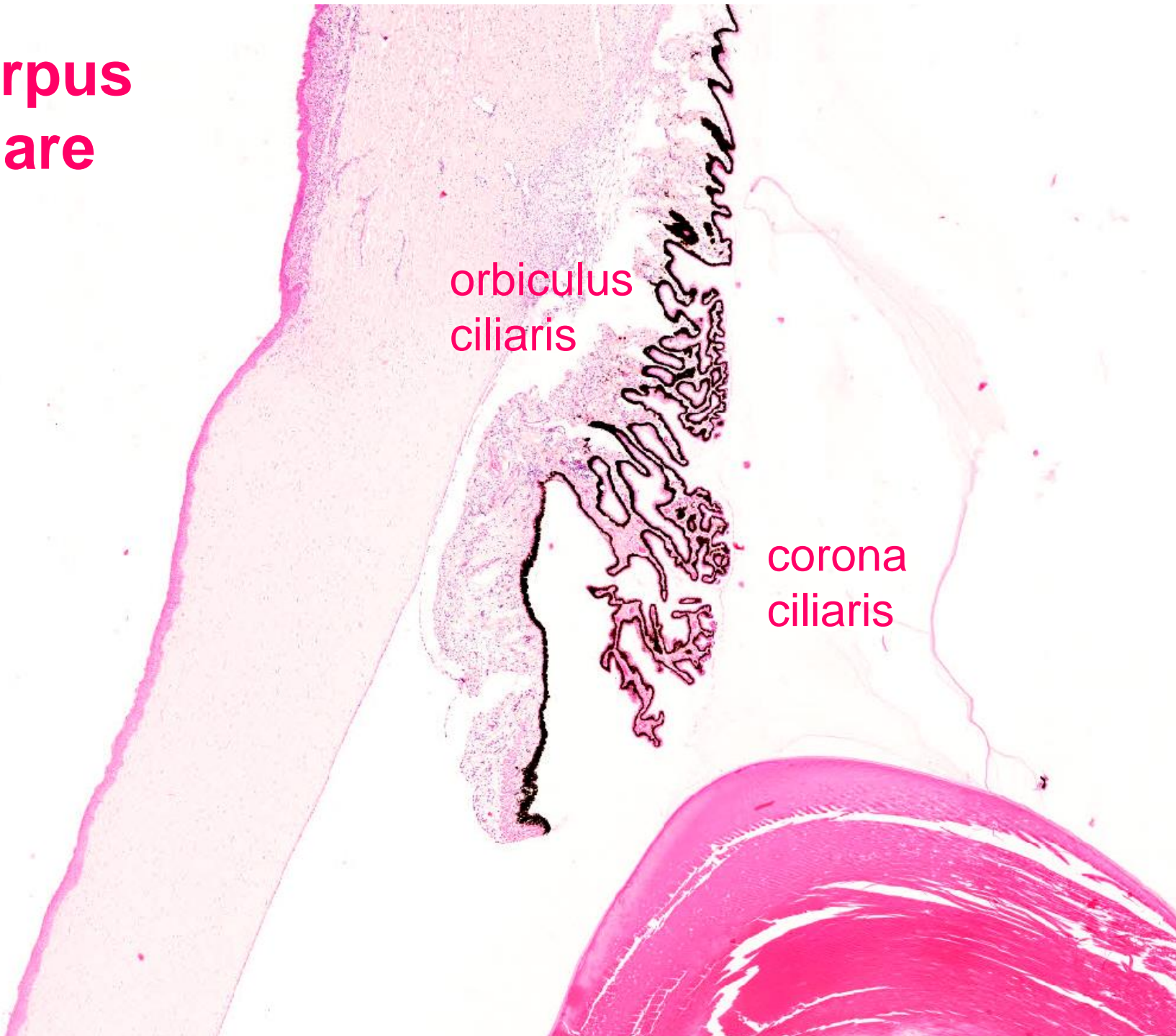
lamina choroidocapillaris

lamina vitrea

Corpus ciliare

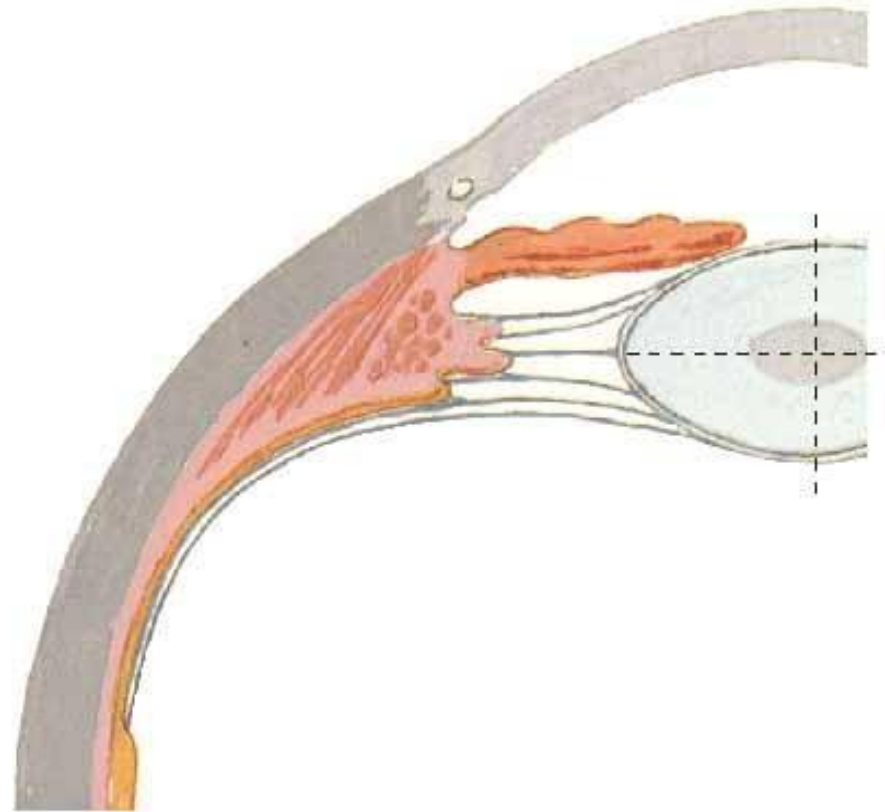
orbiculus ciliaris

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



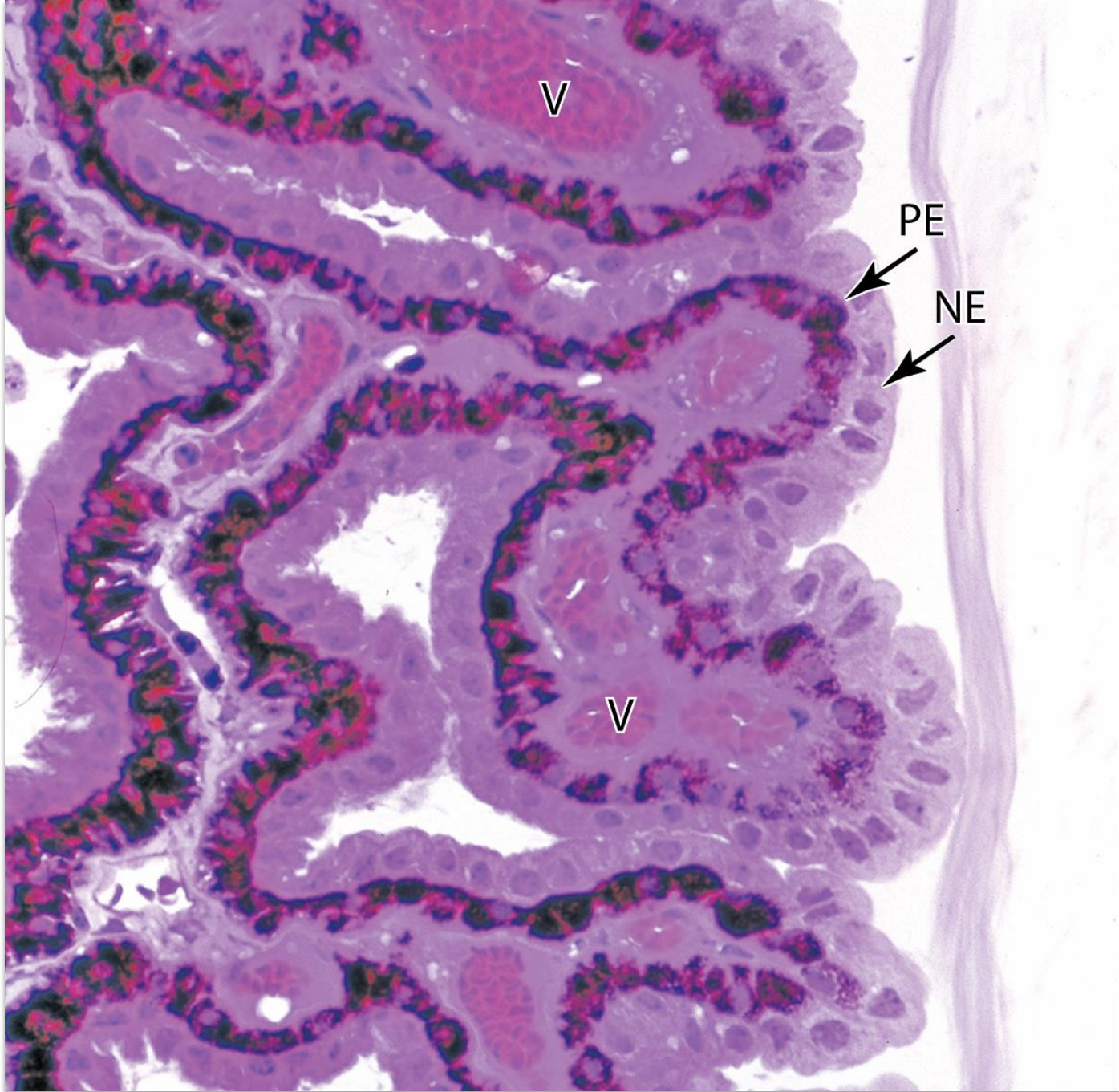
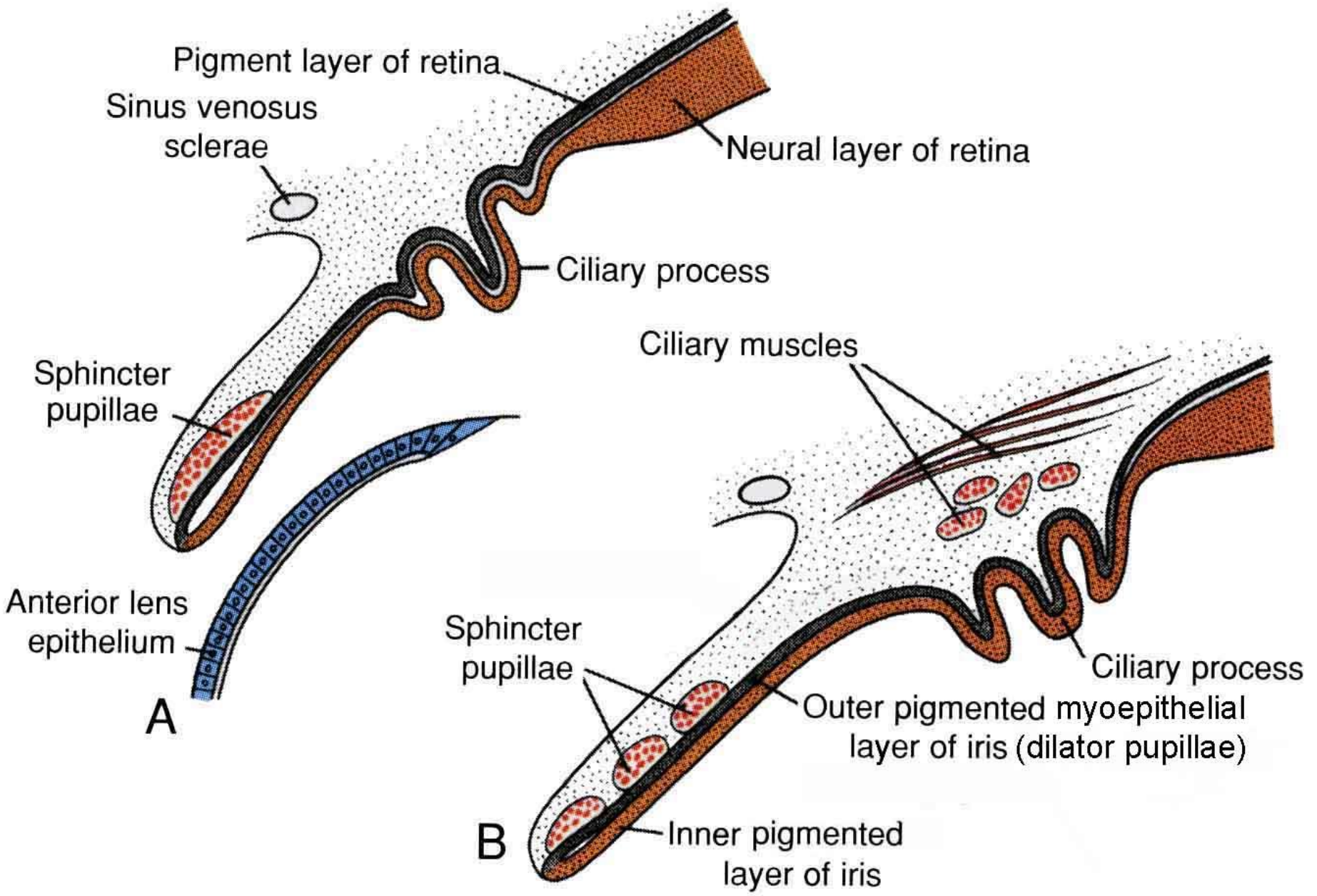
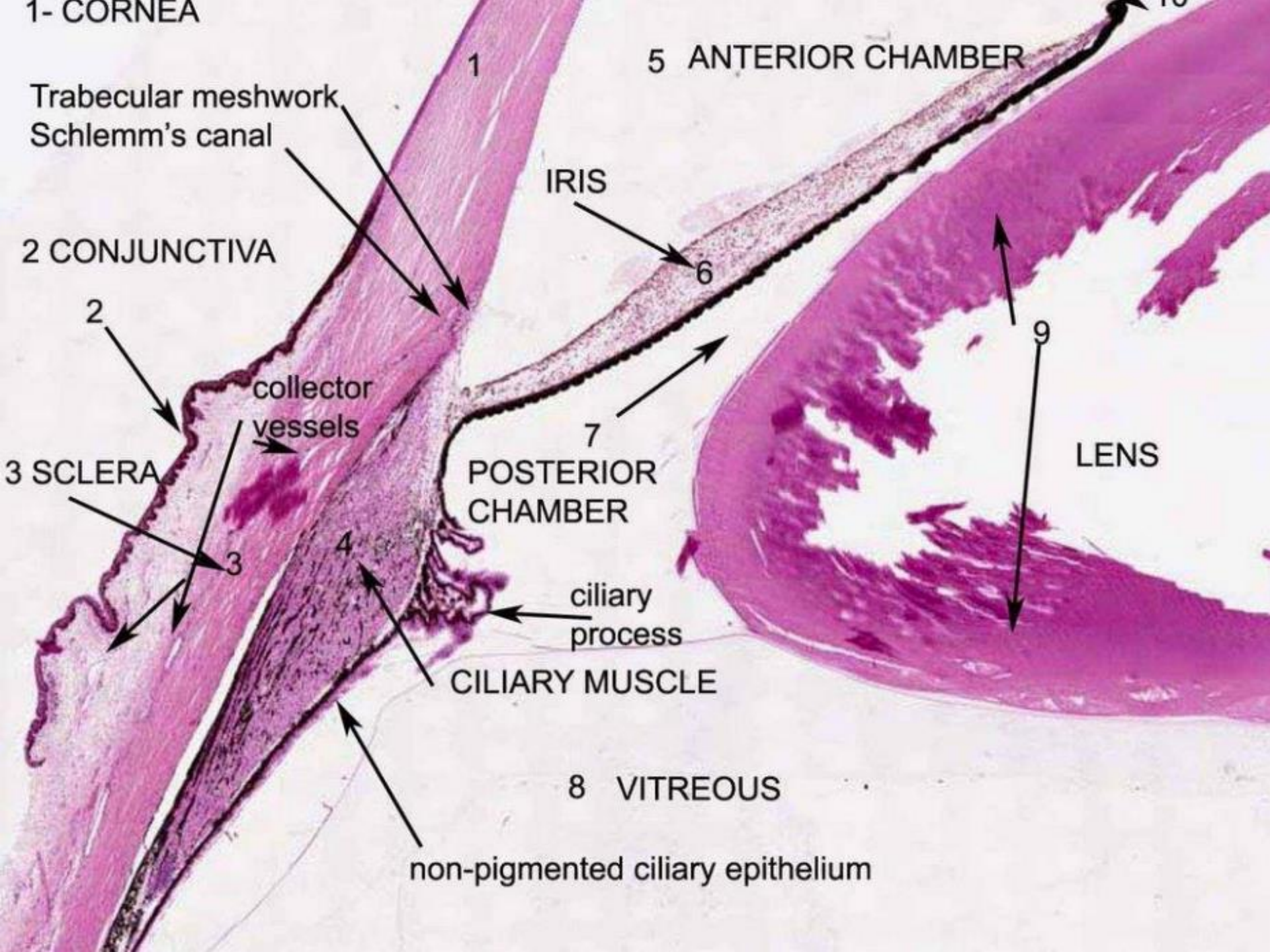


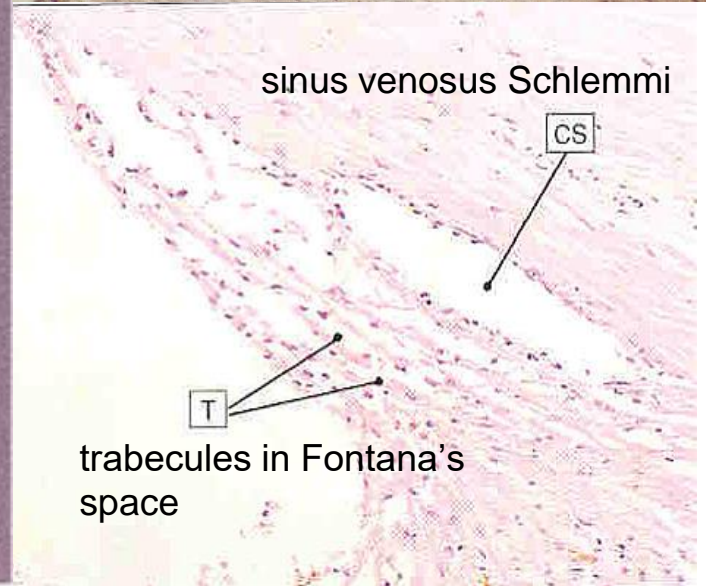
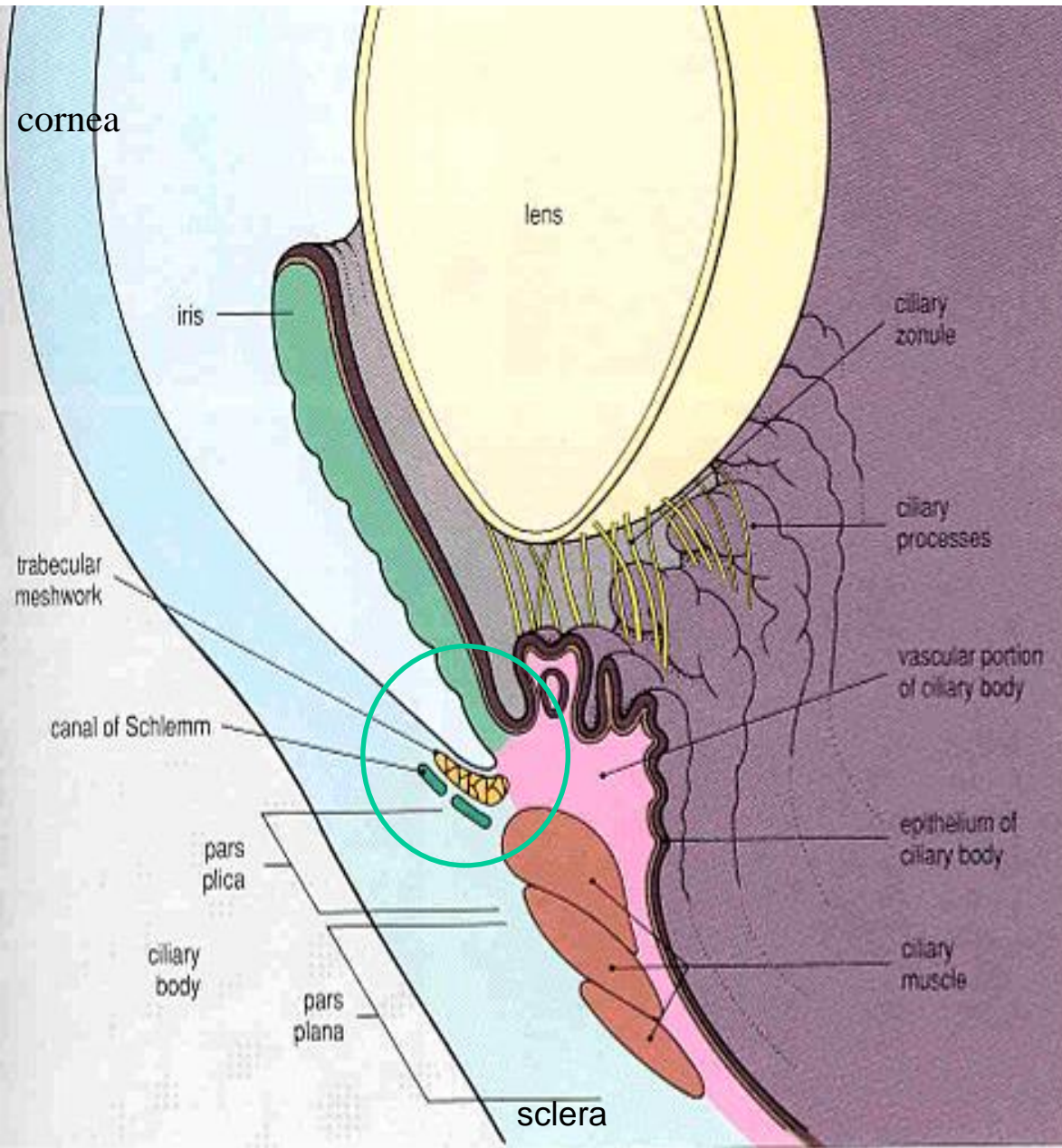
Figure 23-7

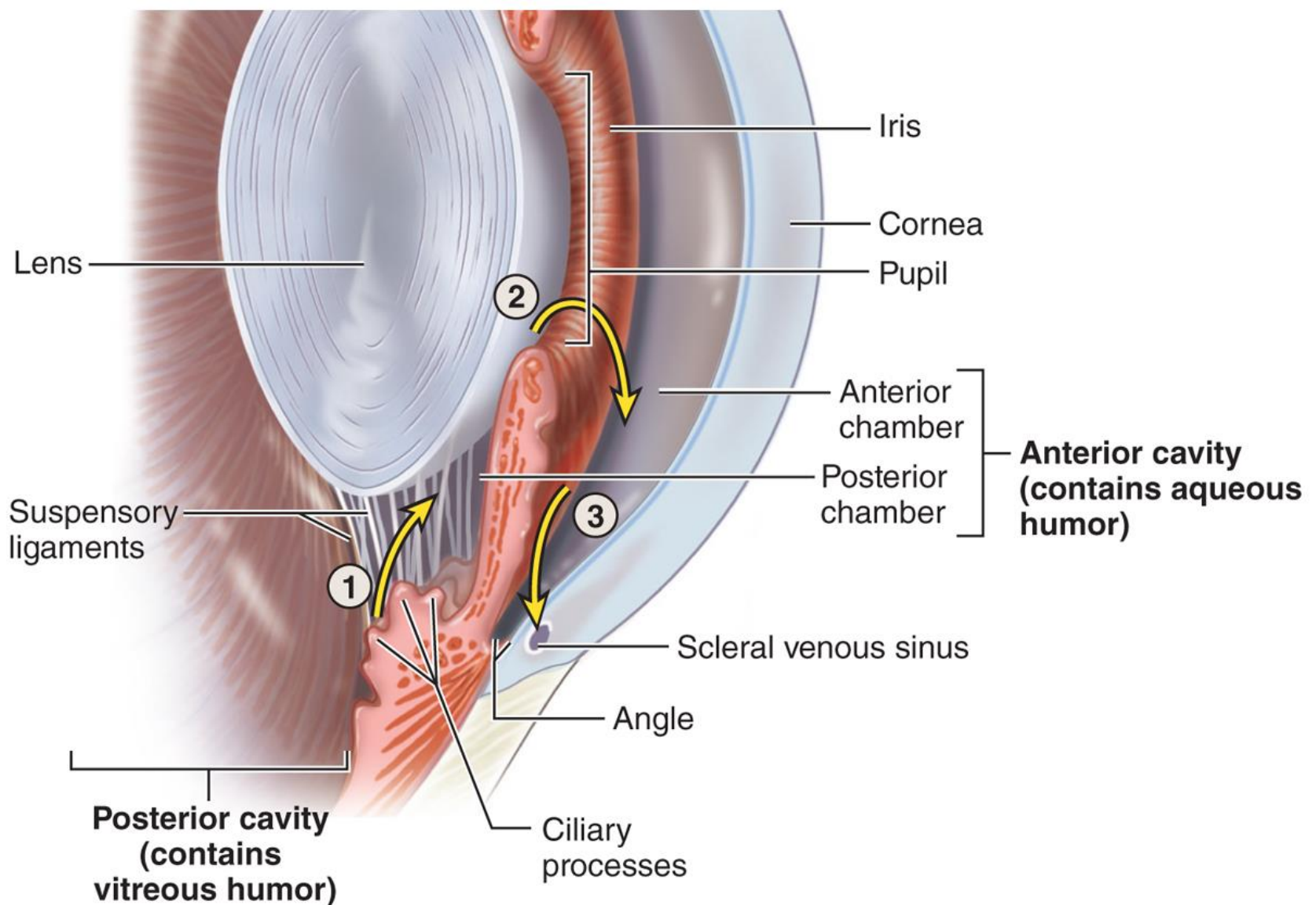






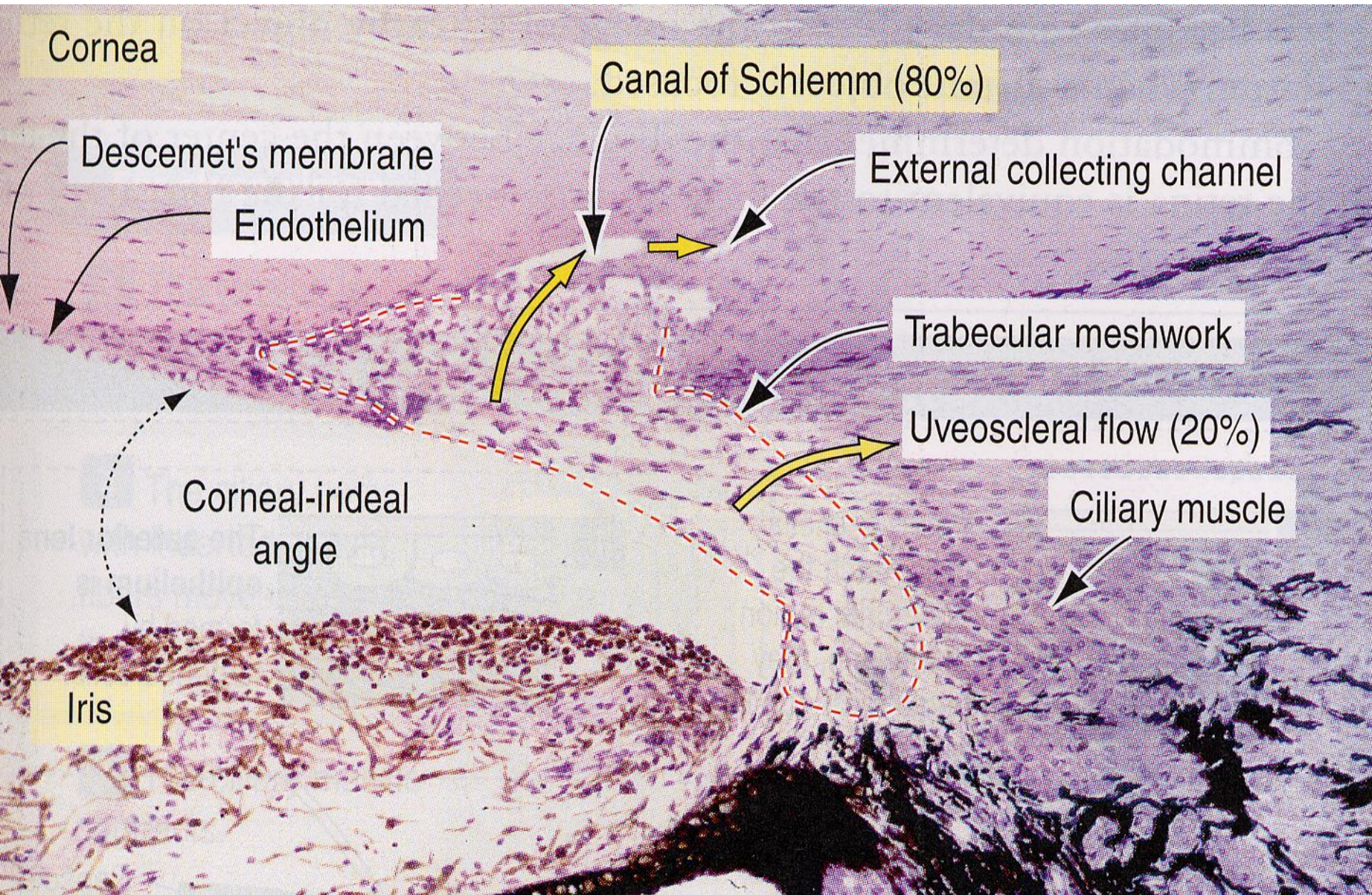
iridocorneal angle





- 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

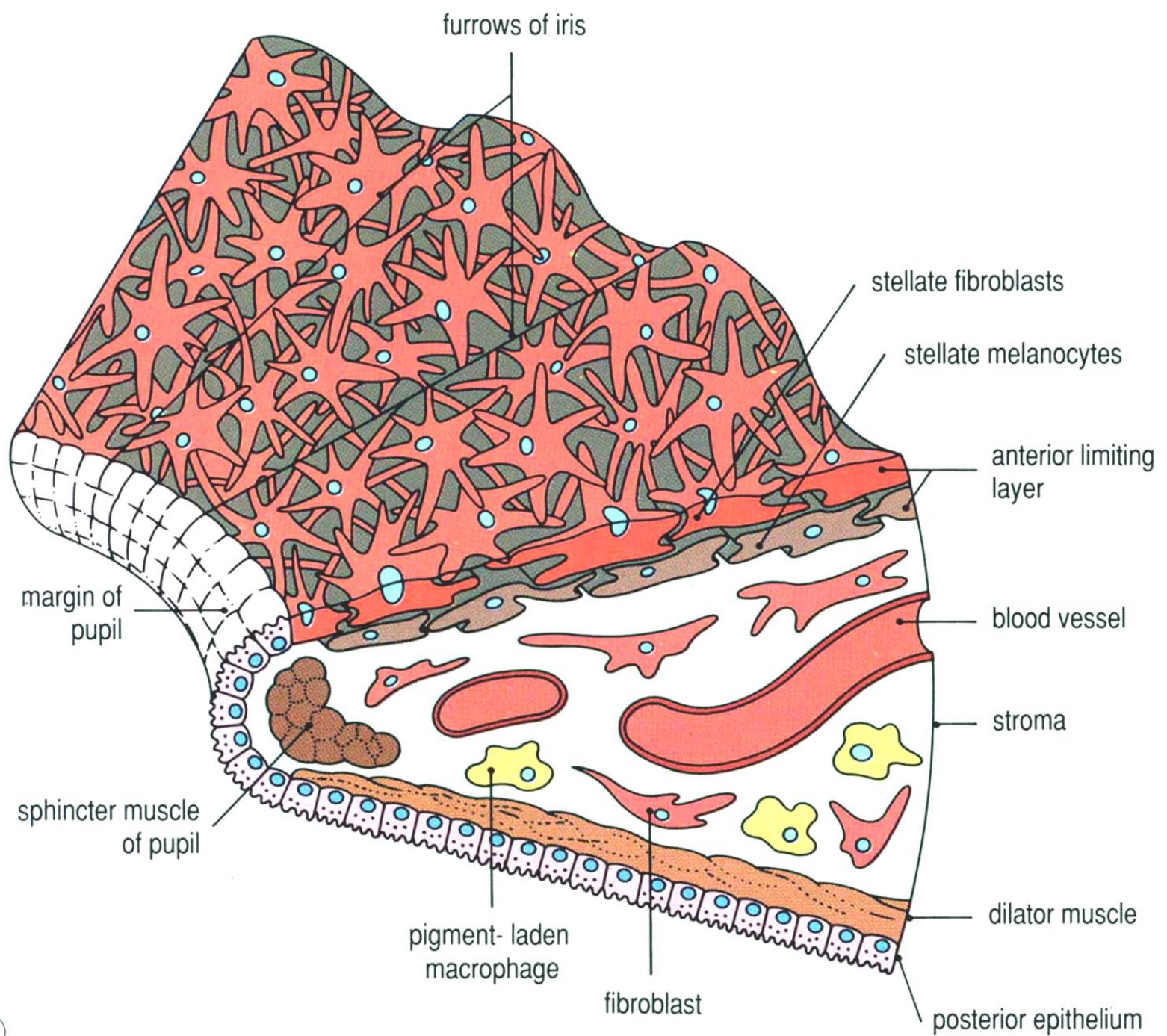
Iris

- annular shape, flat
- aperture function
- pupilla



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





a

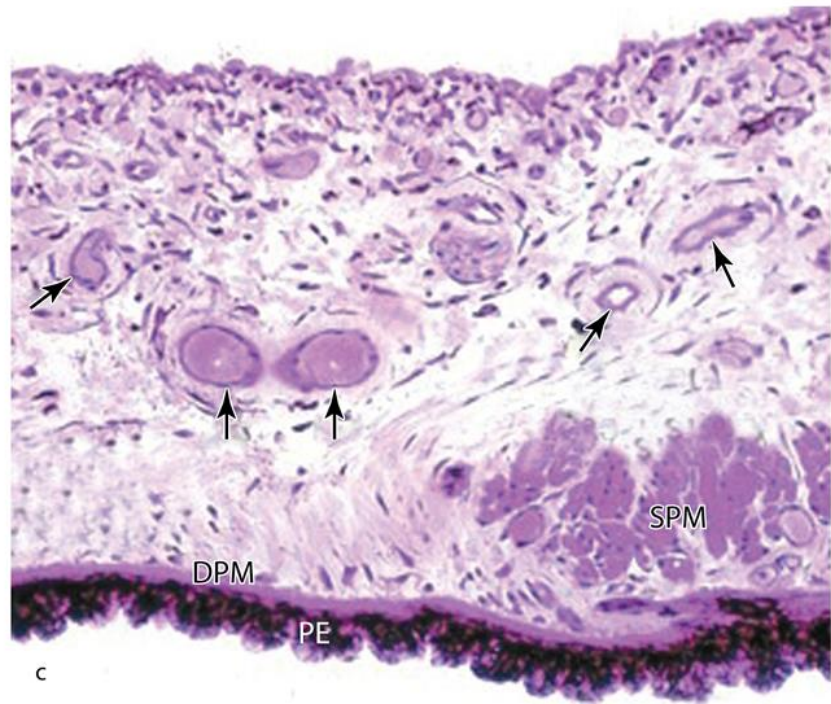
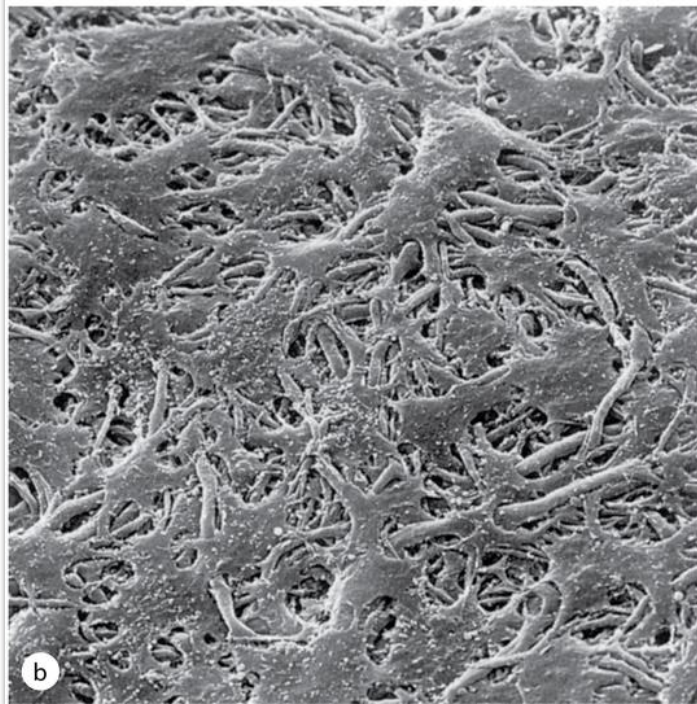
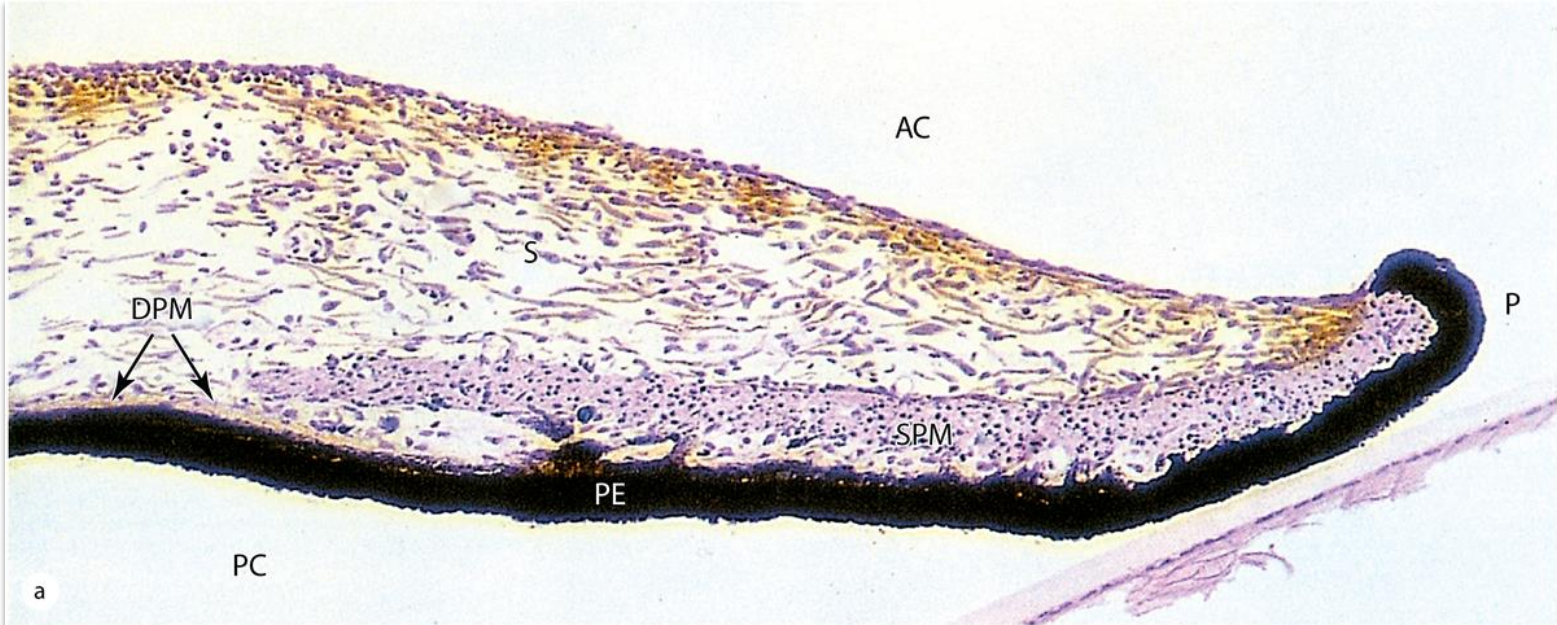
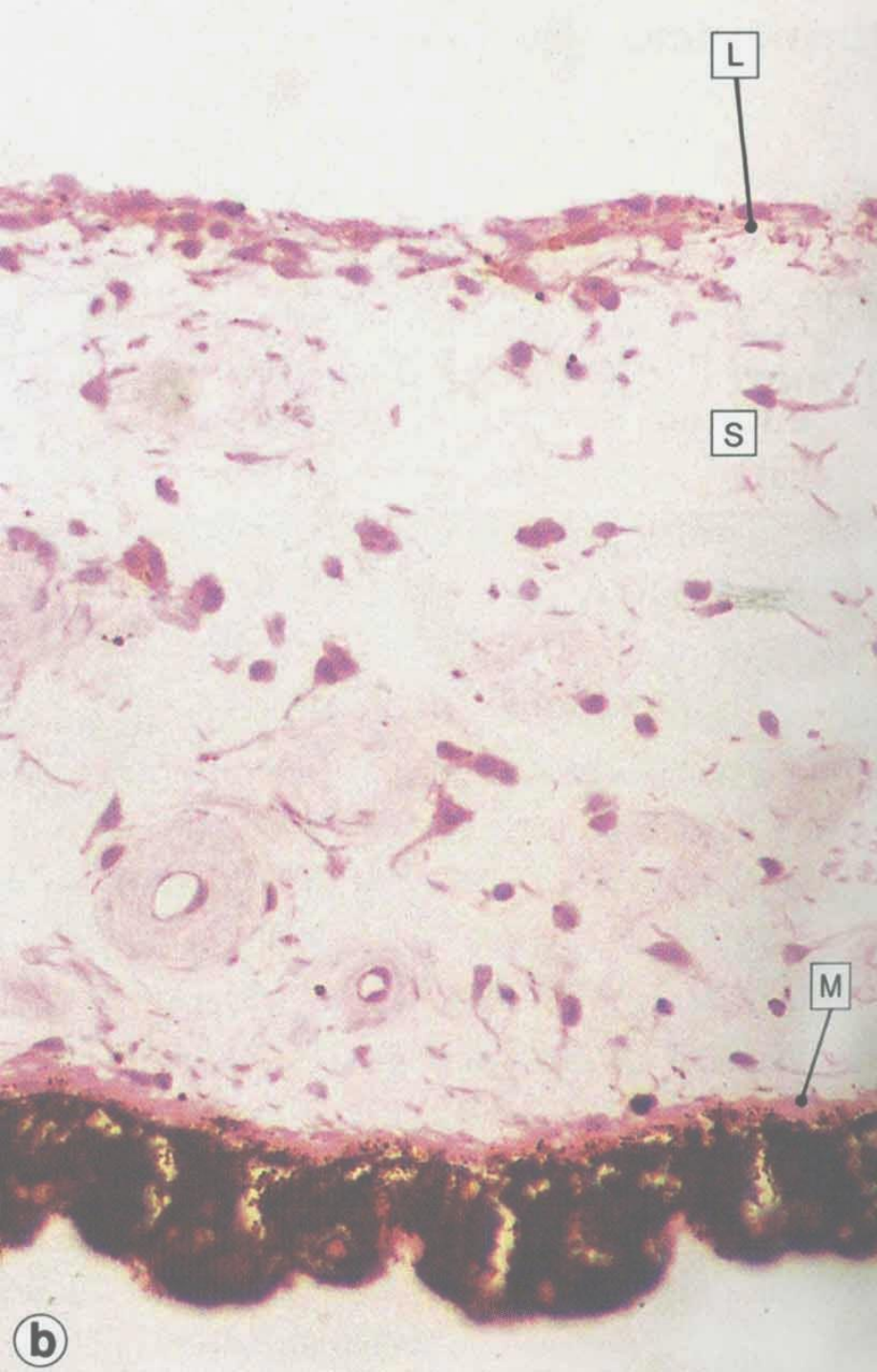


Figure 23-10

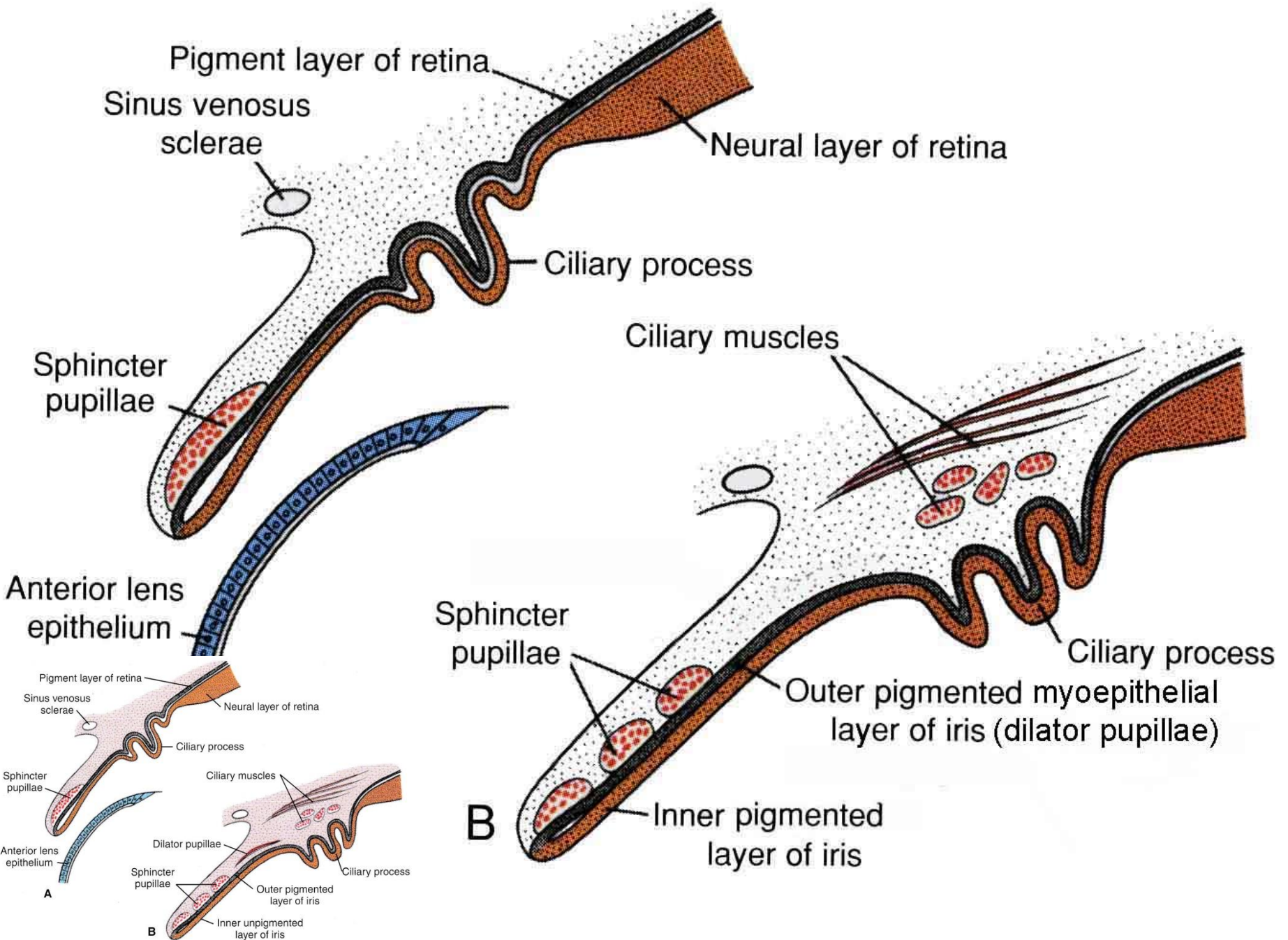


anterior limiting layer

stroma iridis

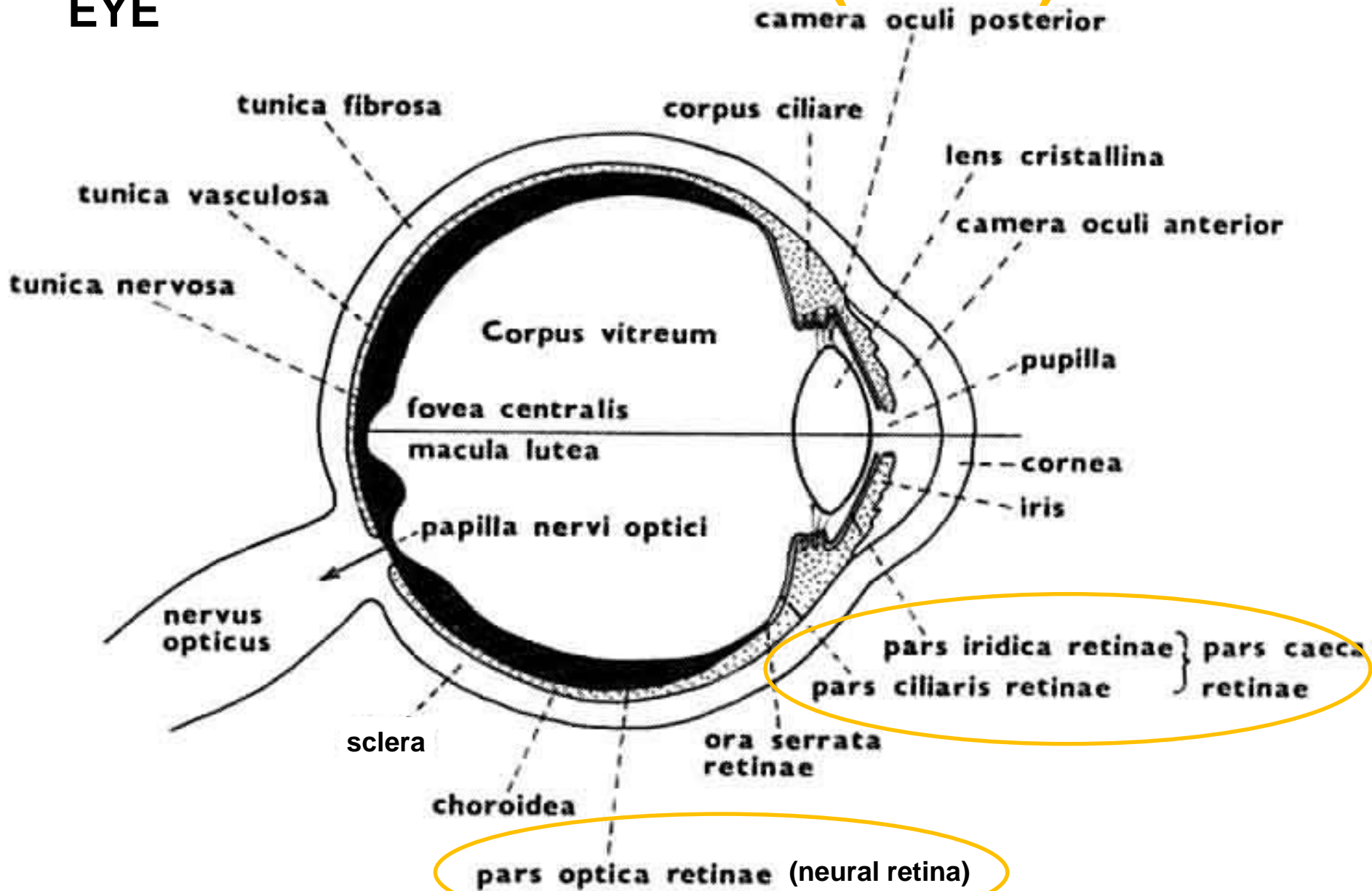
posterior limiting layer (m. dilat.)
posterior epithelium (pigment)

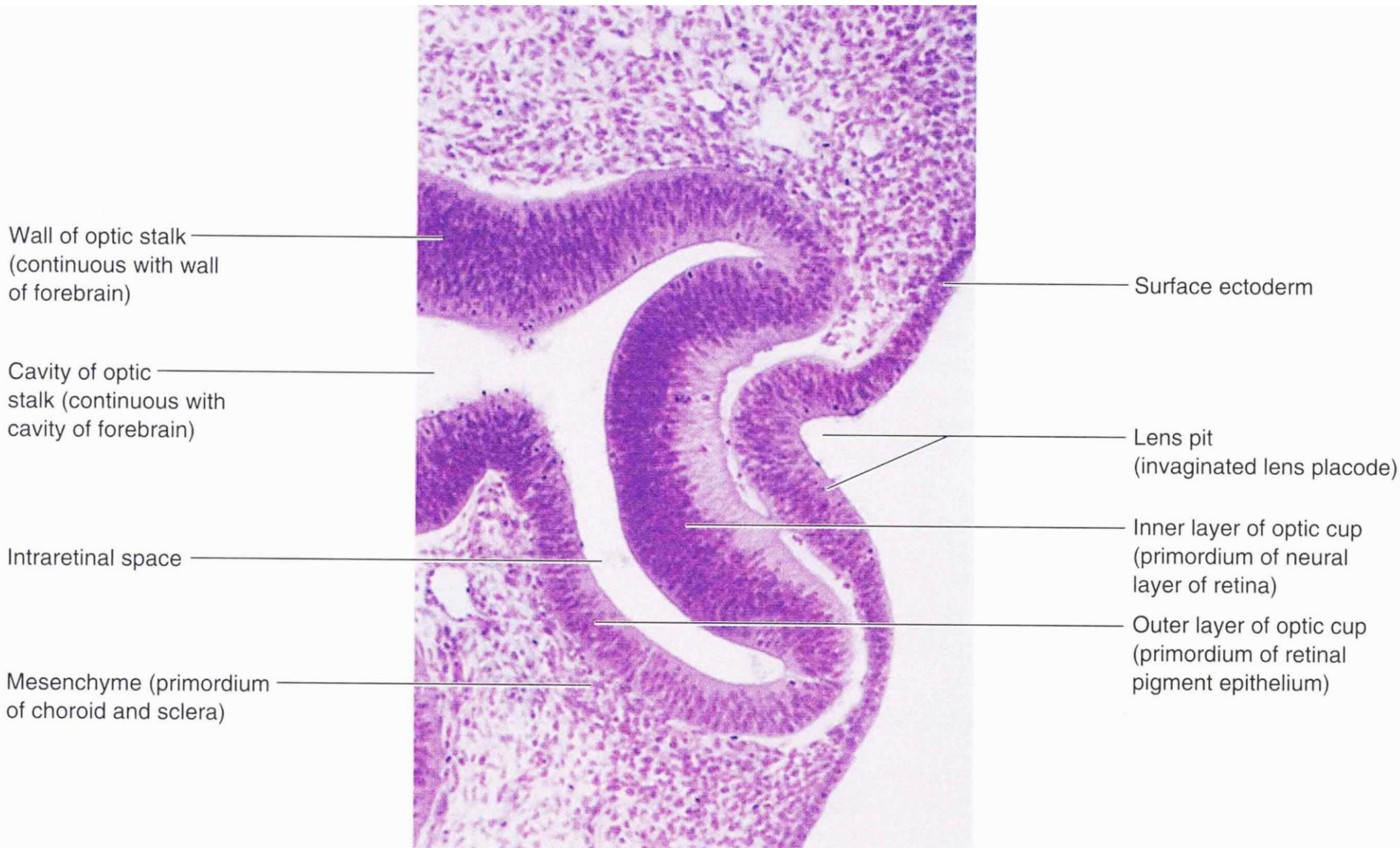
b



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

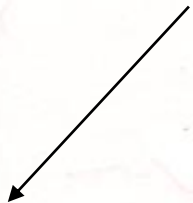
Lens pit
(invaginated lens placode)

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

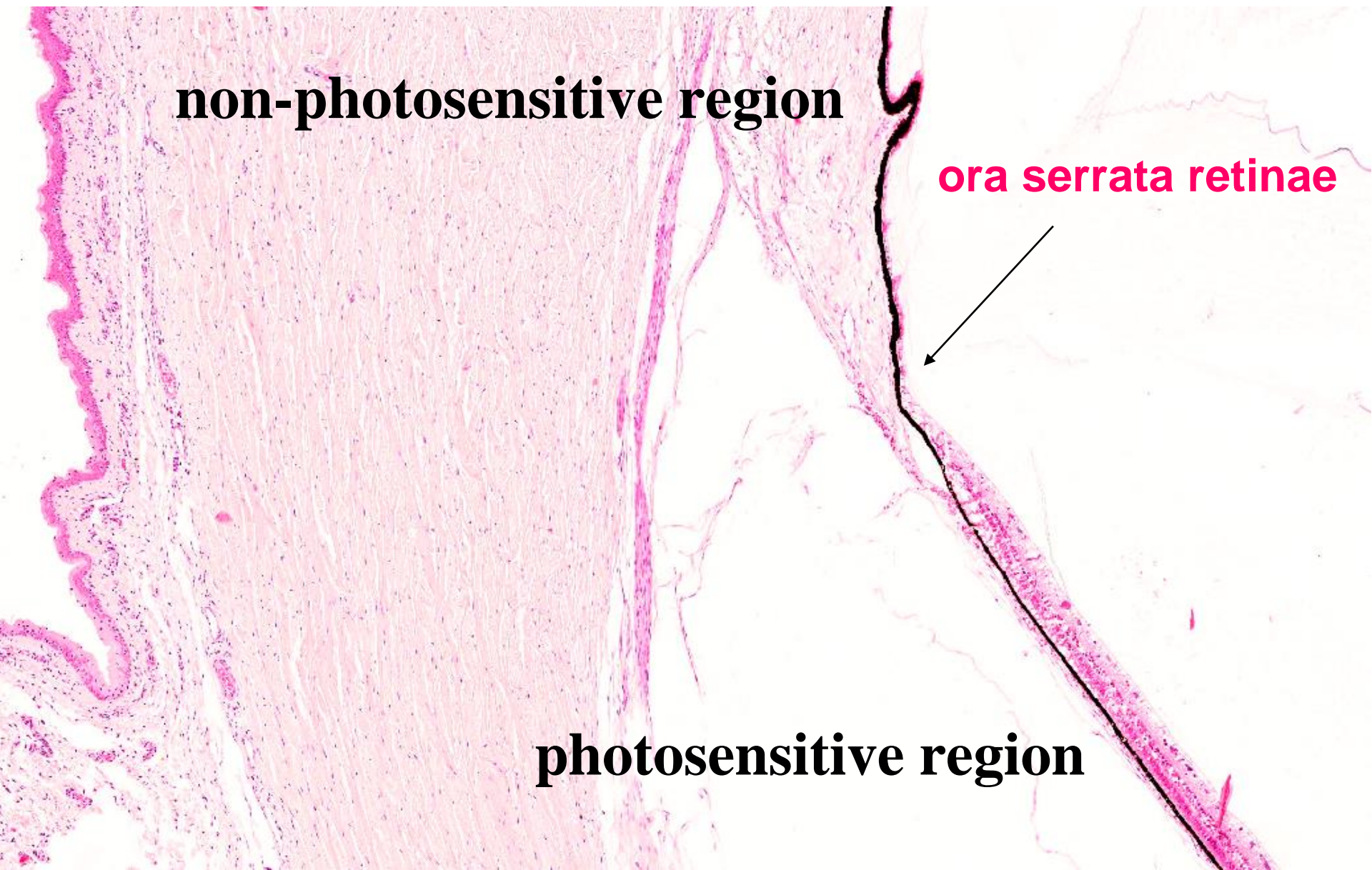
Outer layer of optic cup
(primordium of retinal
pigment epithelium)

non-photosensitive region

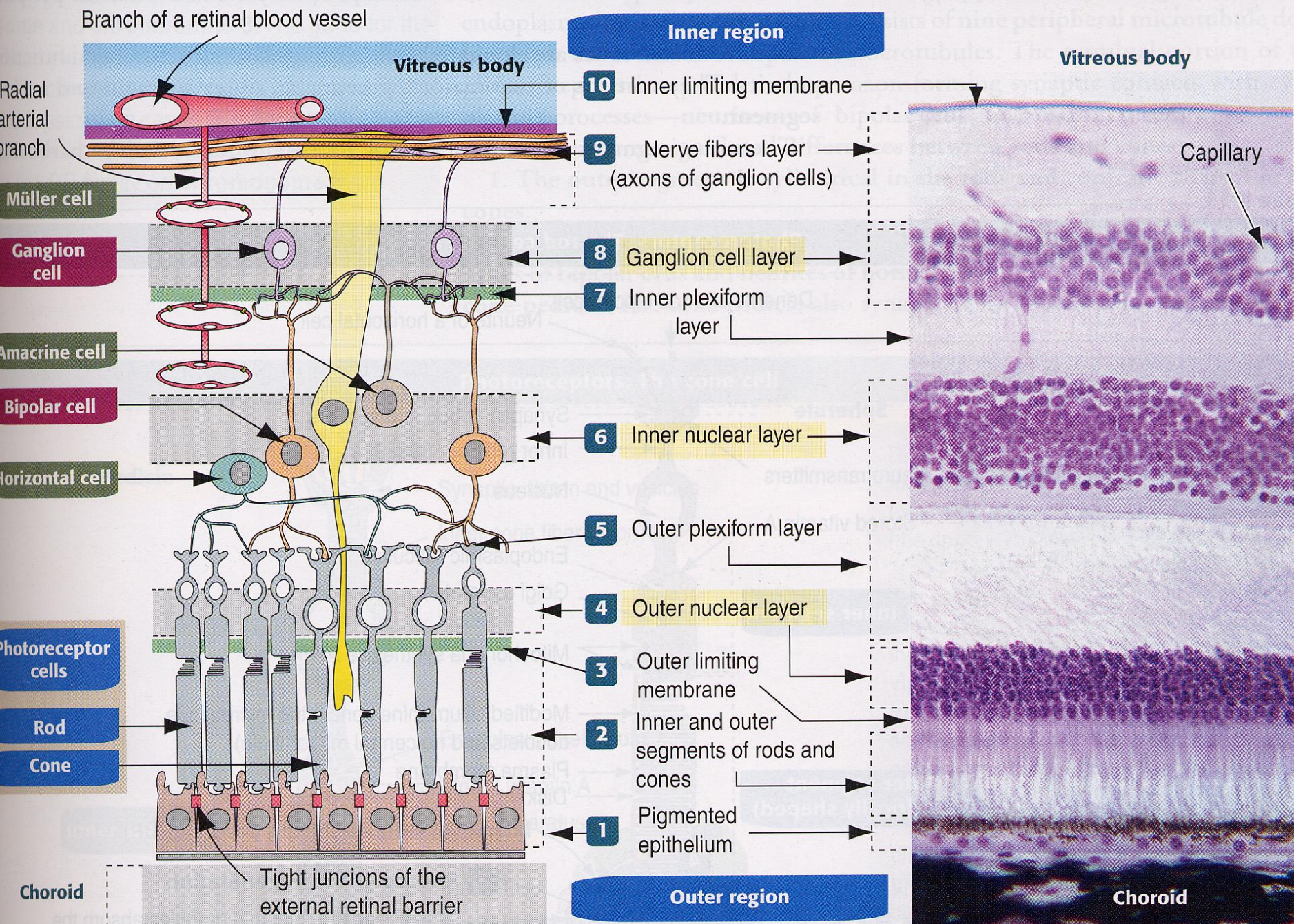
ora serrata retinae



photosensitive region

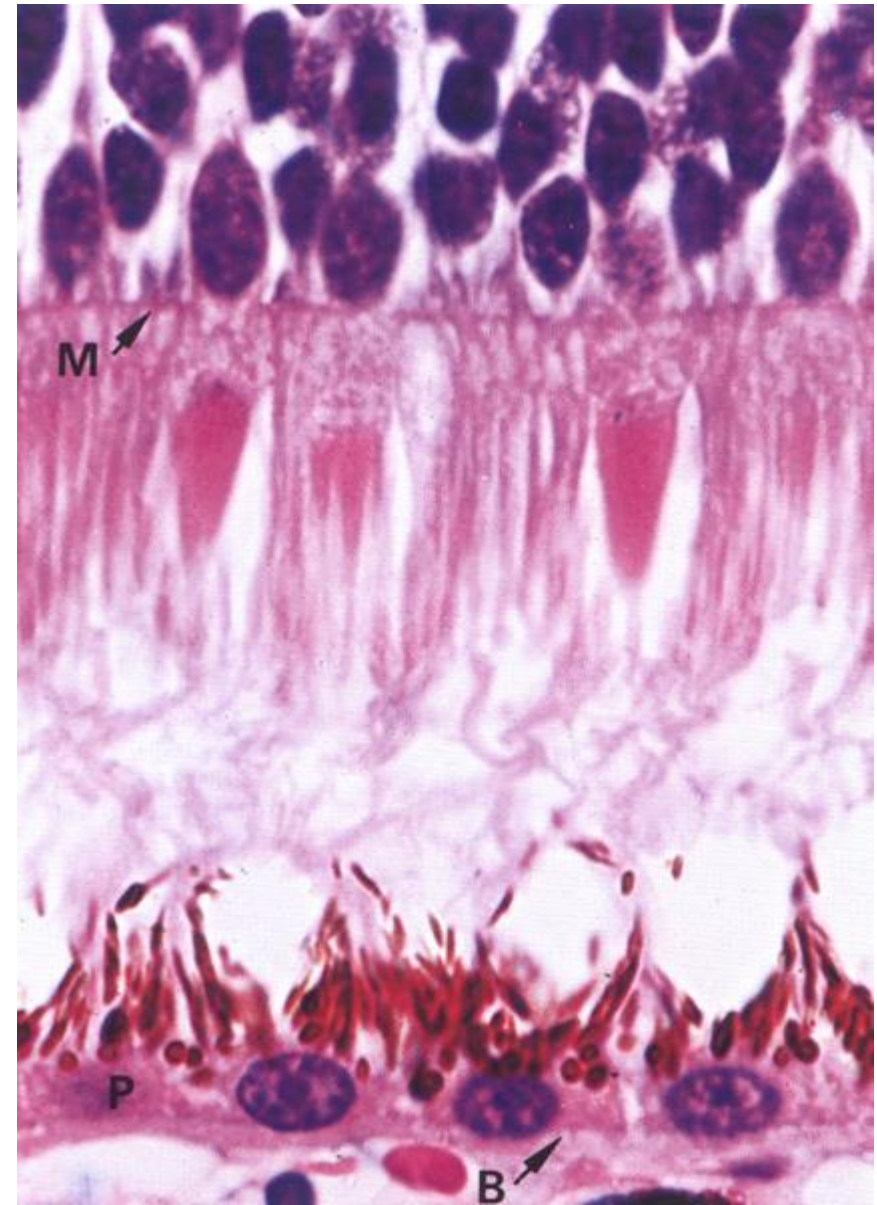
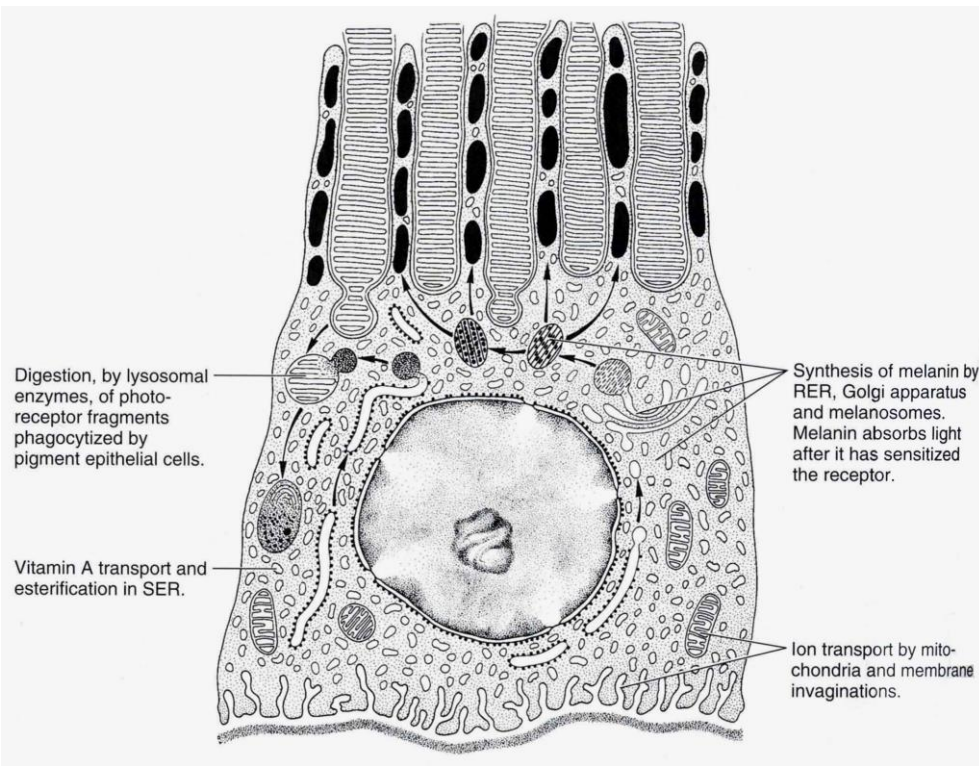


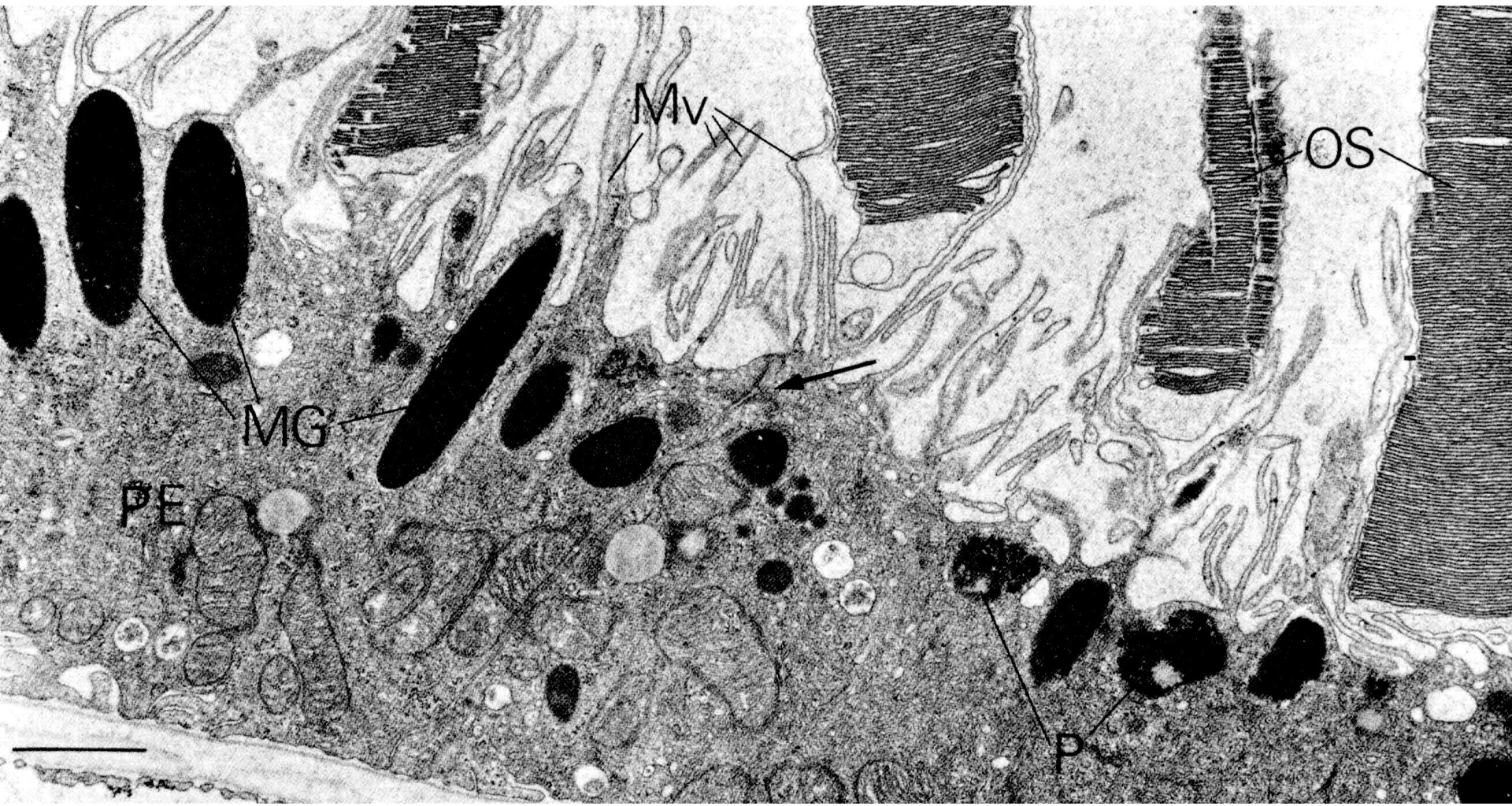
The layers of the retina



1st layer of retina - pigmented epithelium

- absorb light
- barrier
- restoring photosensitivity
- phagocytosis

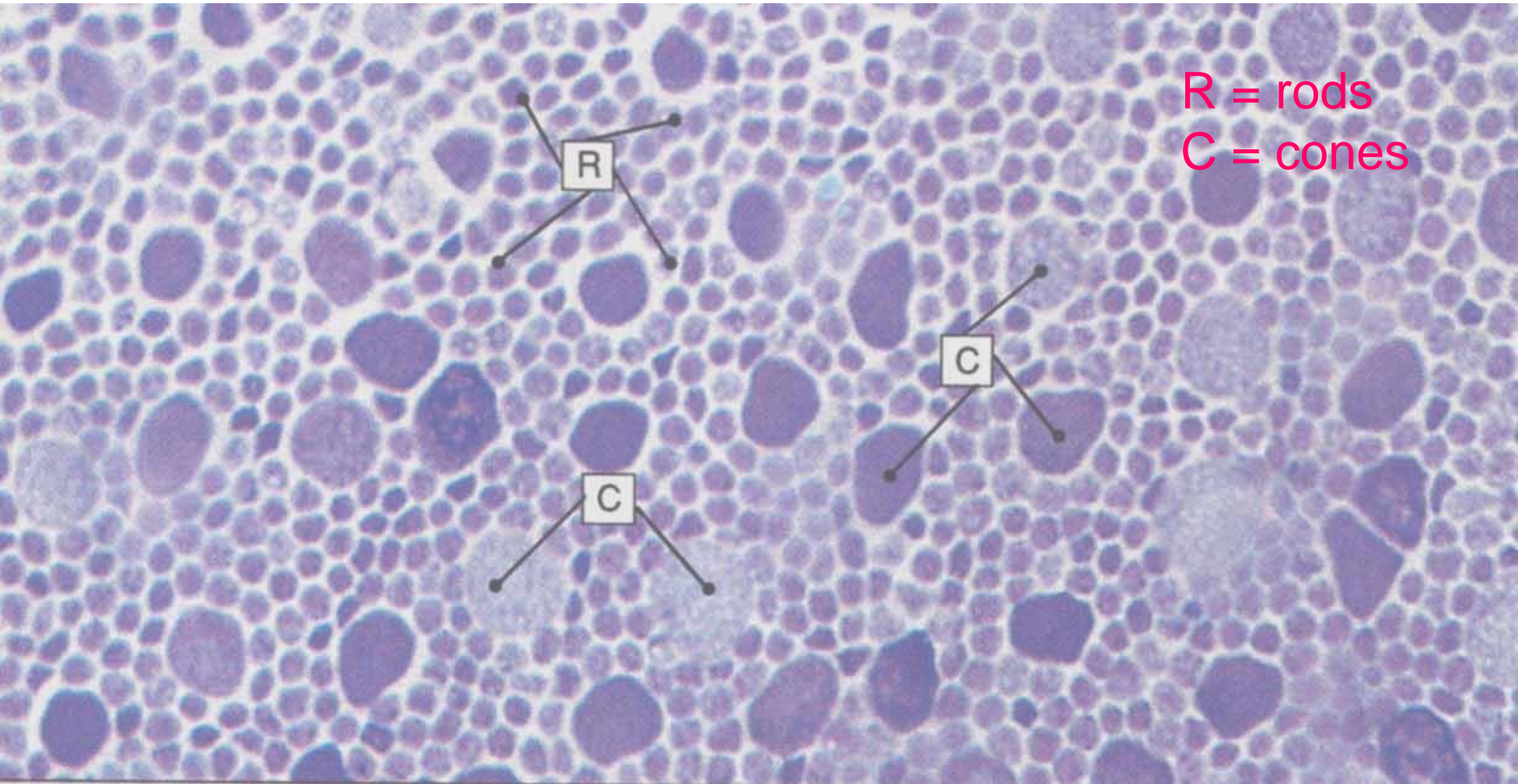




Visual photoreception – ciliary photoreceptors

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

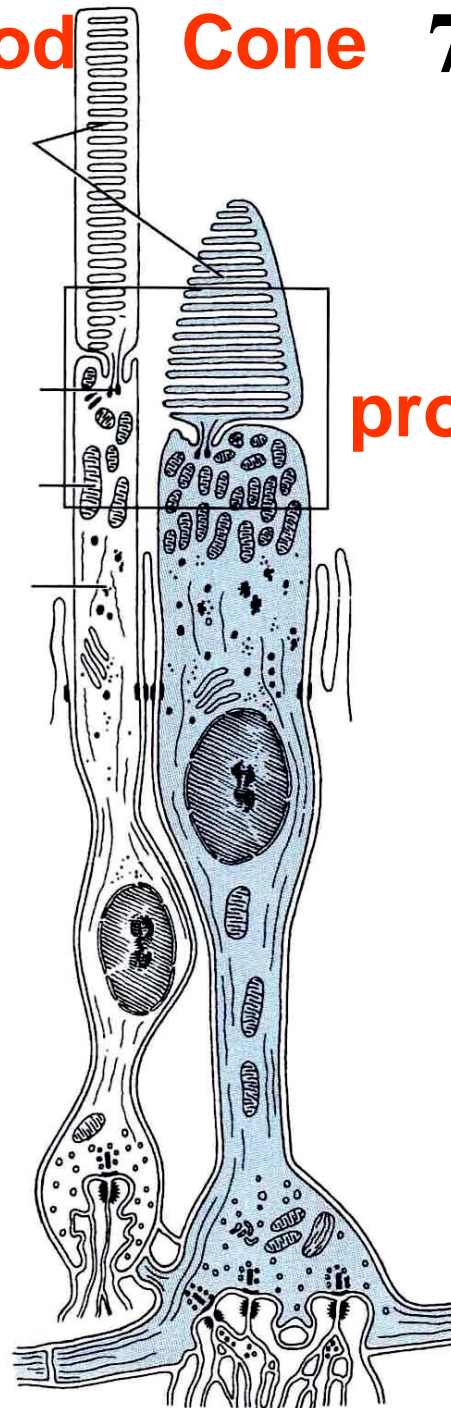
outer segment

constriction

inner segment

area of nucleus

area of synapses



proper rod (cone)

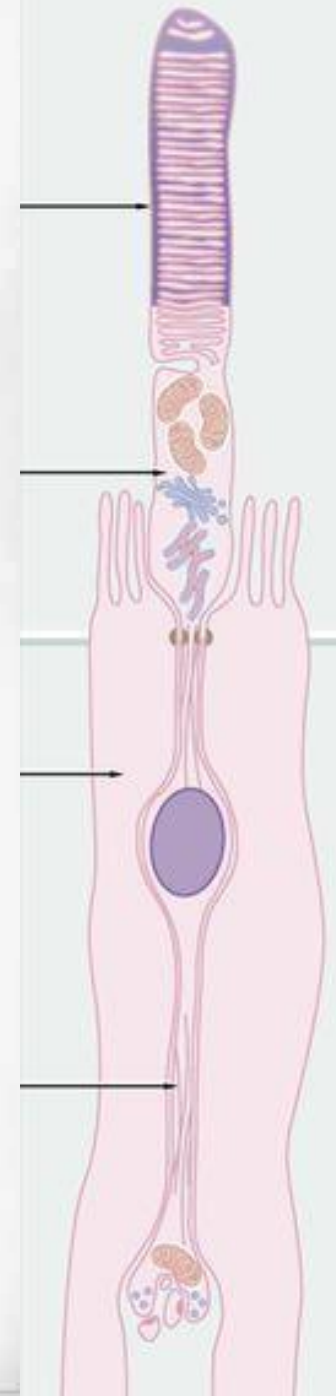
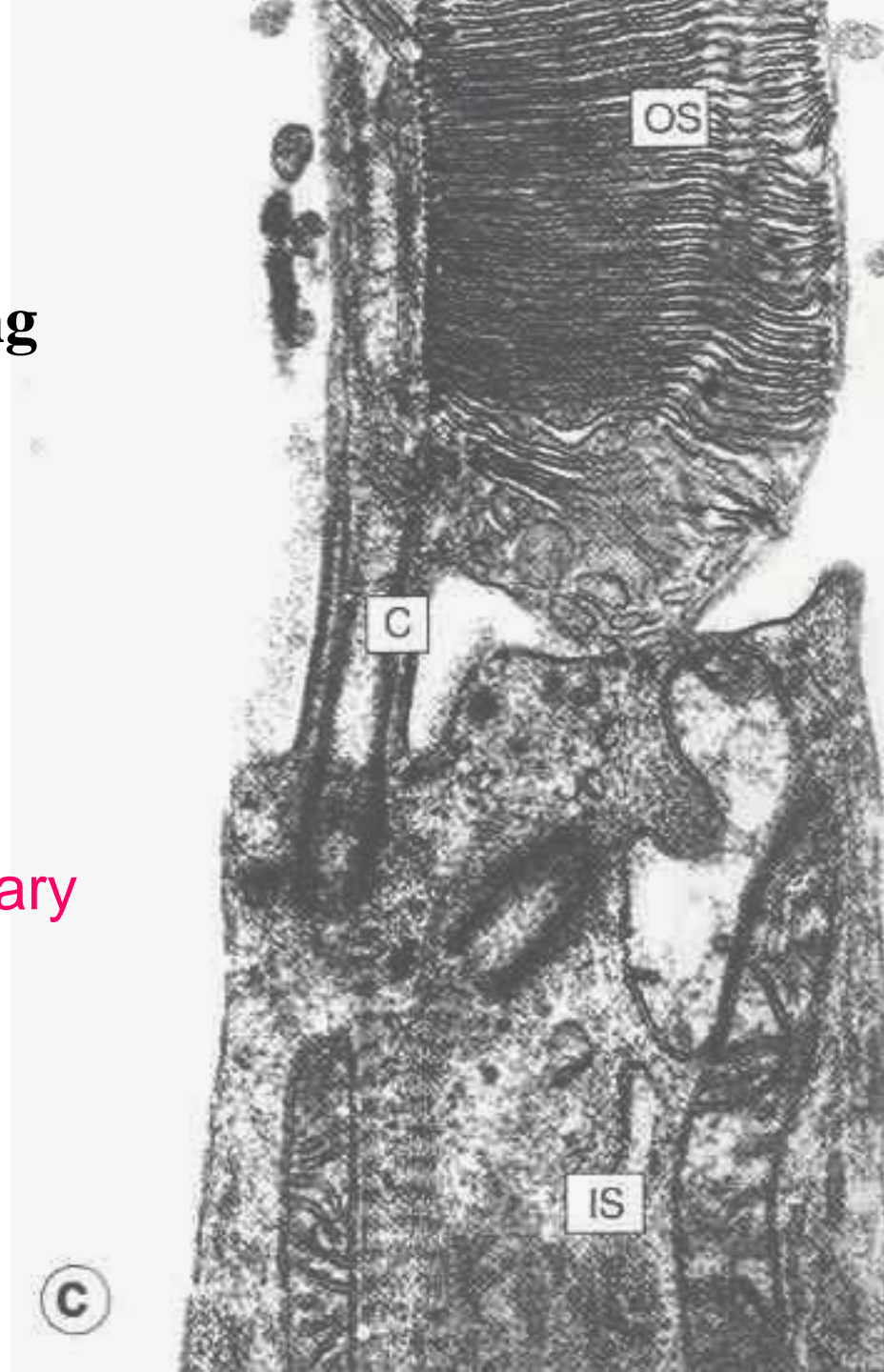
Rod

outer segment

discs containing
rhodopsin

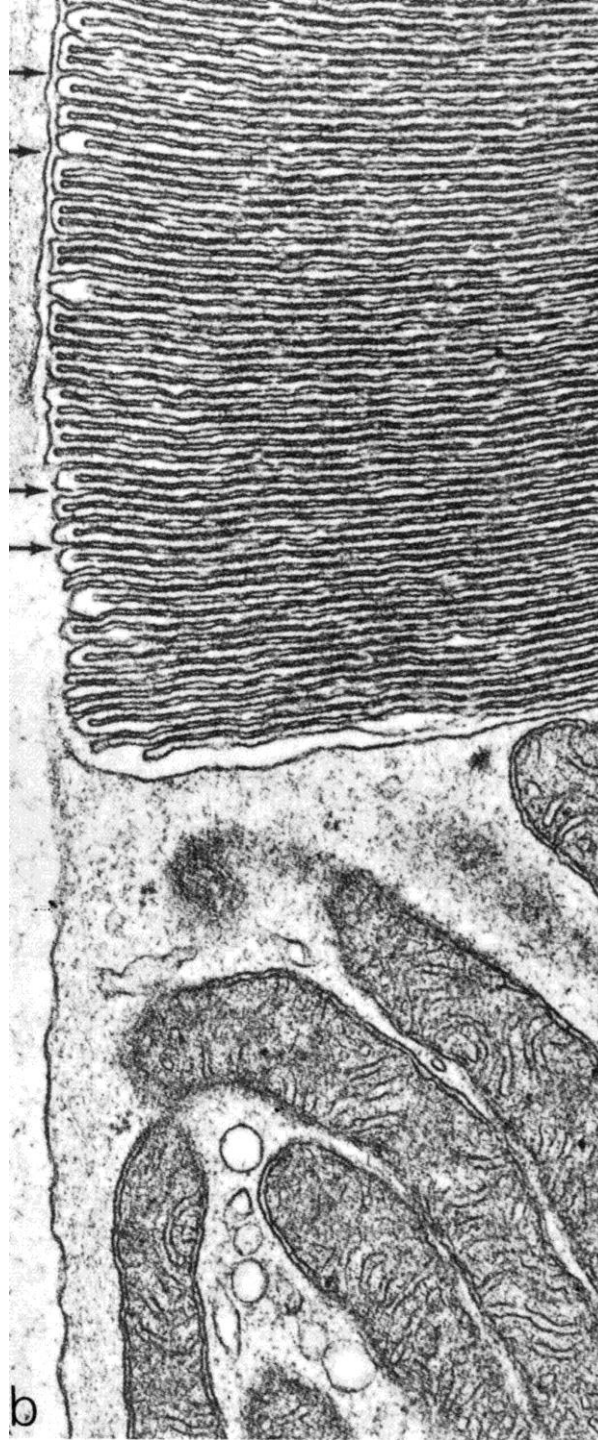
constriction (ciliary
apparatus)

inner segment



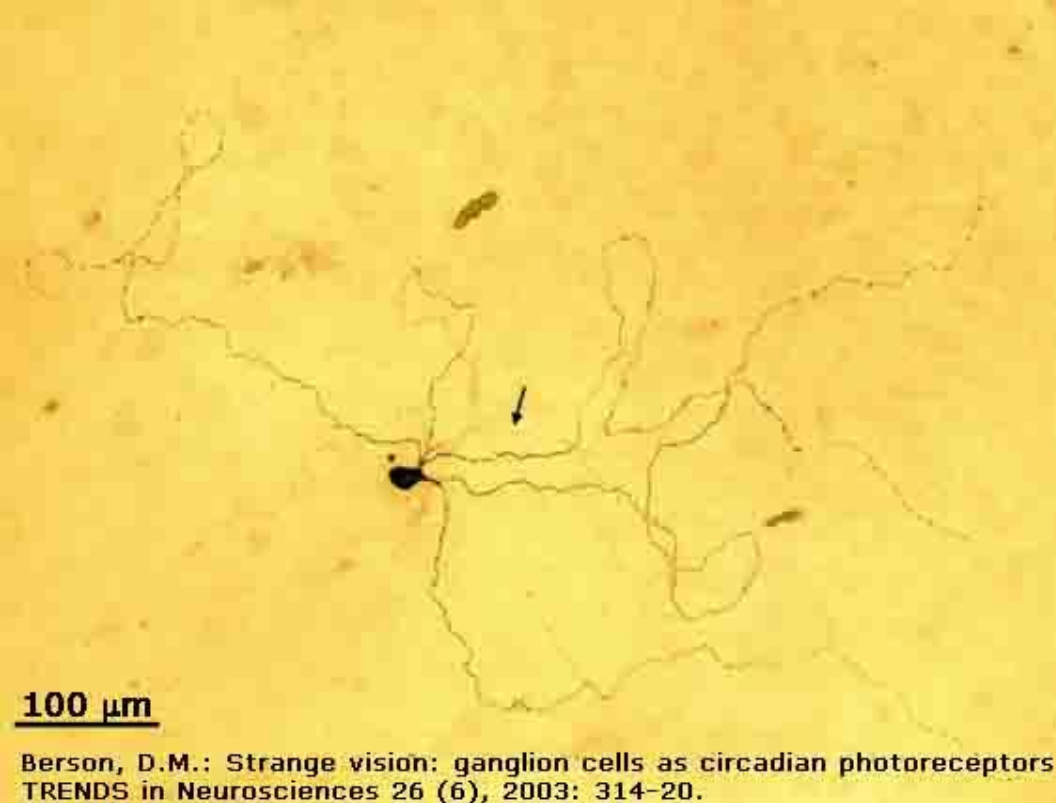
Cone

discs containing
iodopsin are
continuous with
plasma
membrane



Non-visual photoreception

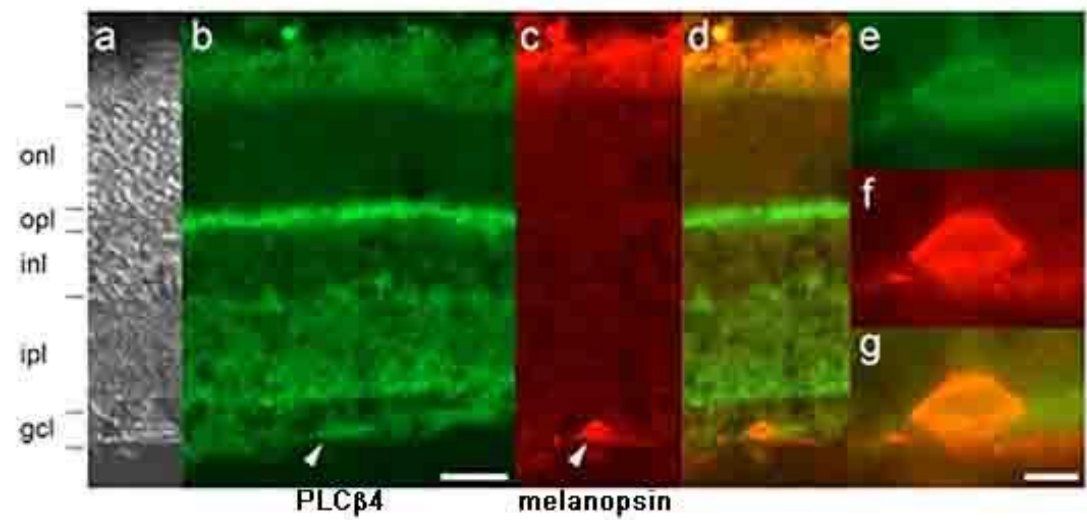
phototransducing ganglion cells - melanopsin



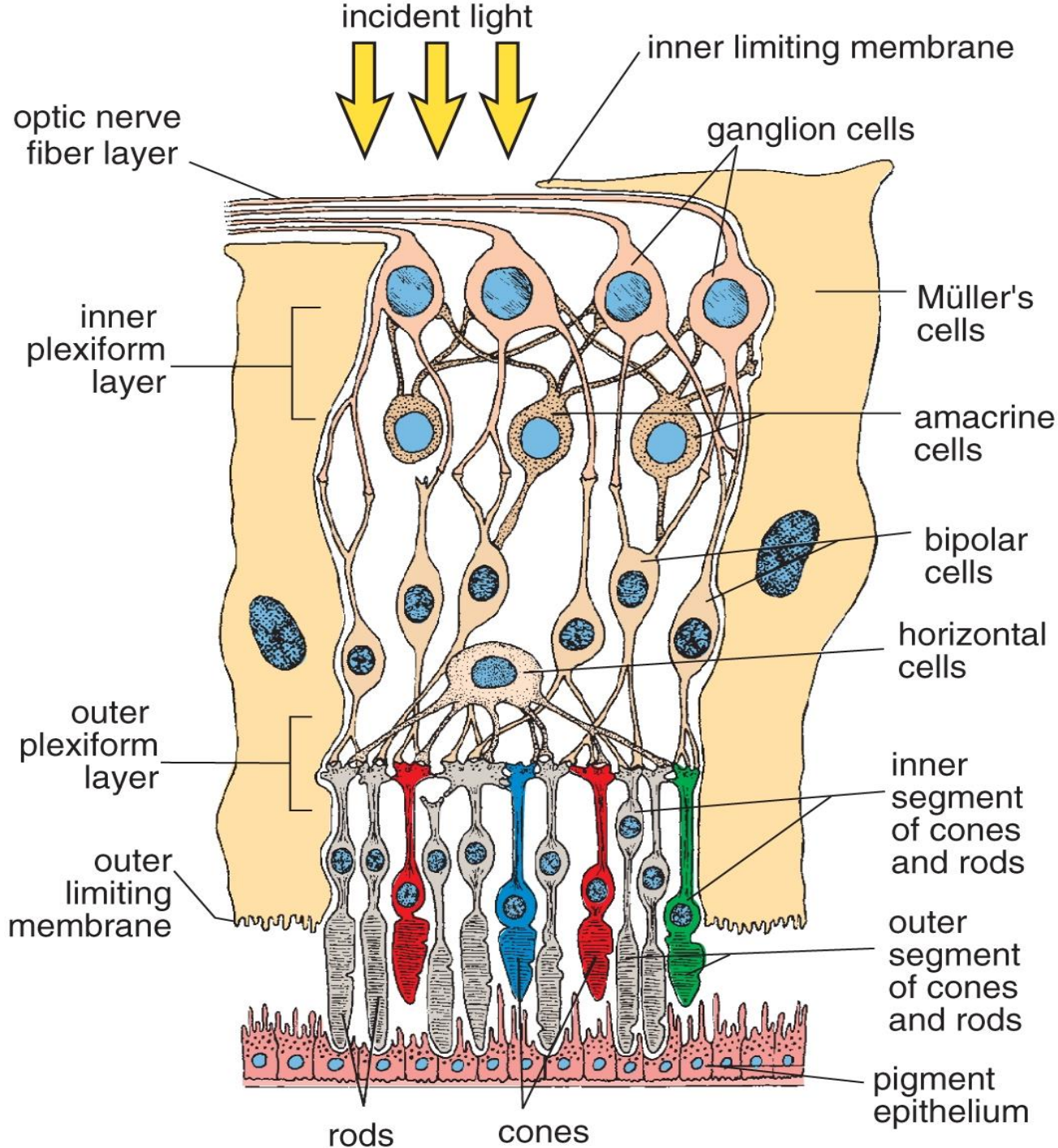
100 μm

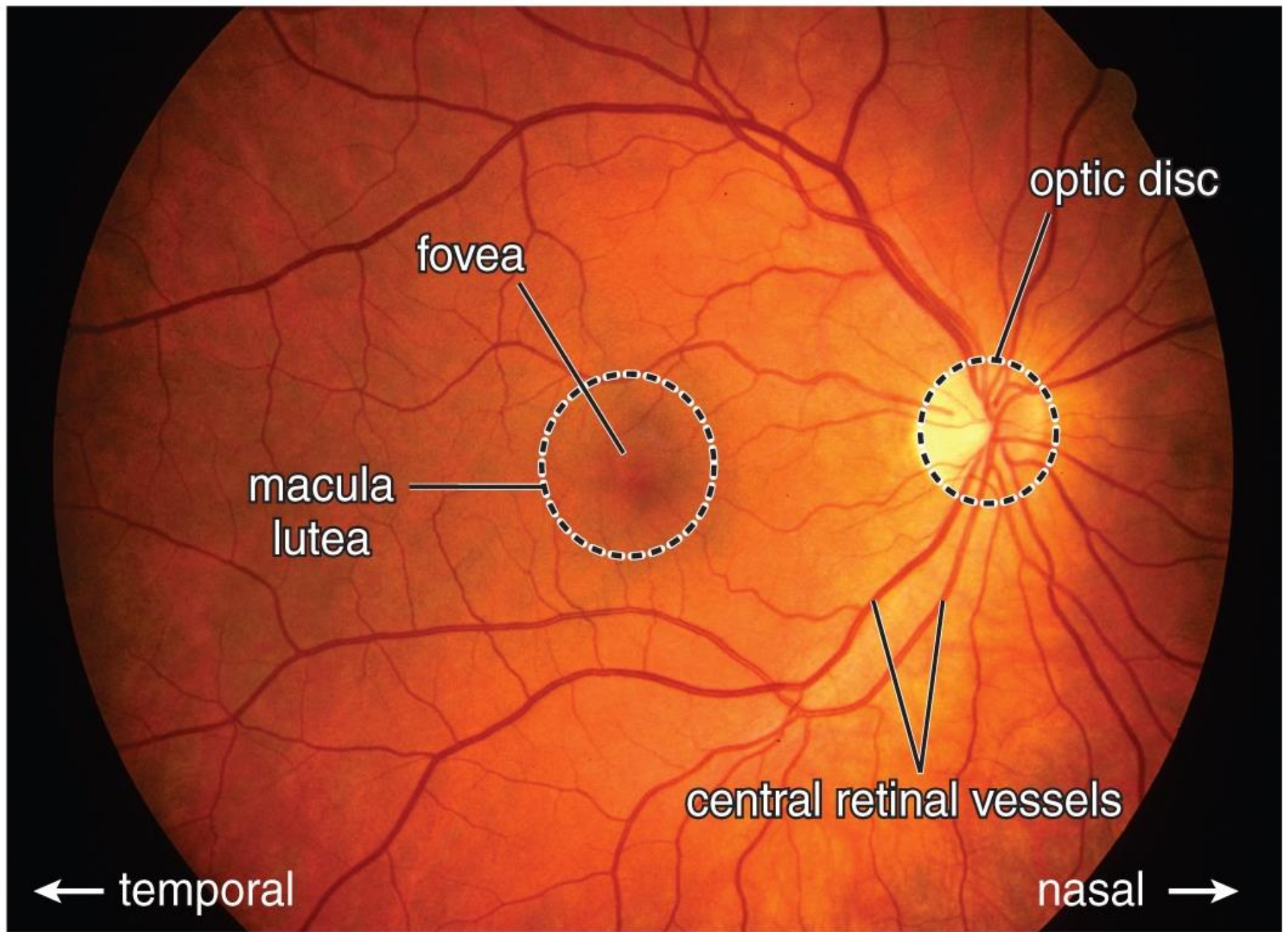
Berson, D.M.: Strange vision: ganglion cells as circadian photoreceptors. *TRENDS in Neurosciences* 26 (6), 2003: 314-20.

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

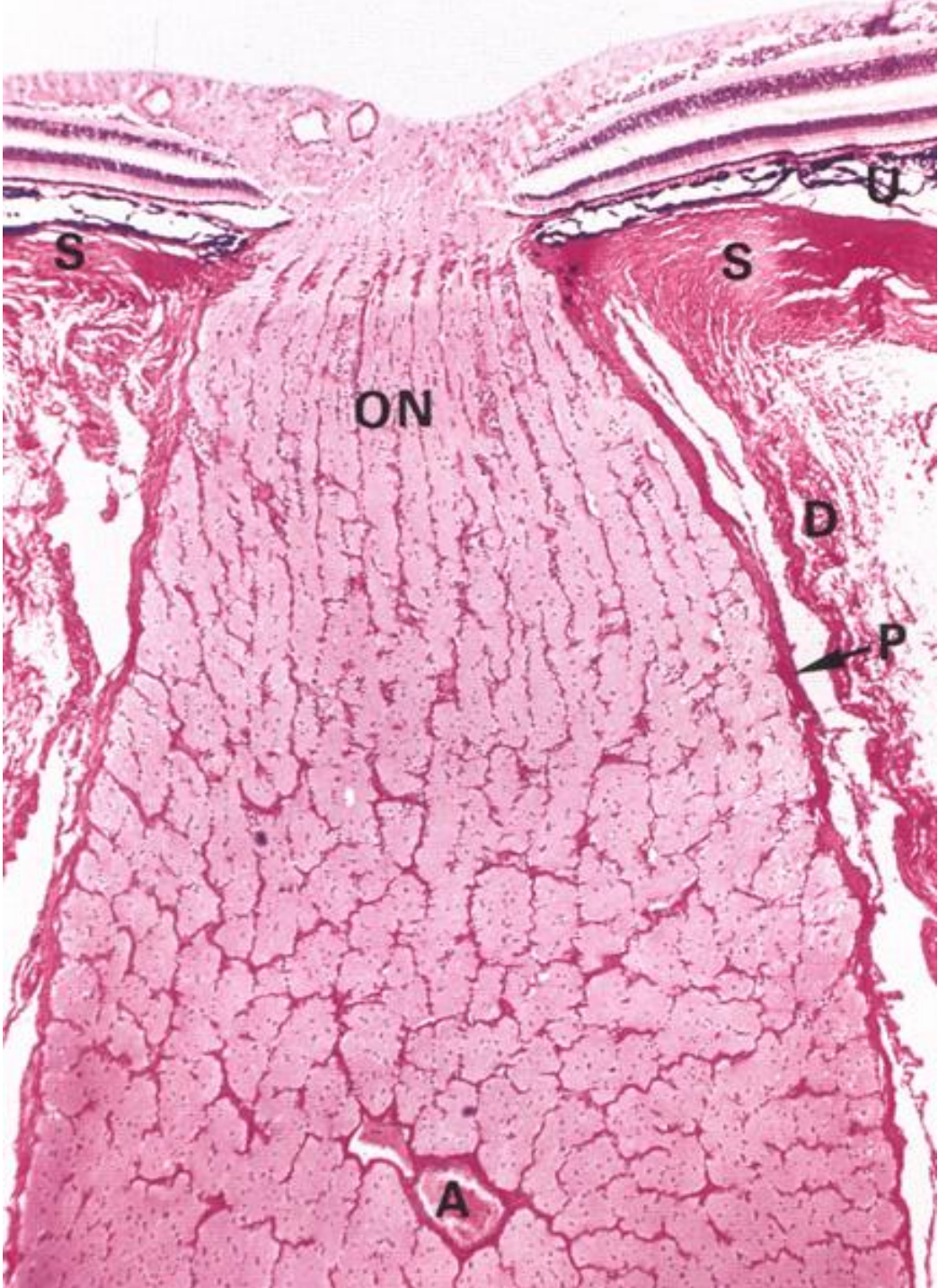
macula
lutea

central retinal vessels

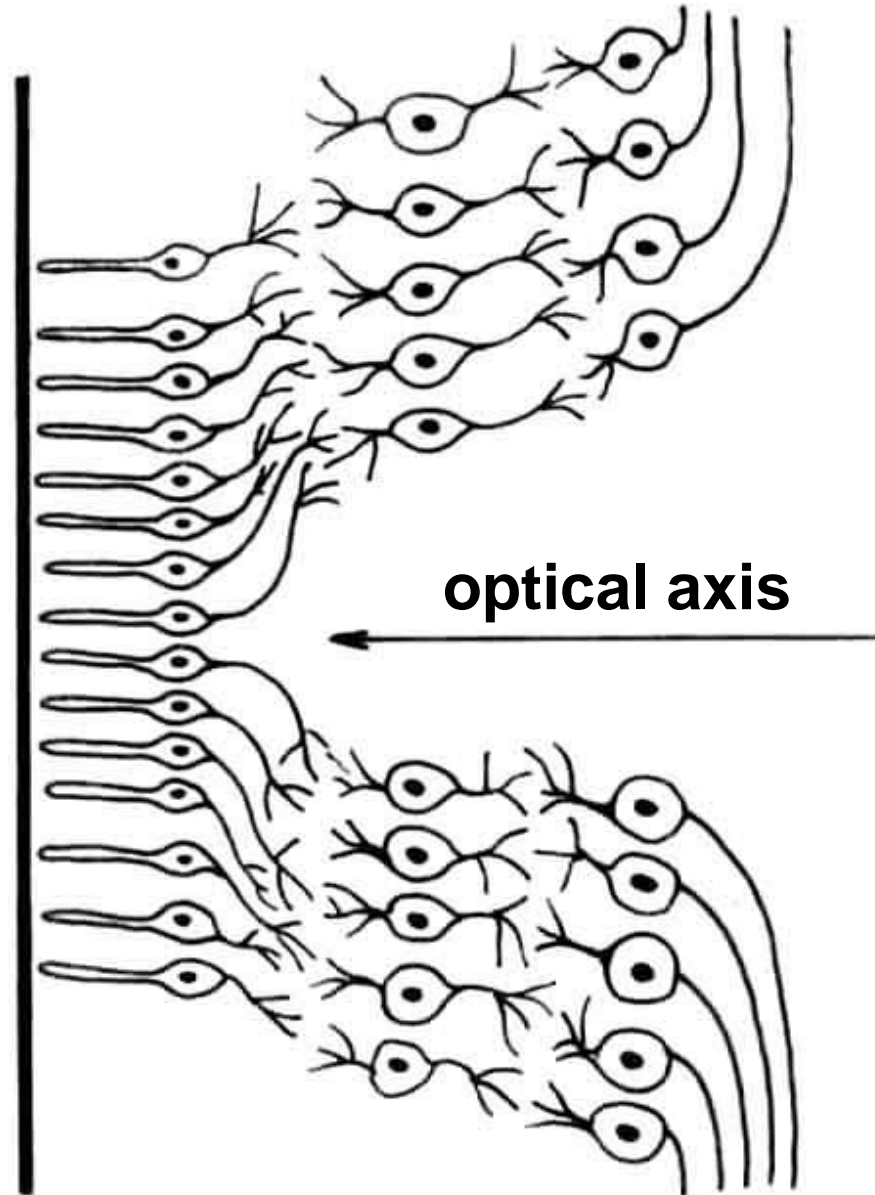
← temporal

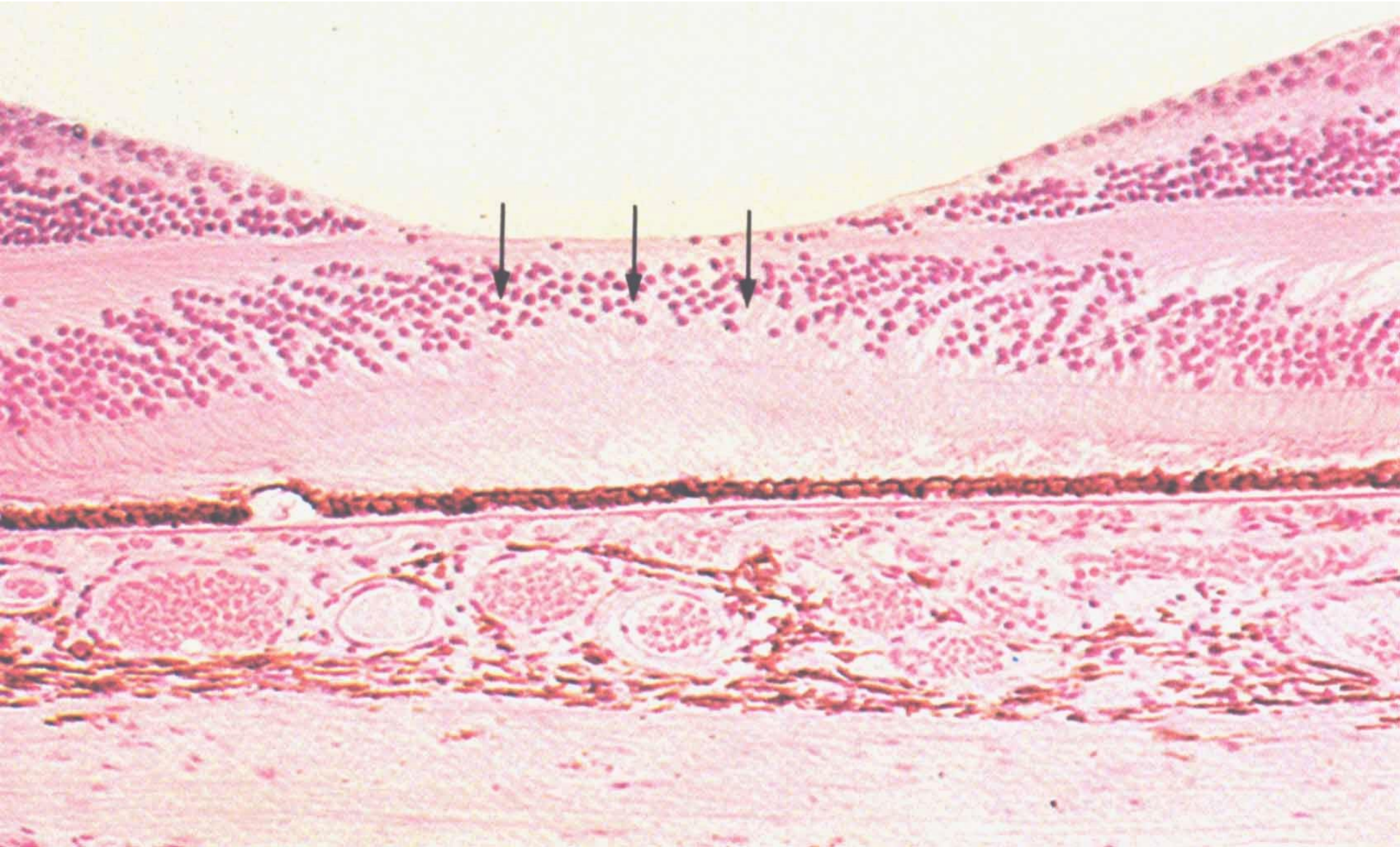
nasal →

Discus n.optici



FOVEA CENTRALIS





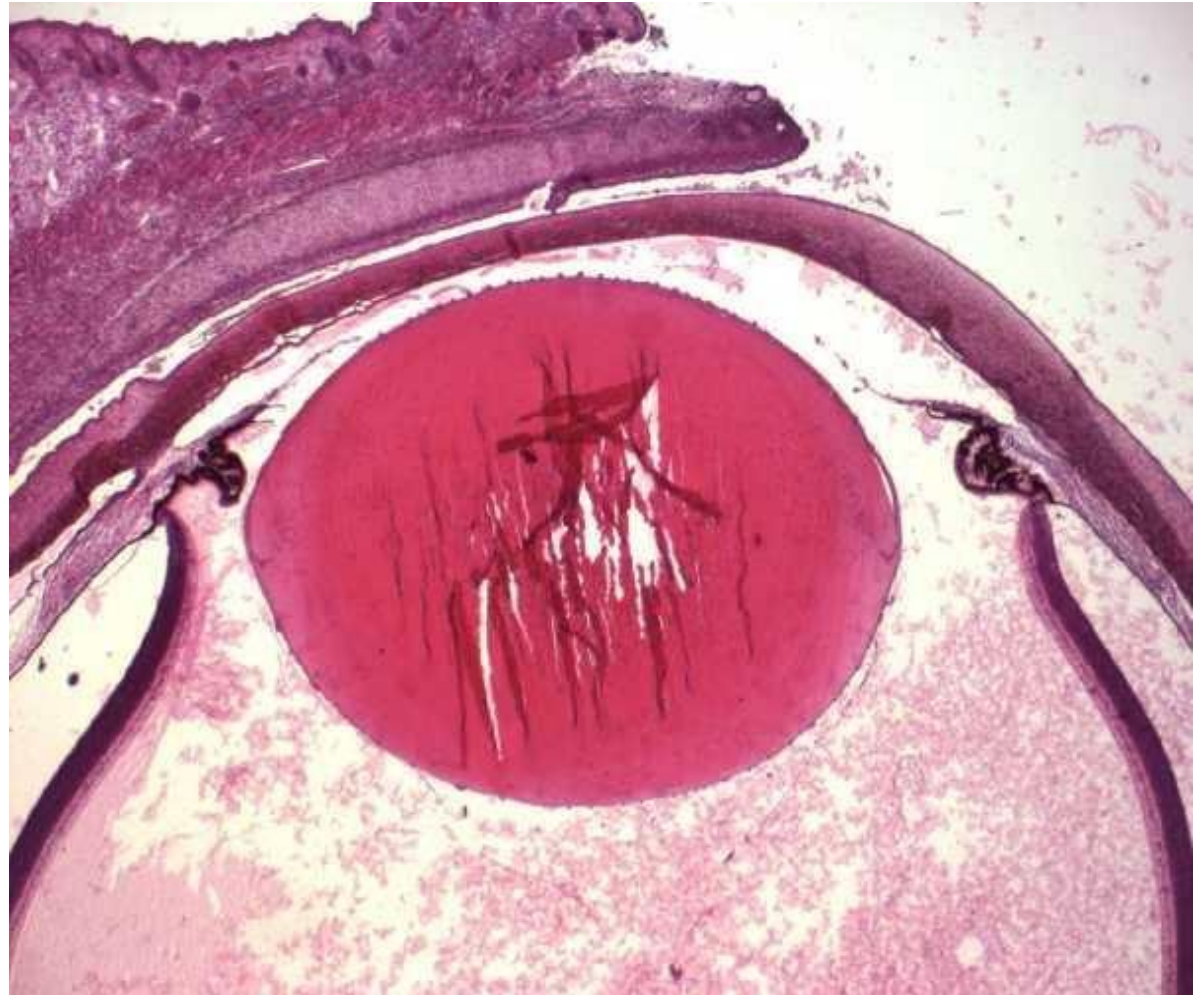
Refractive structures of the eye

cornea

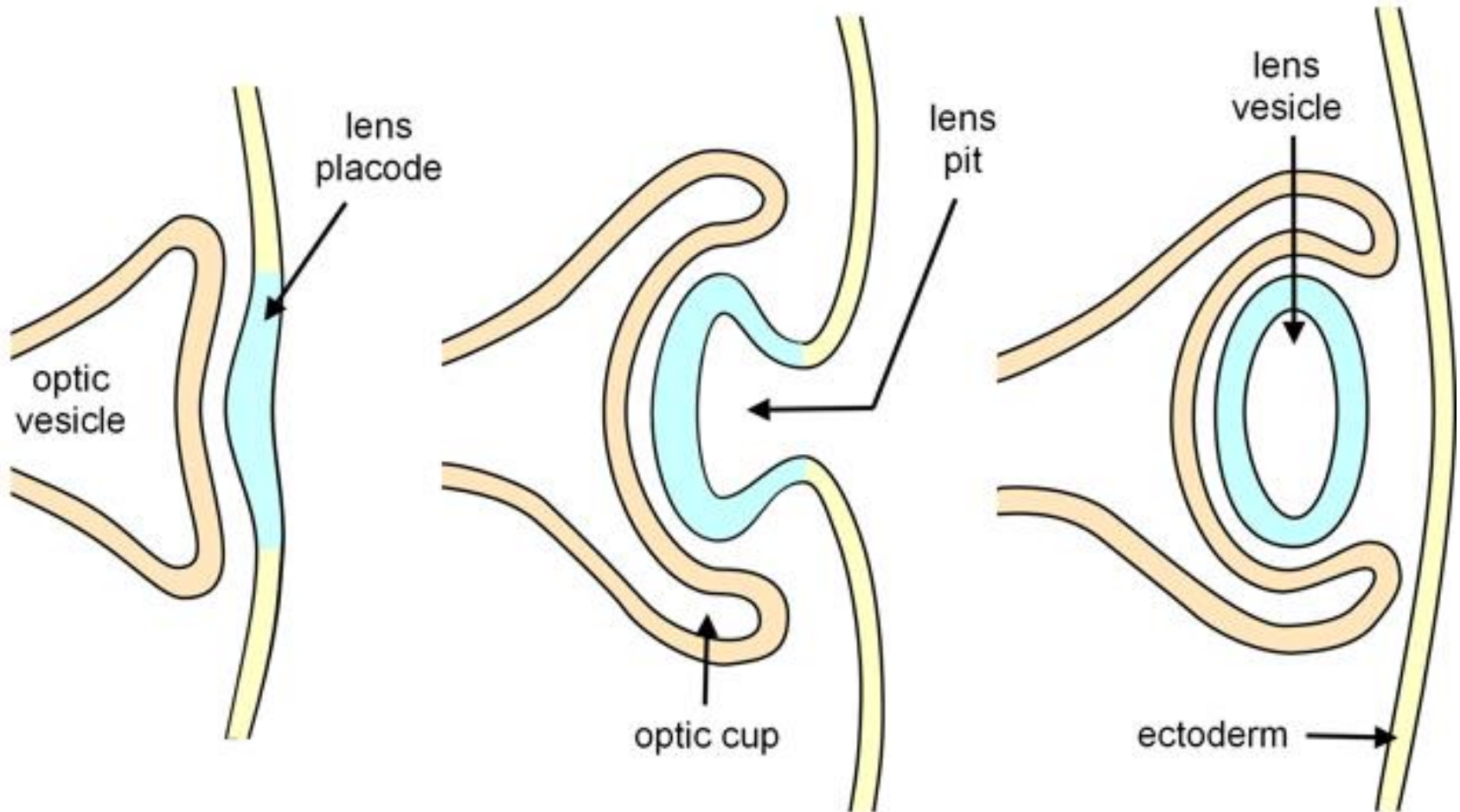
aqueous humor

crystalline lens

vitreous body

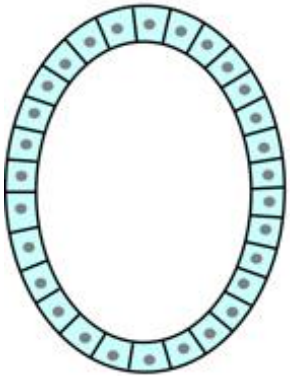


Lens development

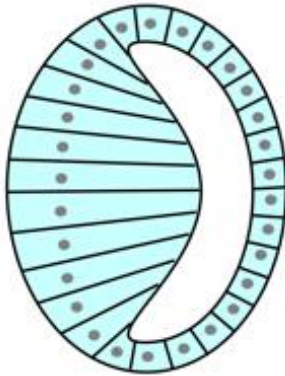


Lens development

lens vesicle

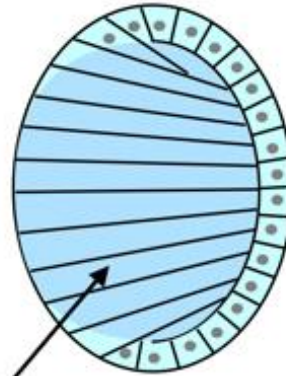


foetal lens

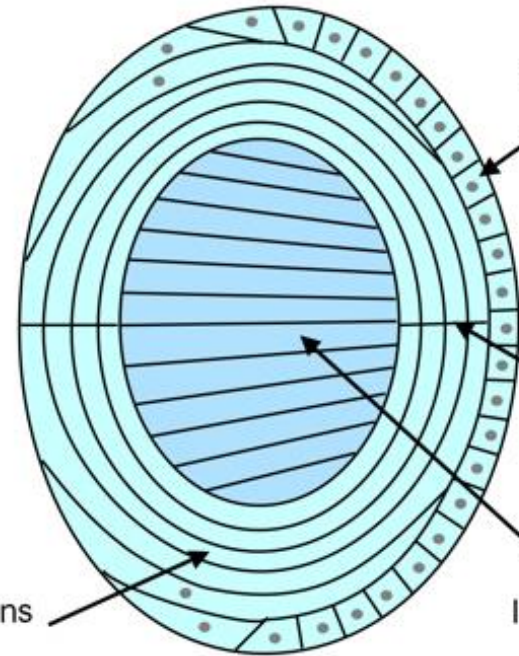


primary lens fibres

secondary lens fibres



mature lens

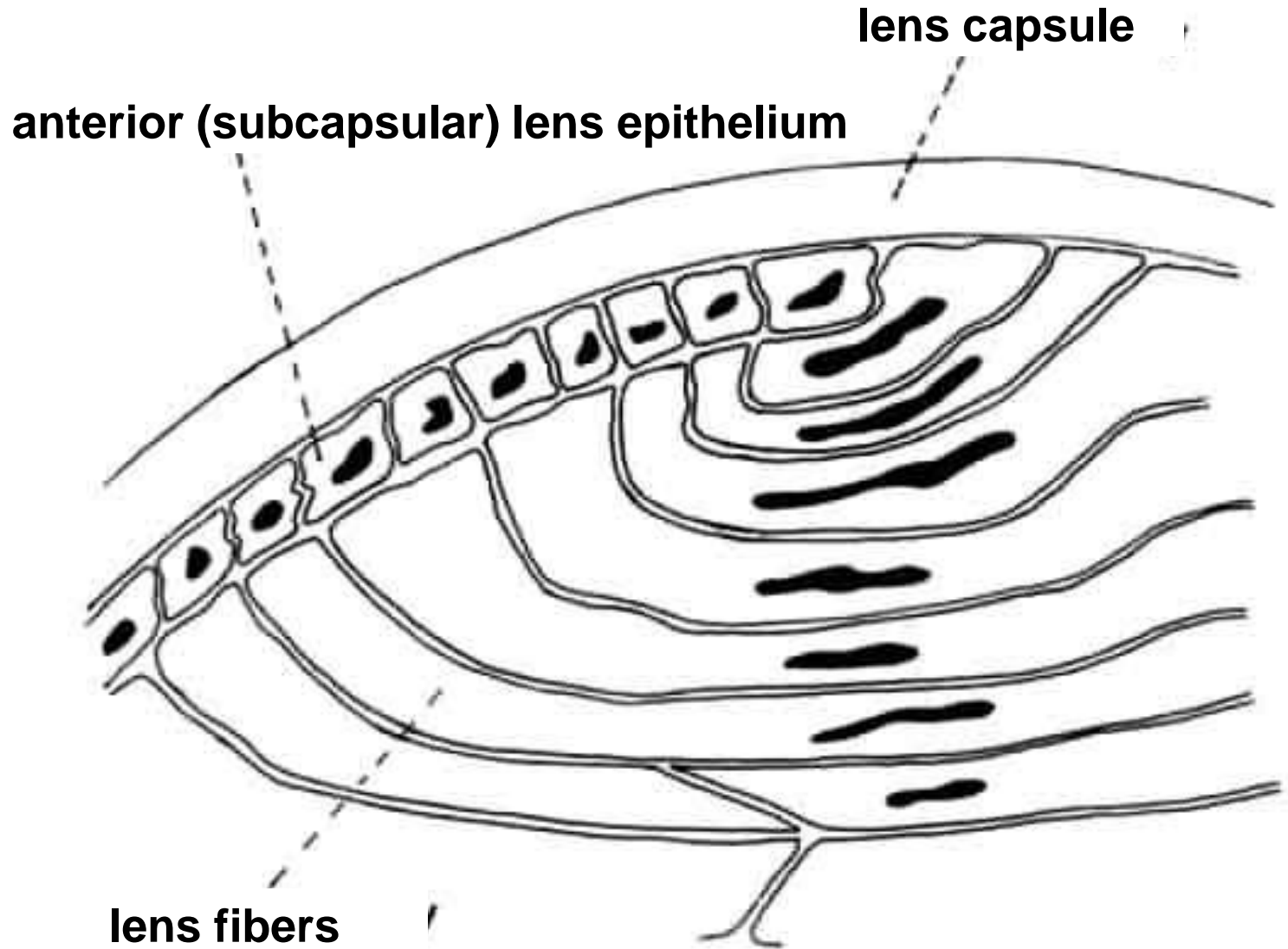


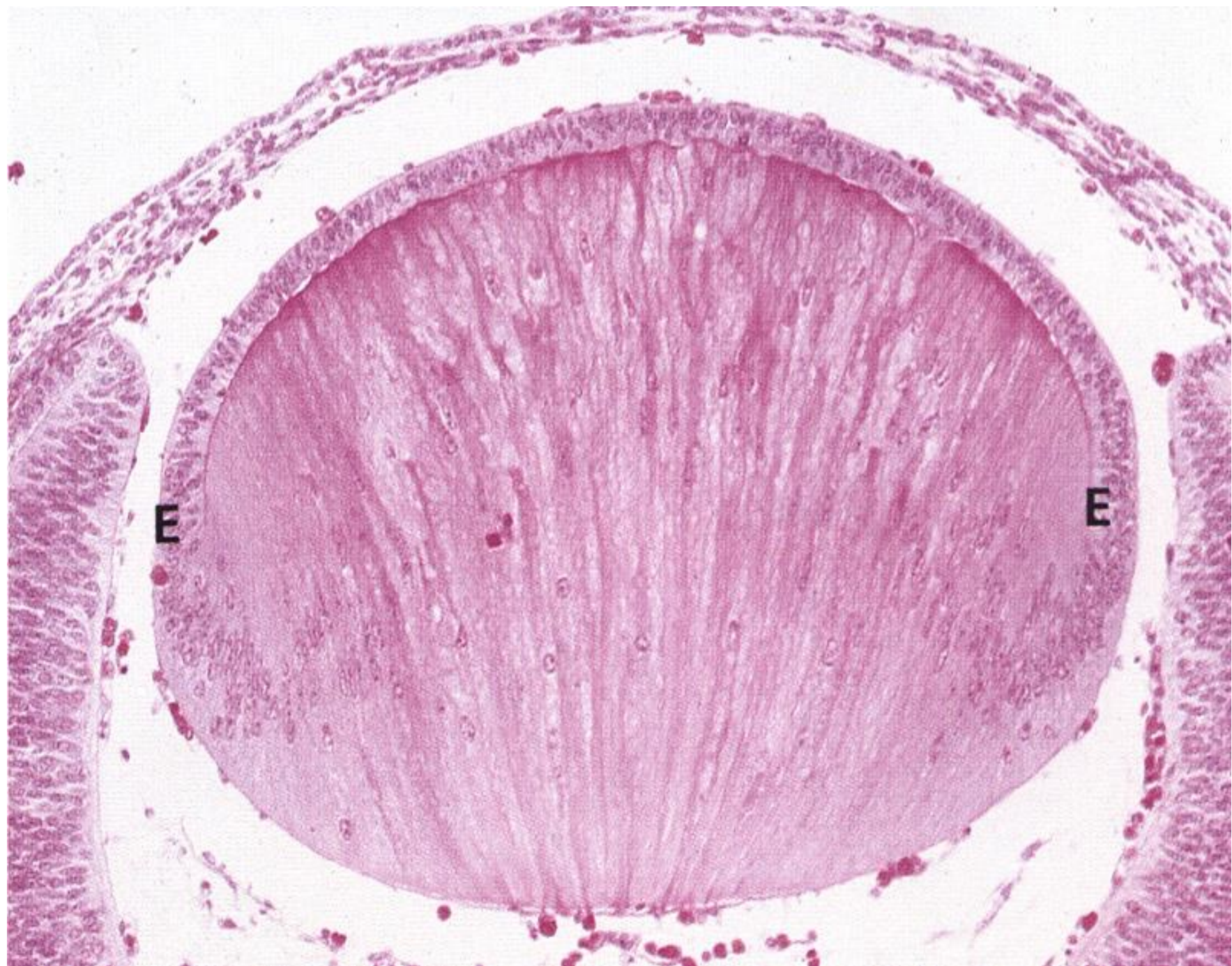
epithelium

lens suture

lens nucleus

ANTERIOR PART OF THE LENS

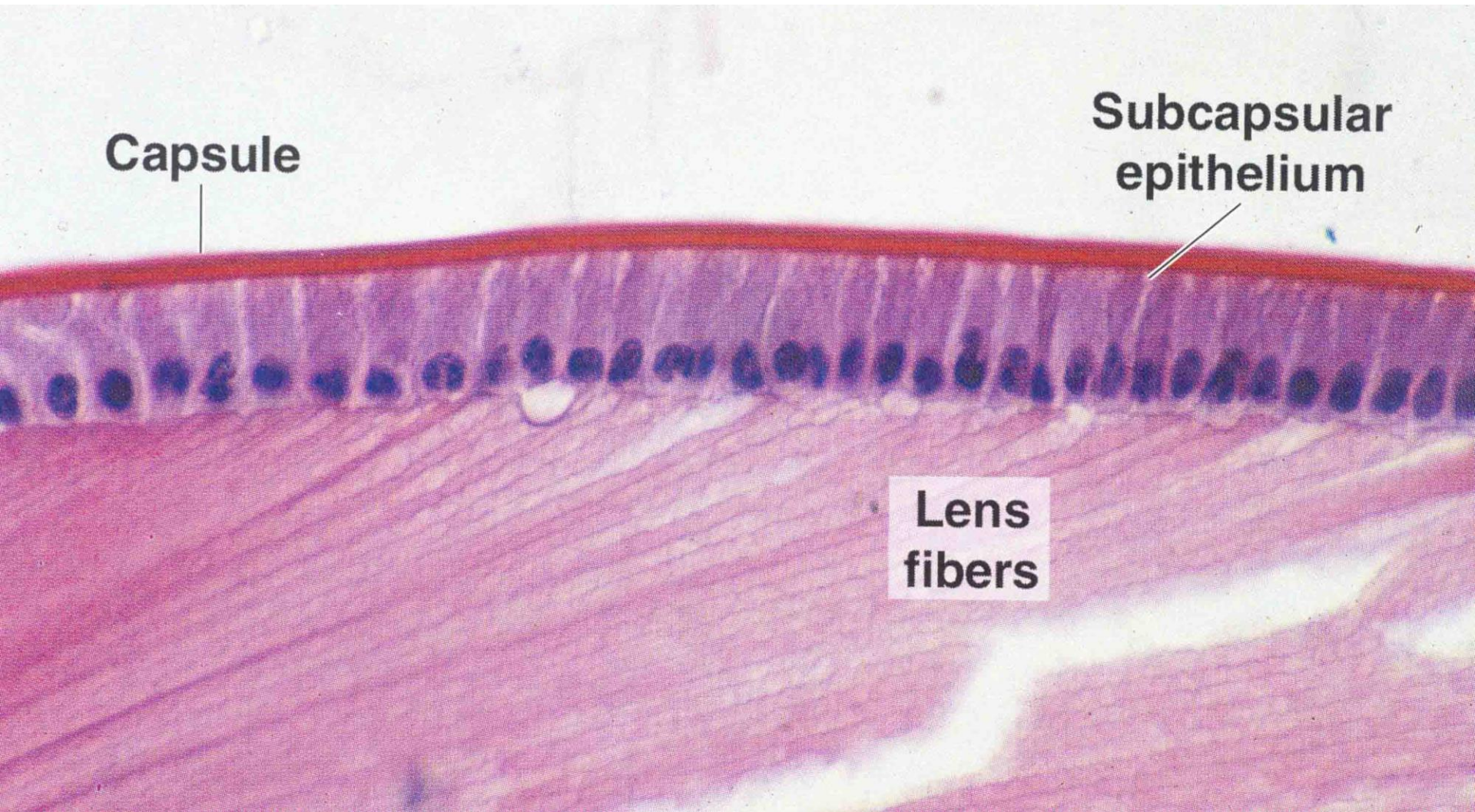


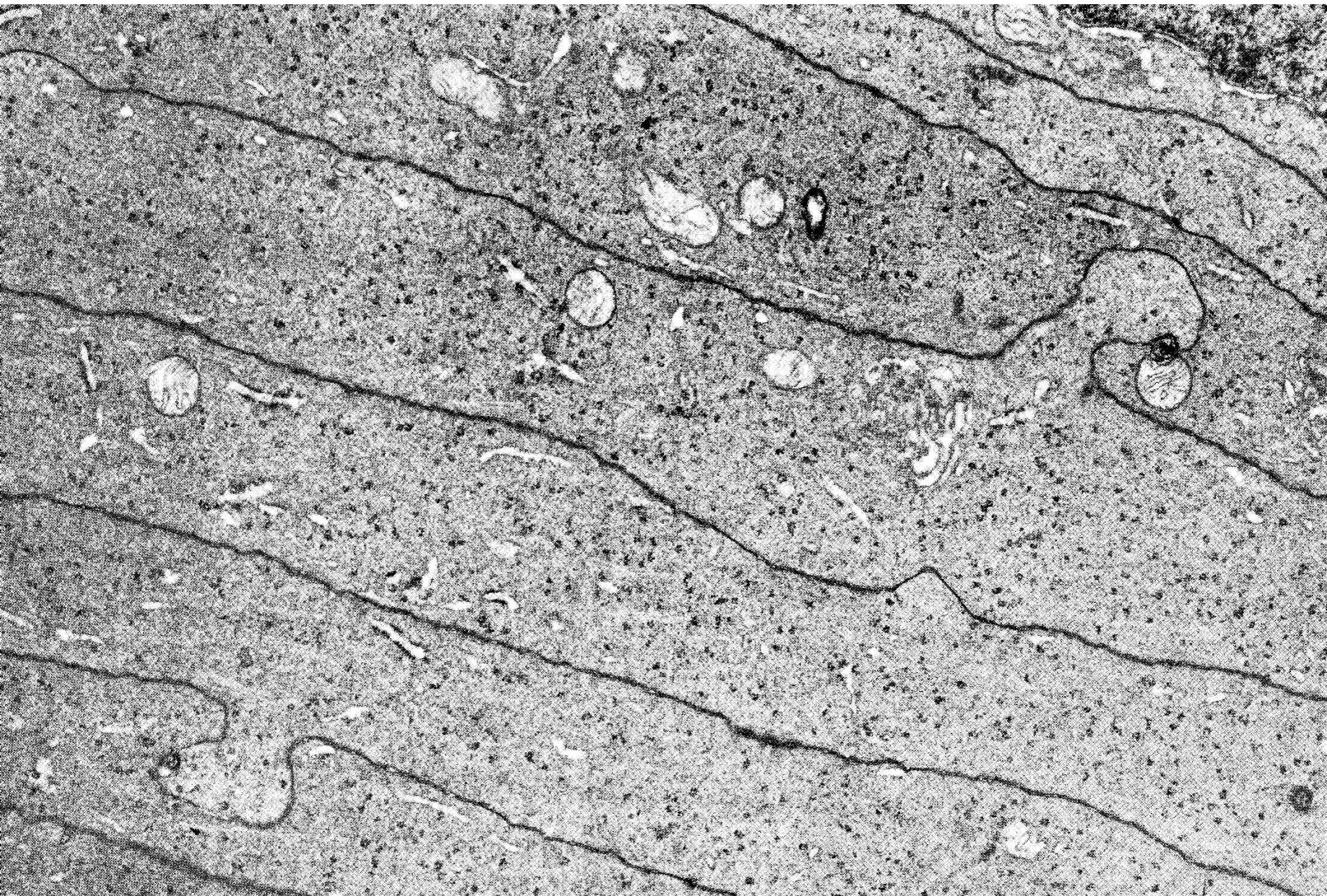


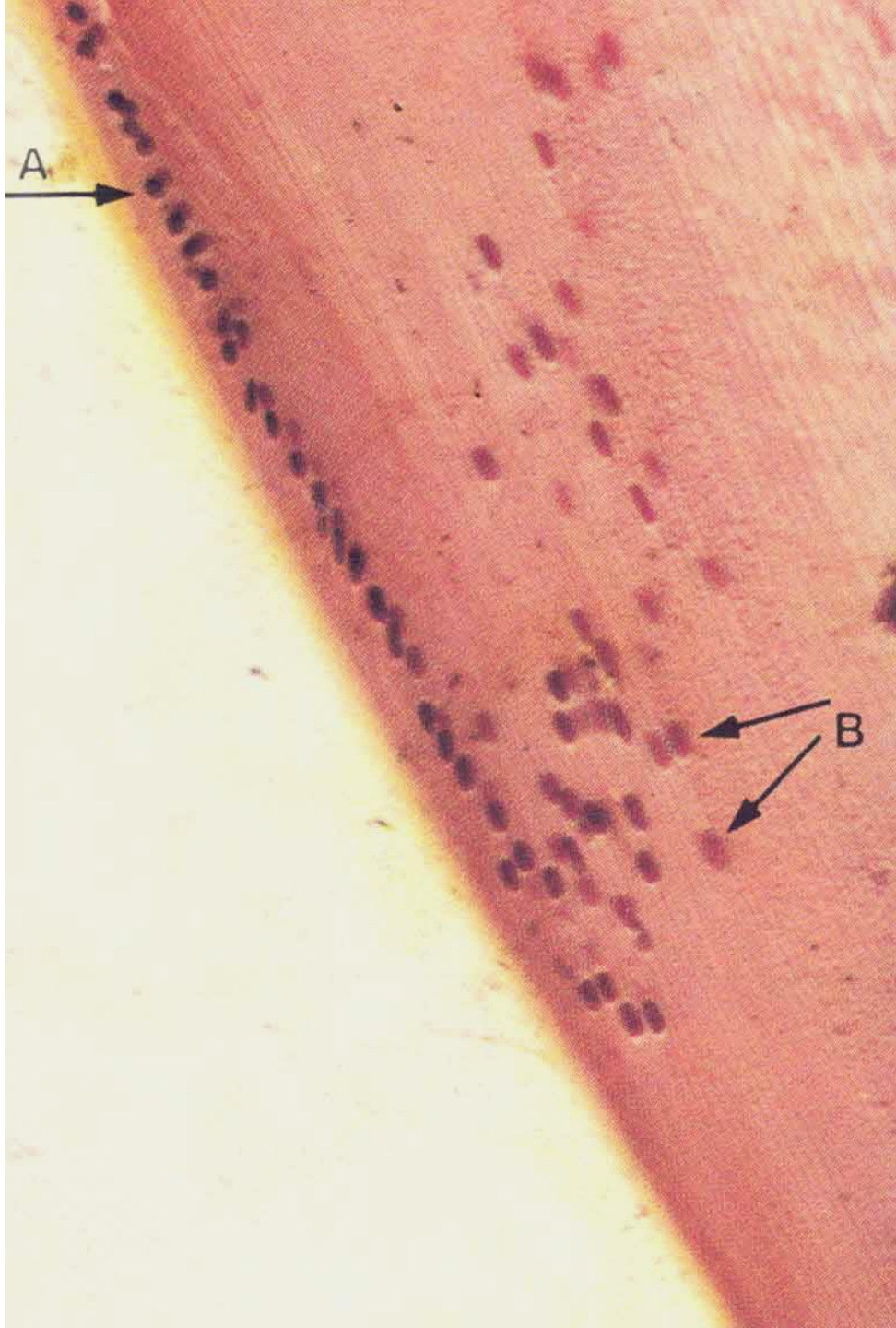
Capsule

**Subcapsular
epithelium**

**Lens
fibers**







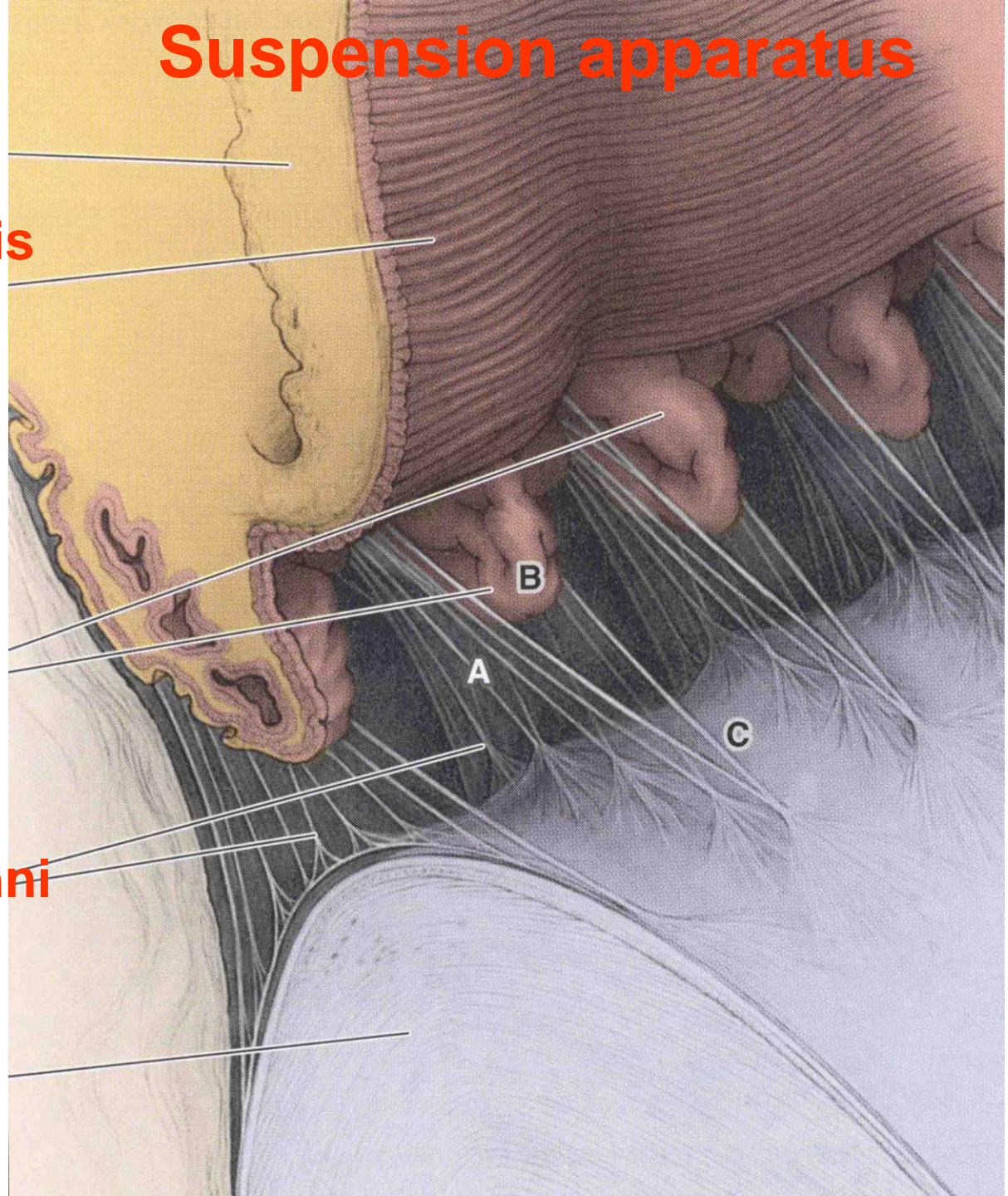
Suspension apparatus

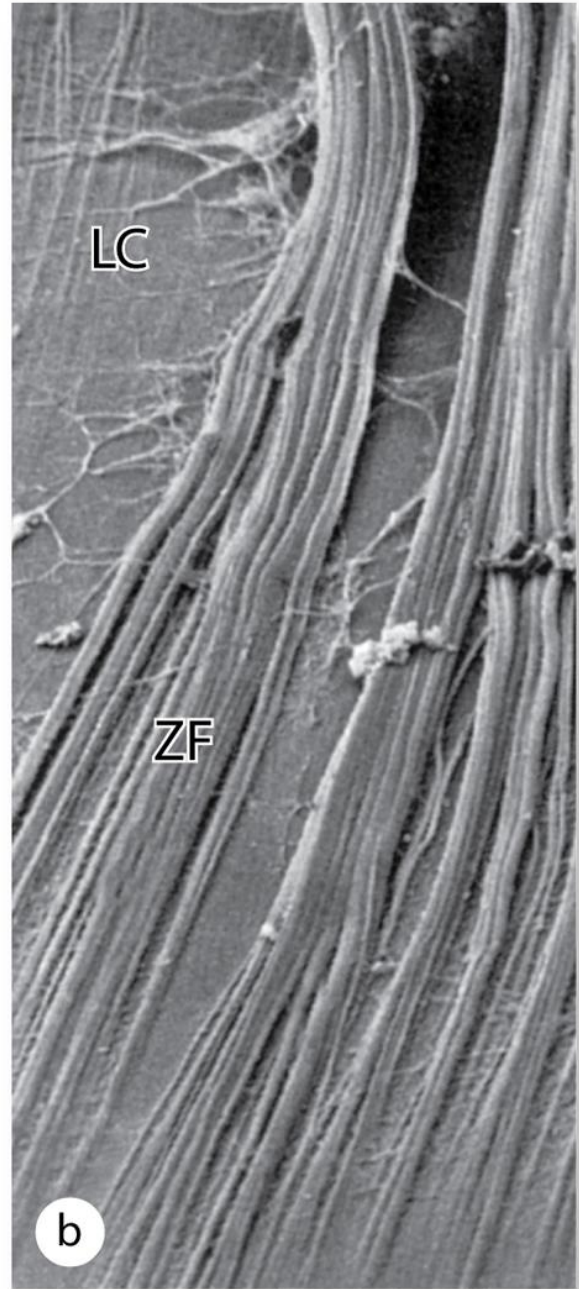
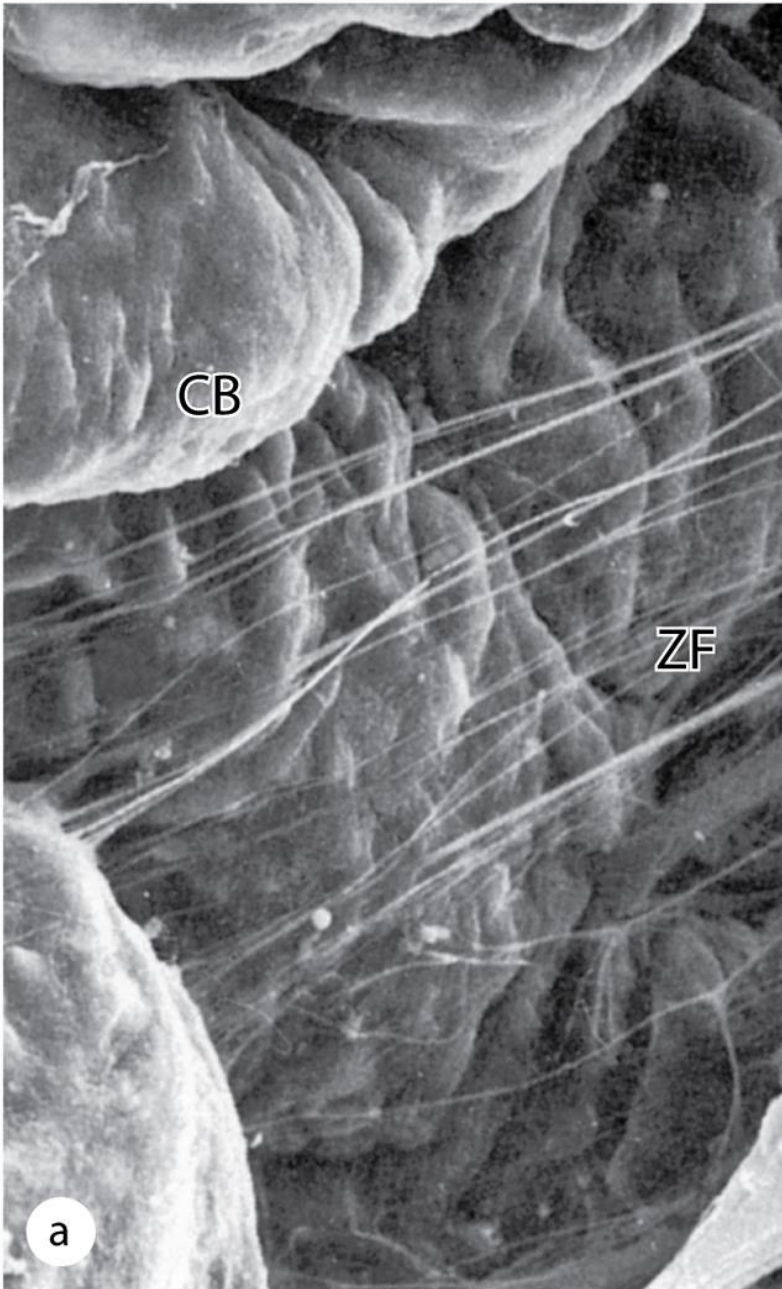
orbiculus ciliaris

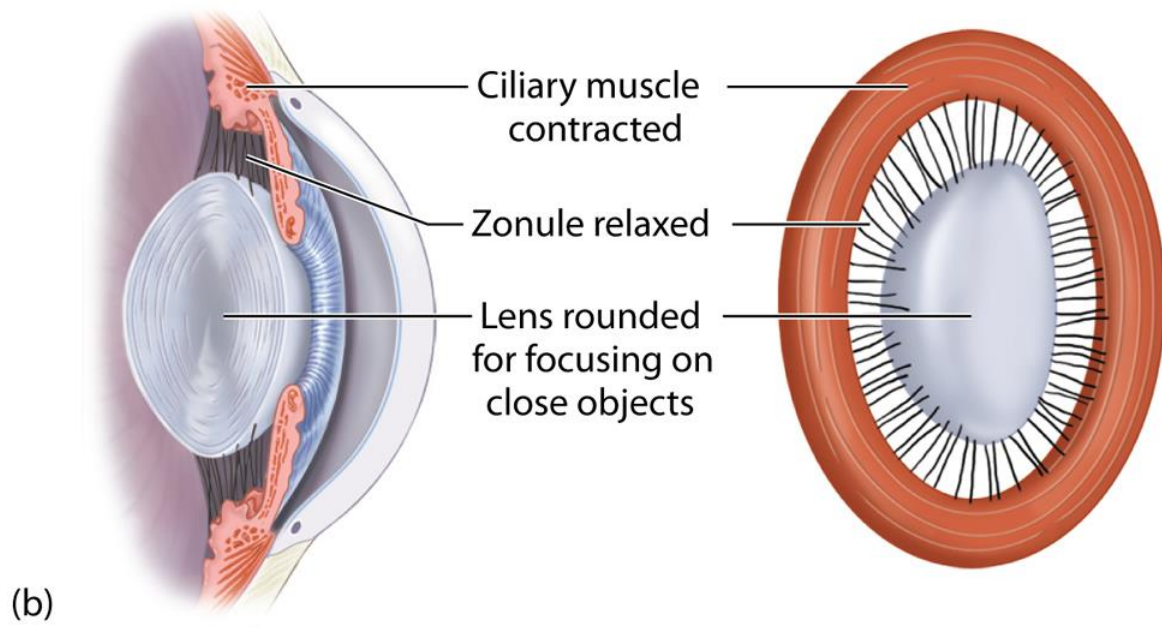
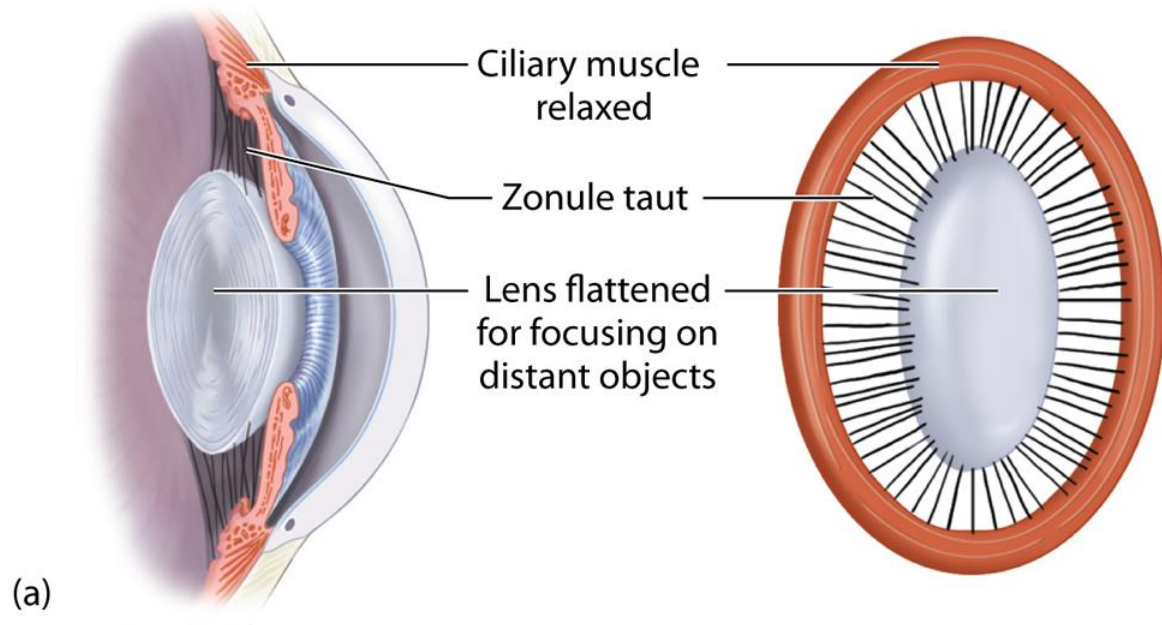
corona ciliaris

zonula ciliaris Zinni

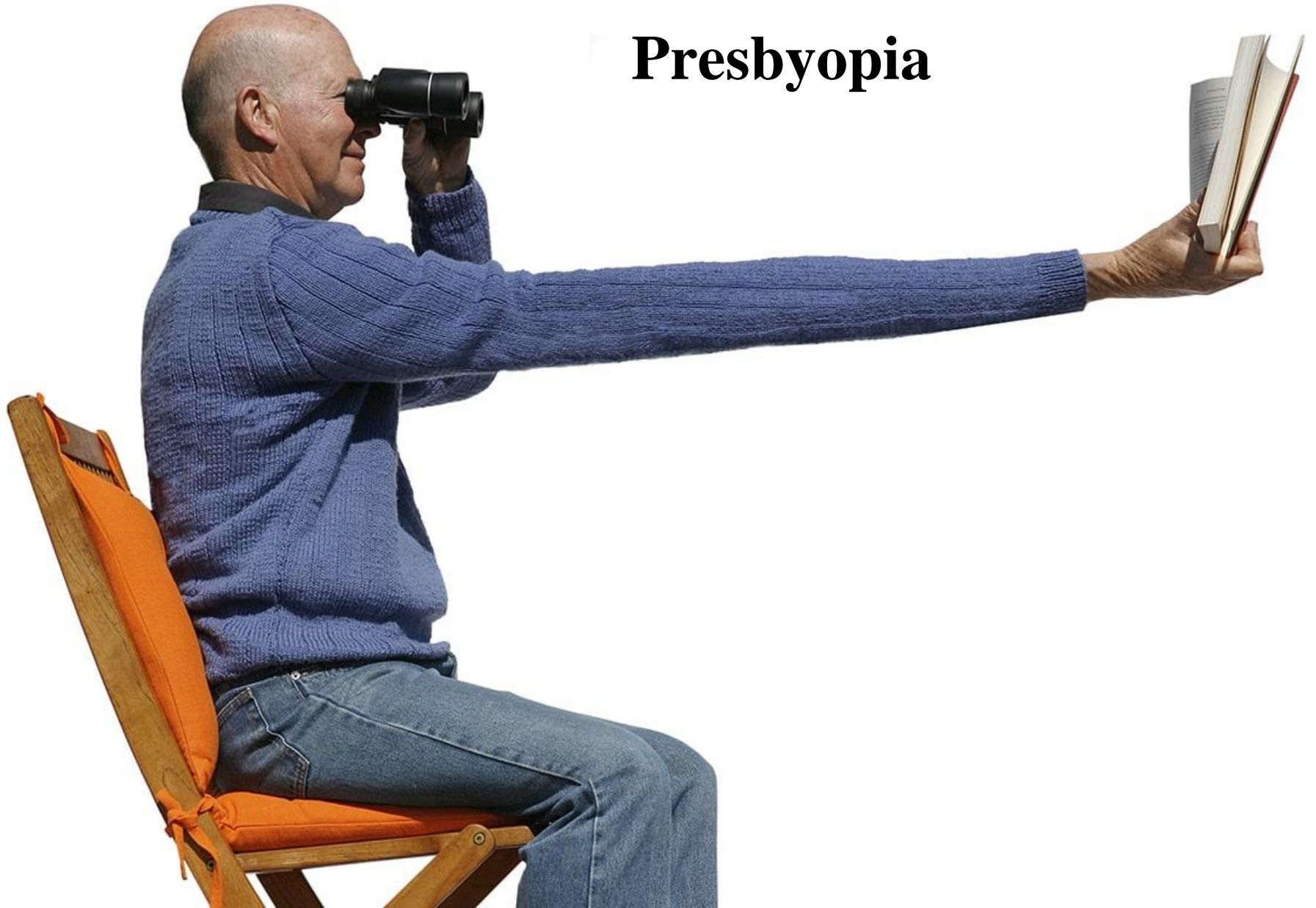
lens



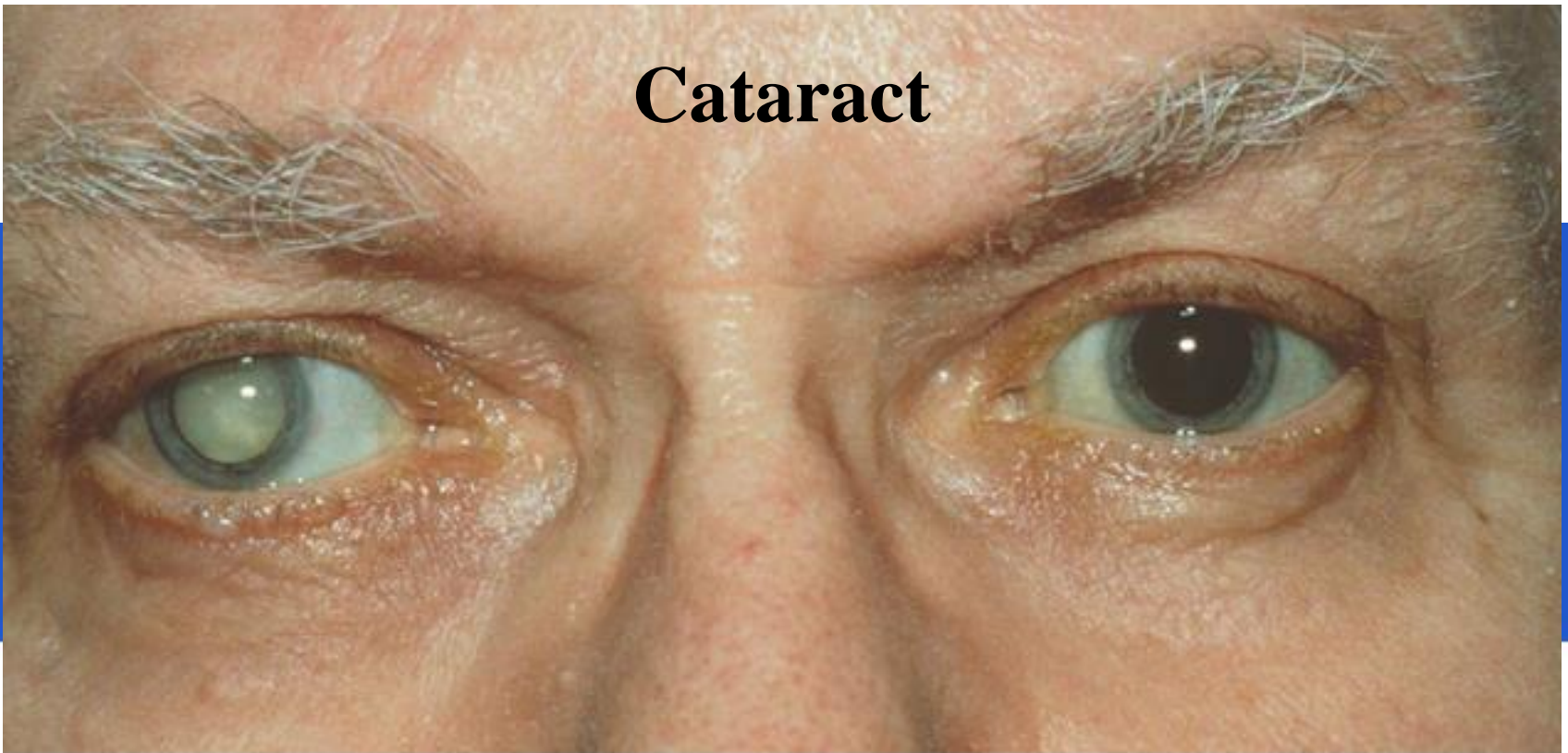




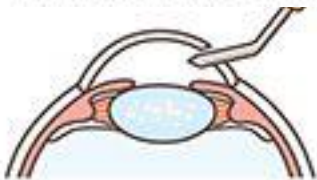
Presbyopia



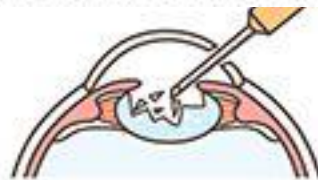
Cataract



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1.
Incision is
made



2.
Emulsification:
breaks up
cloudy lens



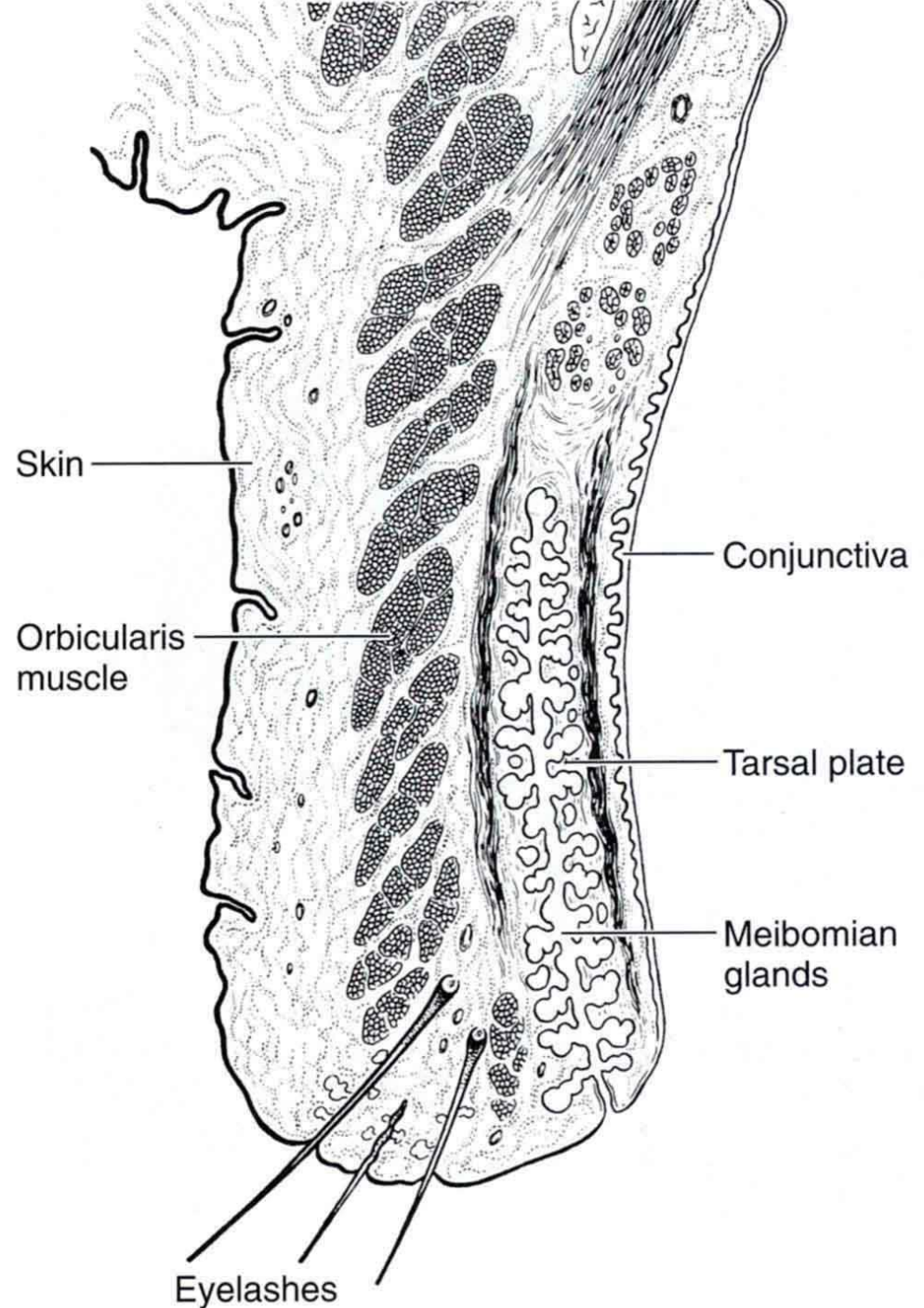
3.
Intraocular lens
is implanted



4.
The incision
heals on
its own

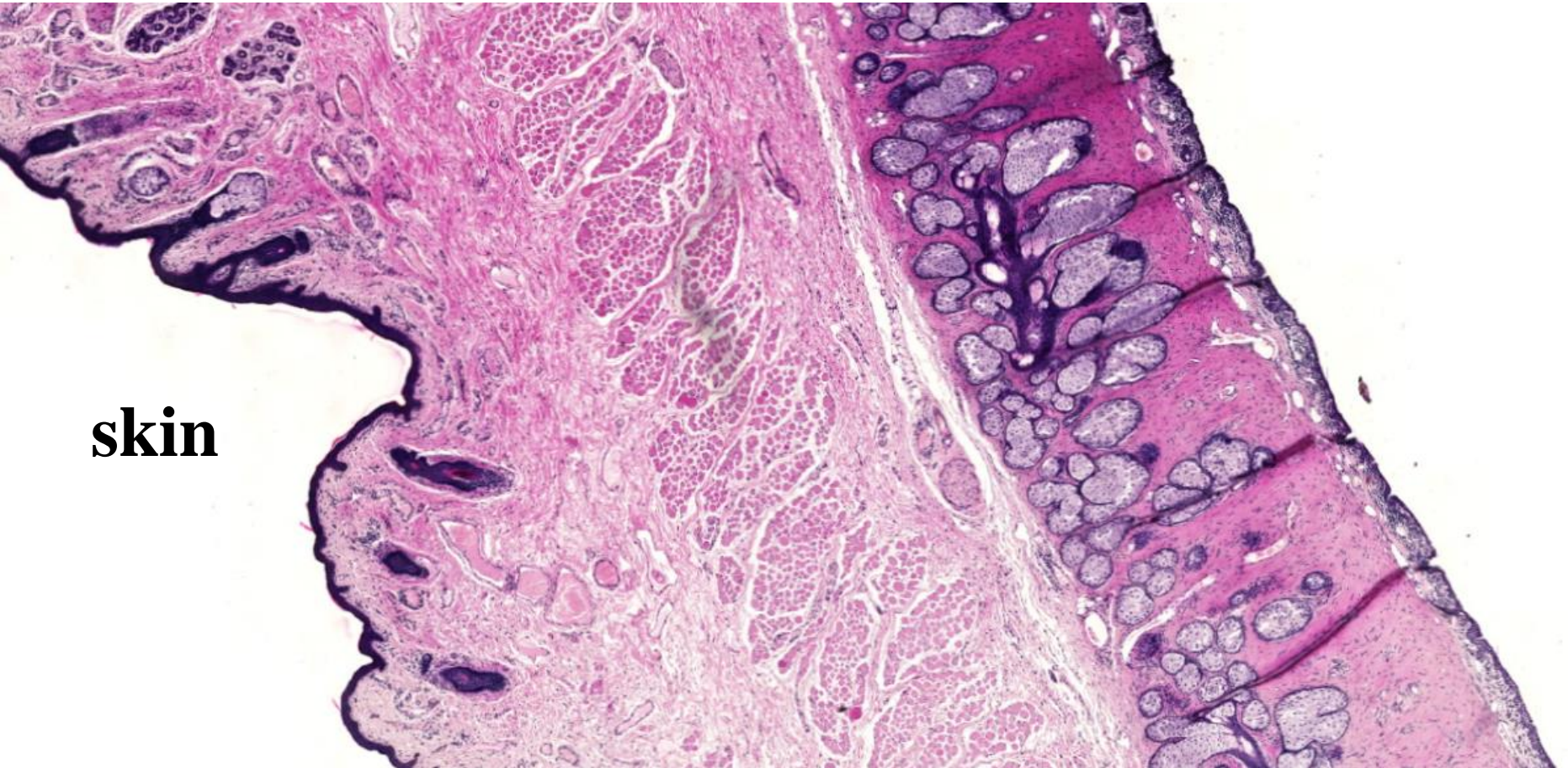
Accessory structures of the eye

- conjunctiva
- eyelid
- lacrimal apparatus





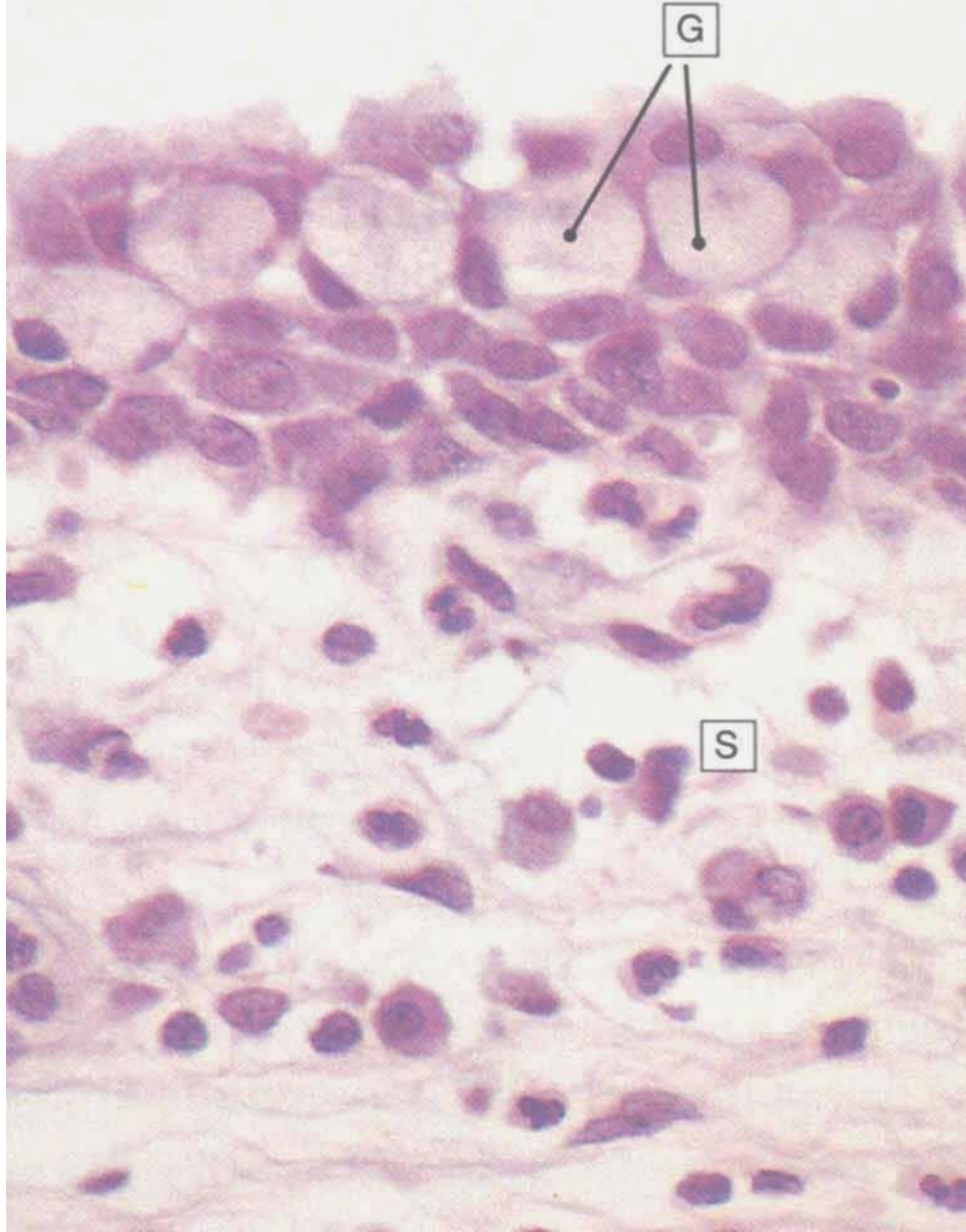
conjunctiva

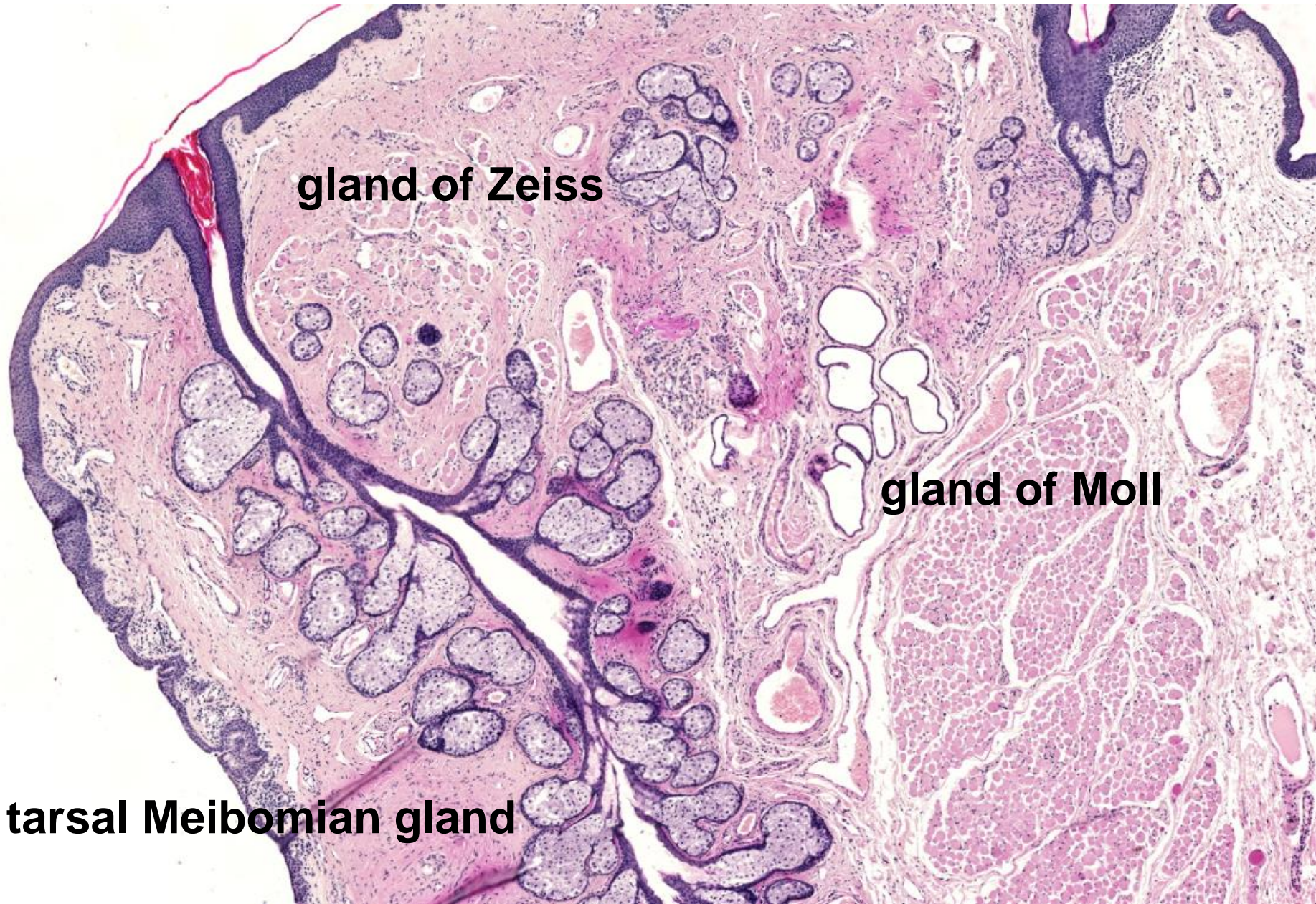


skin

orbicularis oculi muscle

conjunctiva



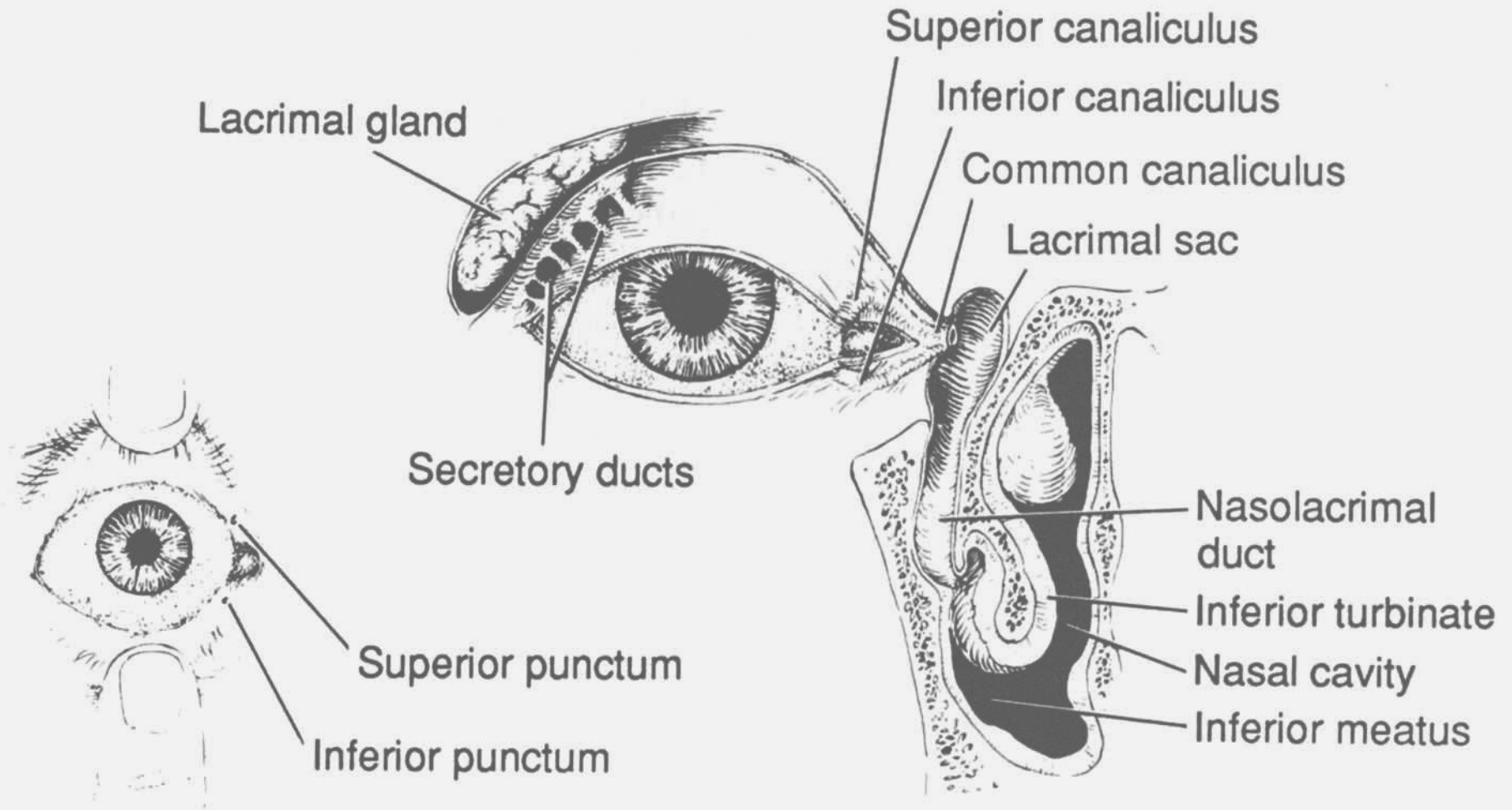


gland of Zeiss

gland of Moll

tarsal Meibomian gland

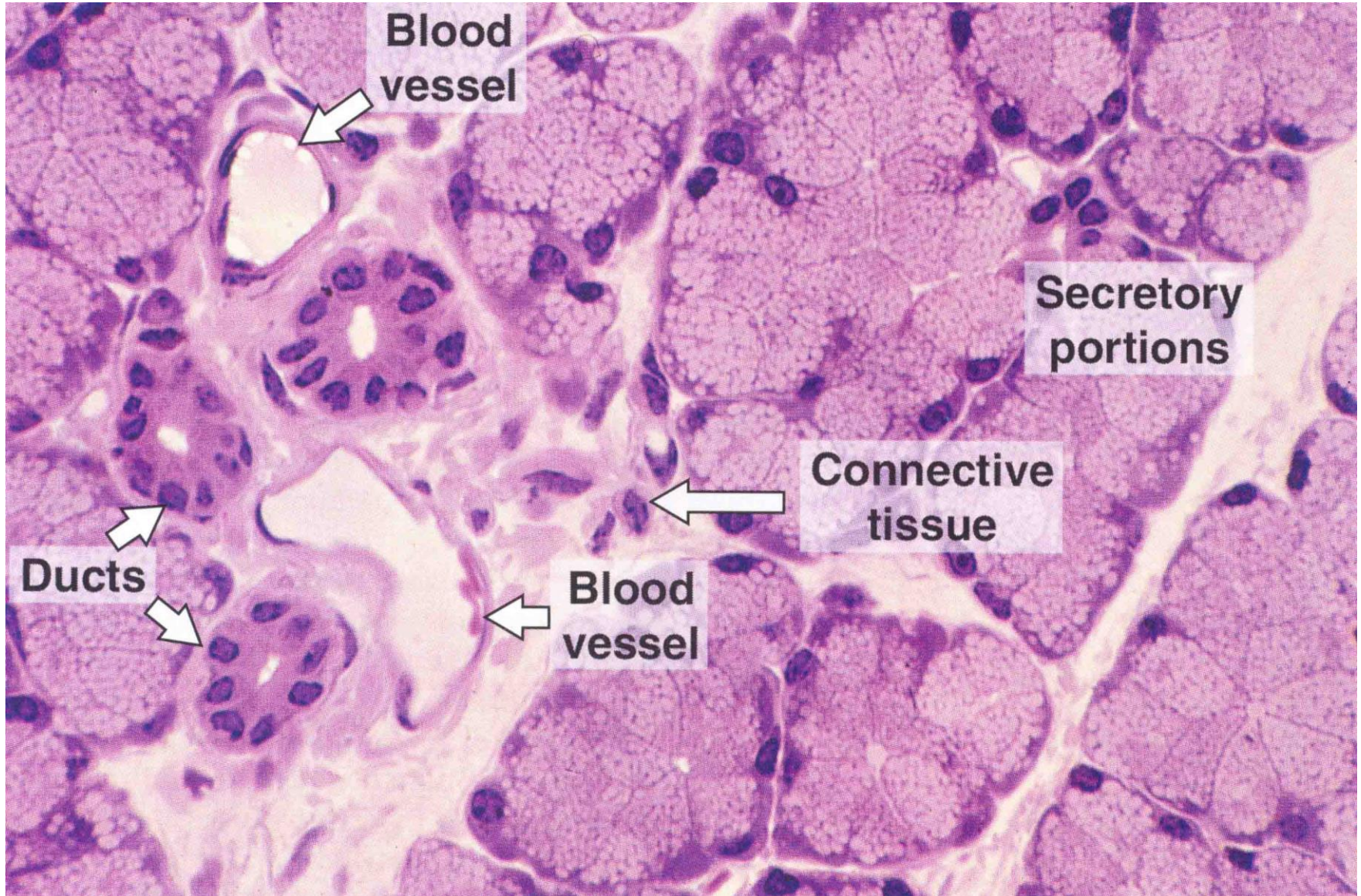
Lacrimal apparatus



Lacrimal gland

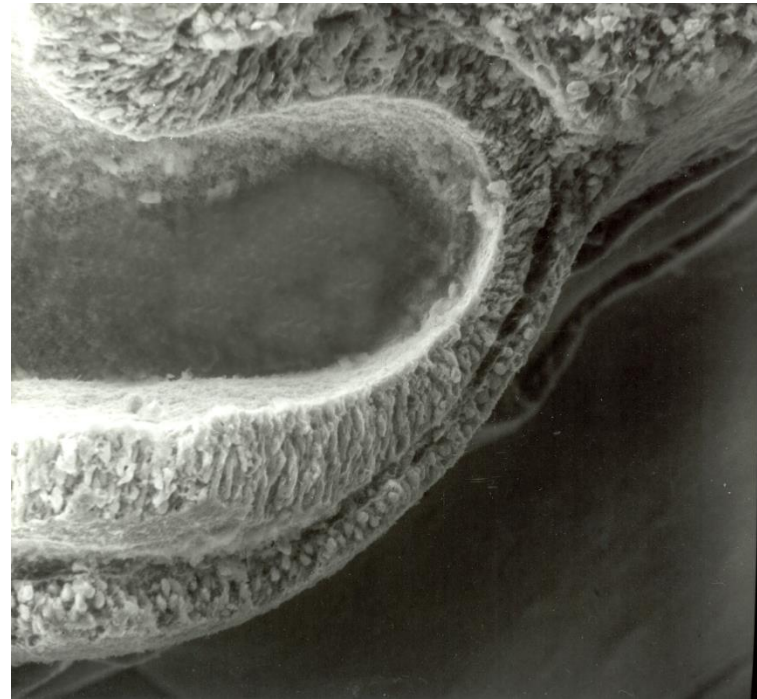
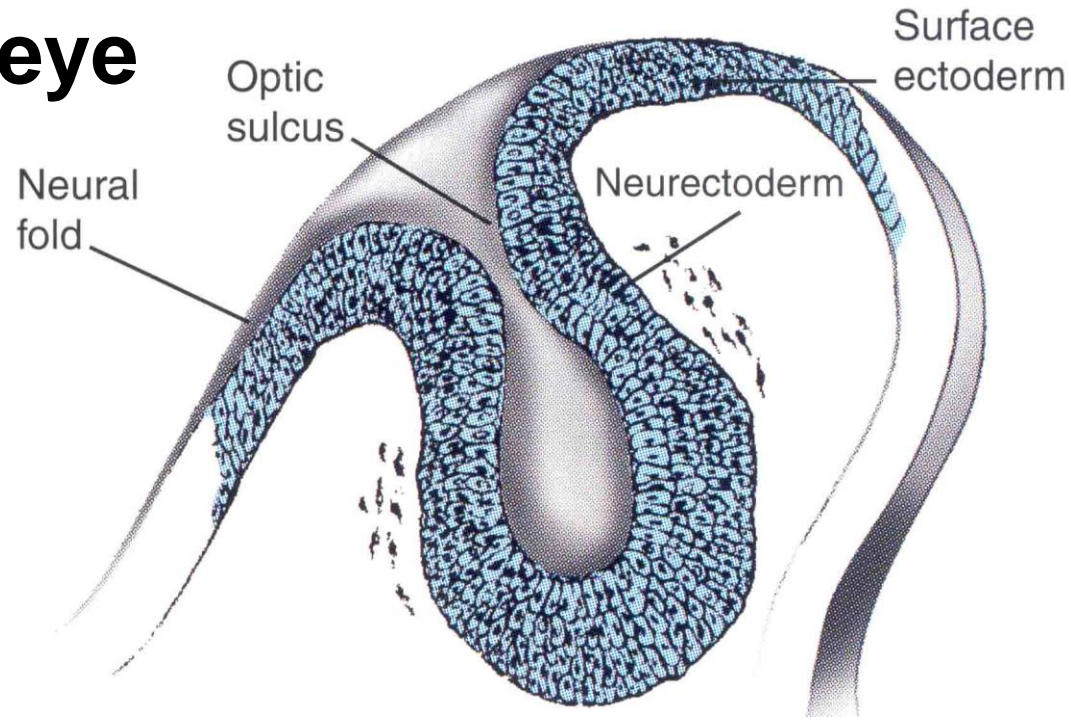
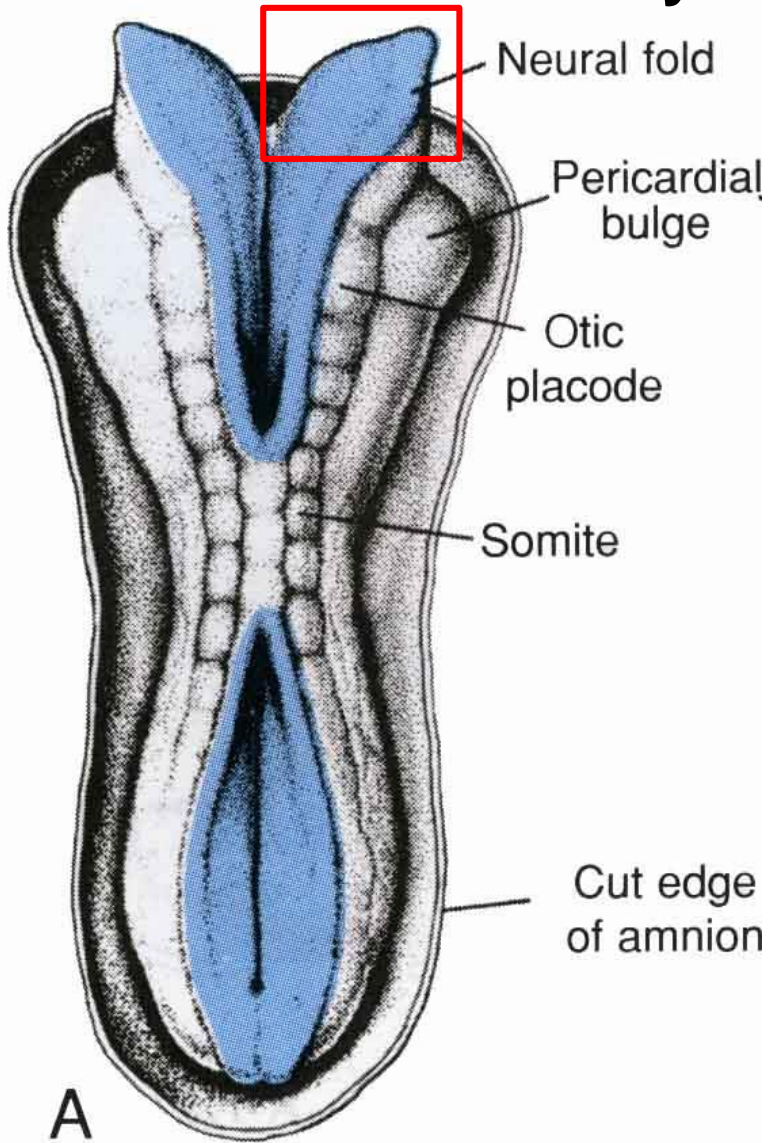
compound tubuloacinar serous

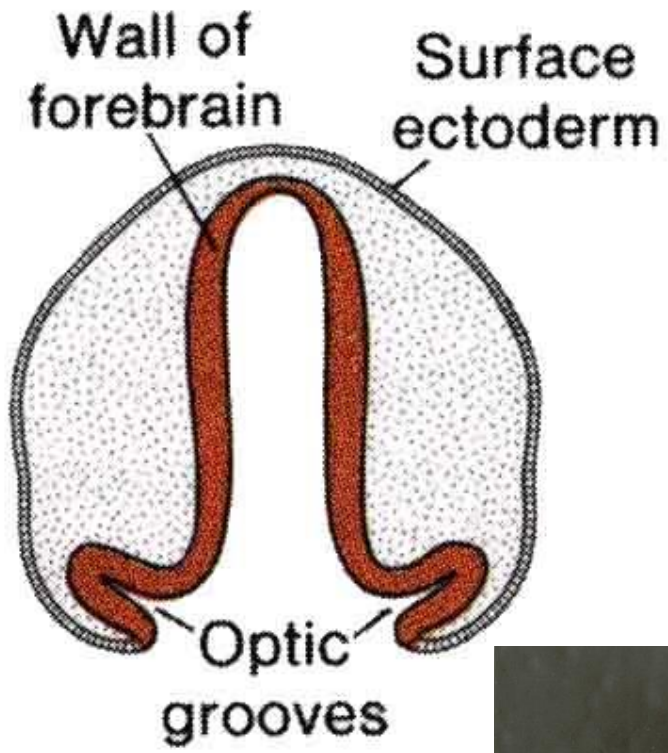
12 – 15 lobes with independent ducts

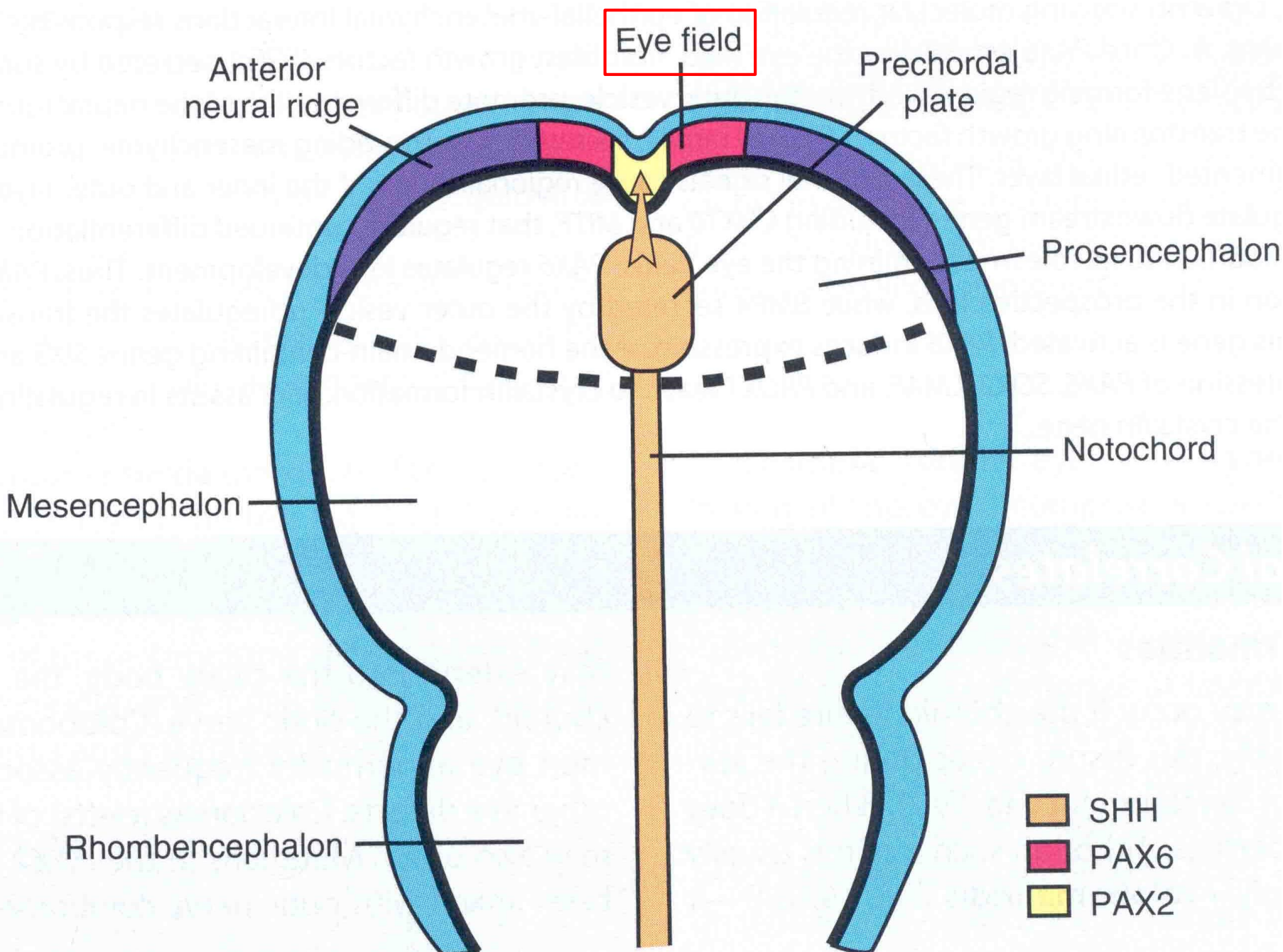


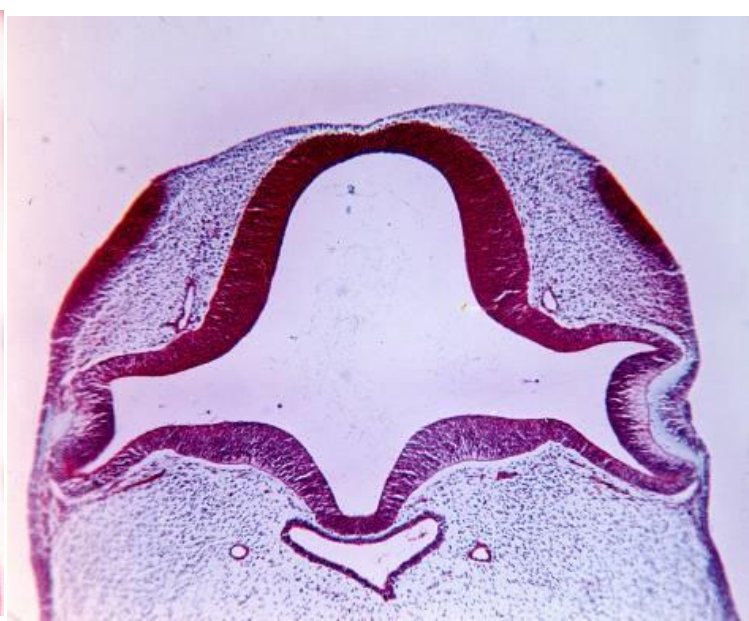
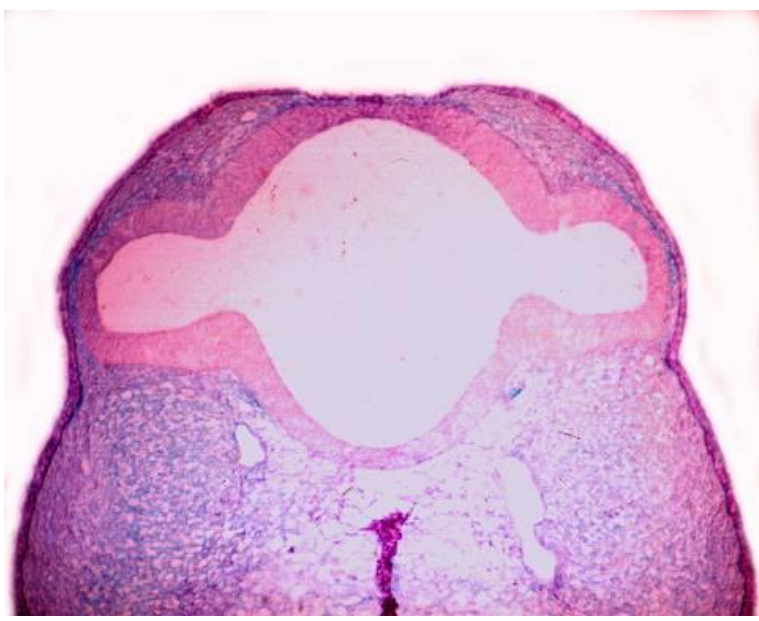
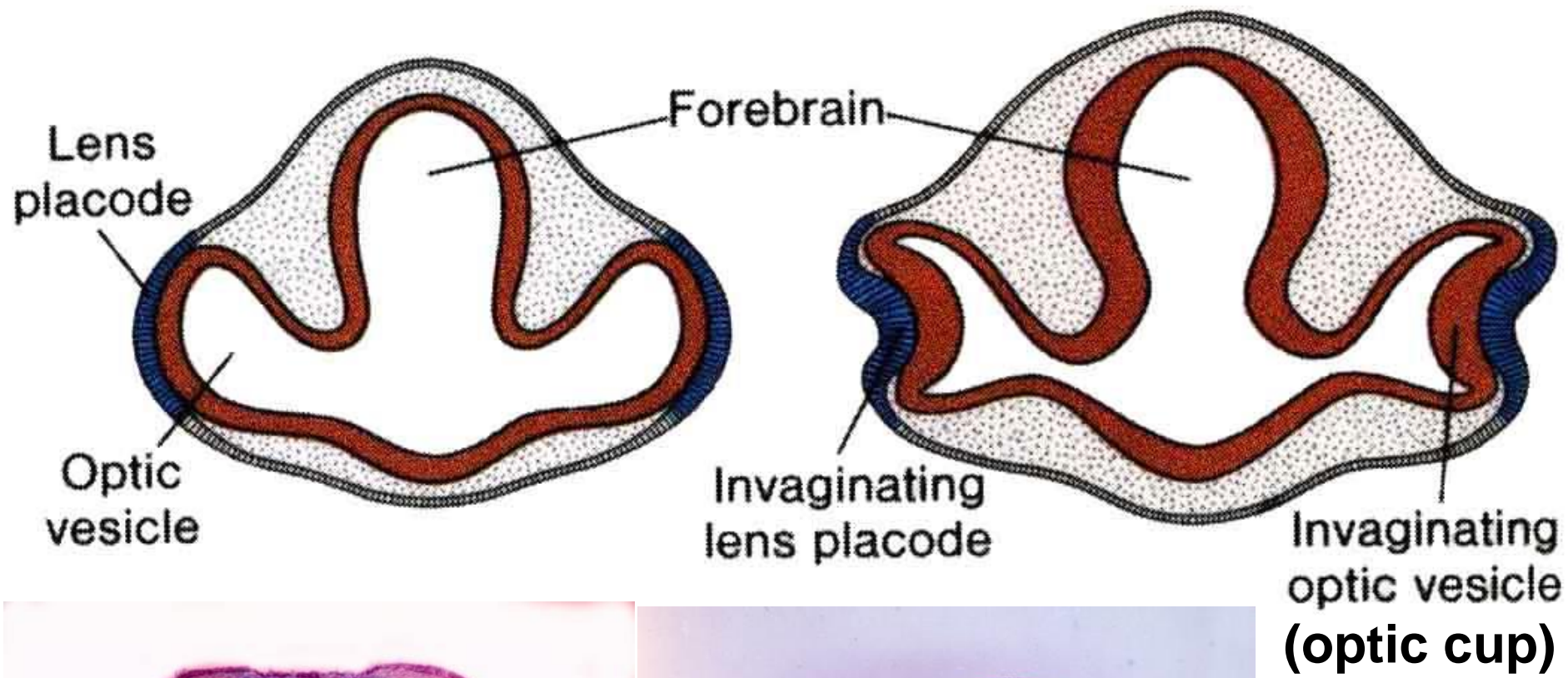
Development of the eye

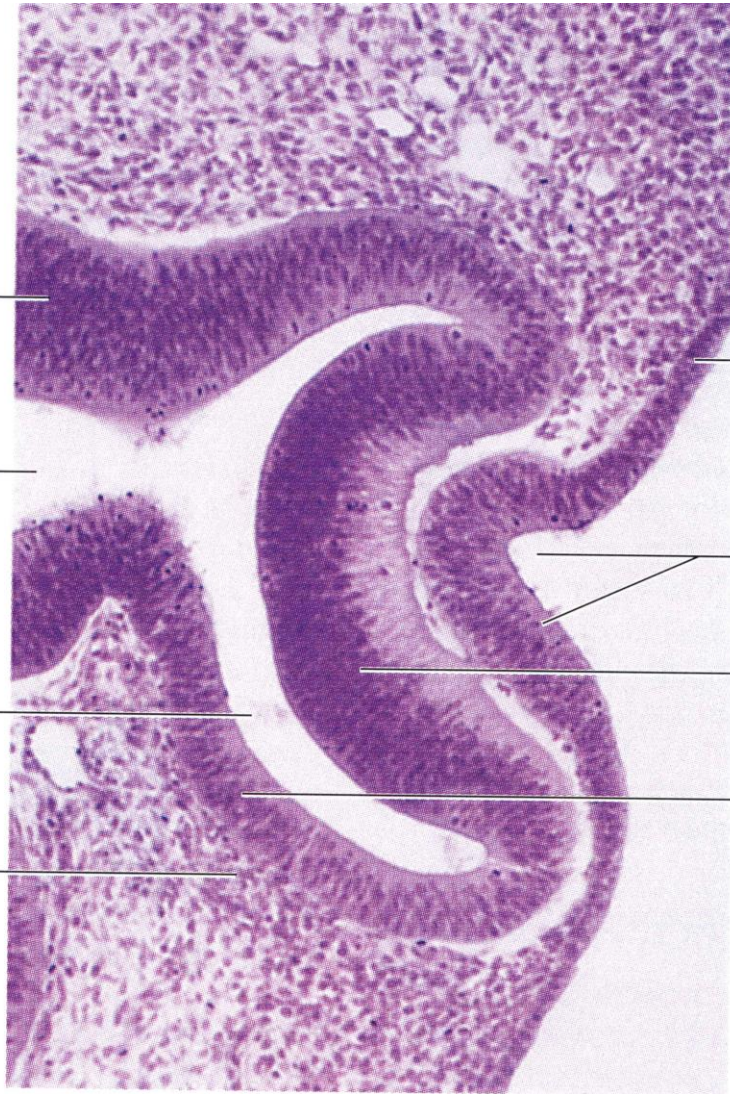
22 days











Wall of optic stalk
(continuous with wall
of forebrain)

Cavity of optic
stalk (continuous with
cavity of forebrain)

Intraretinal space

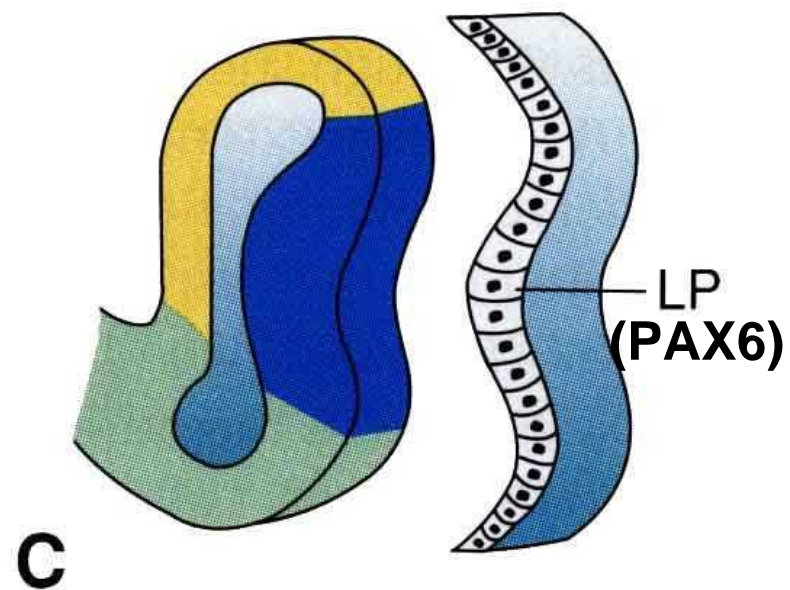
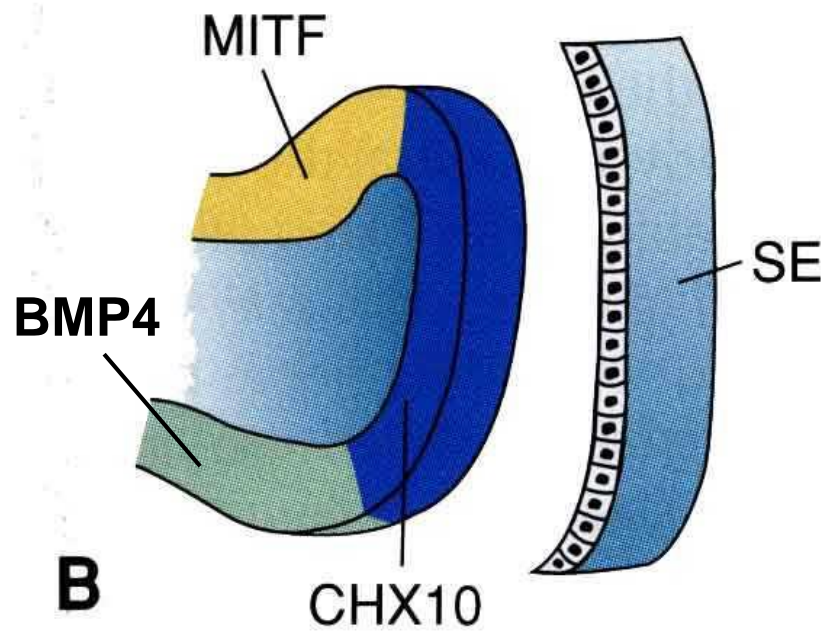
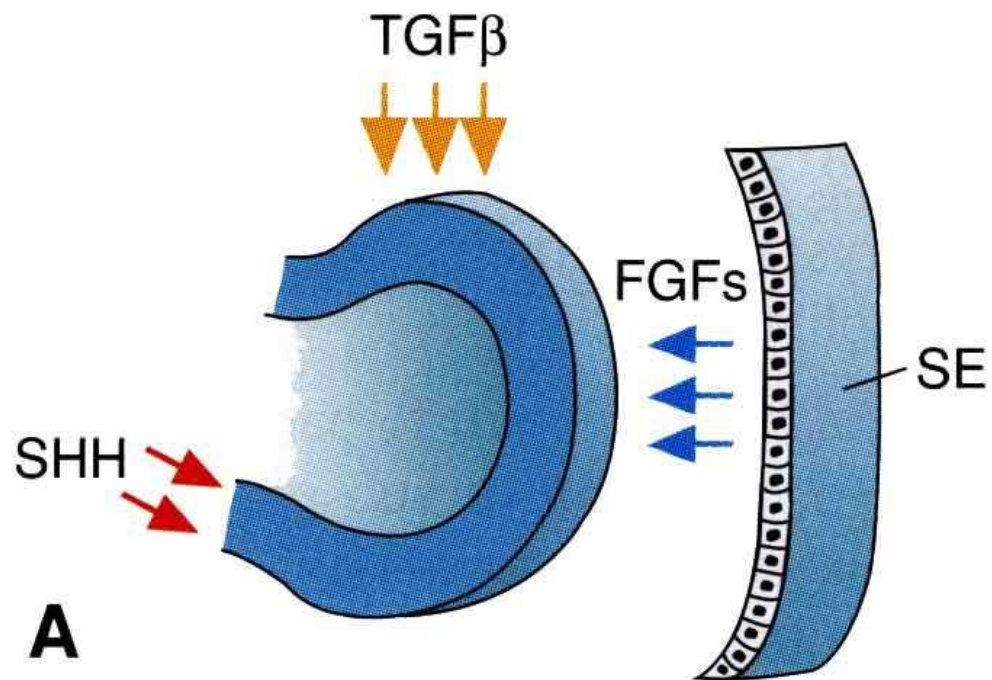
Mesenchyme (primordium
of choroid and sclera)

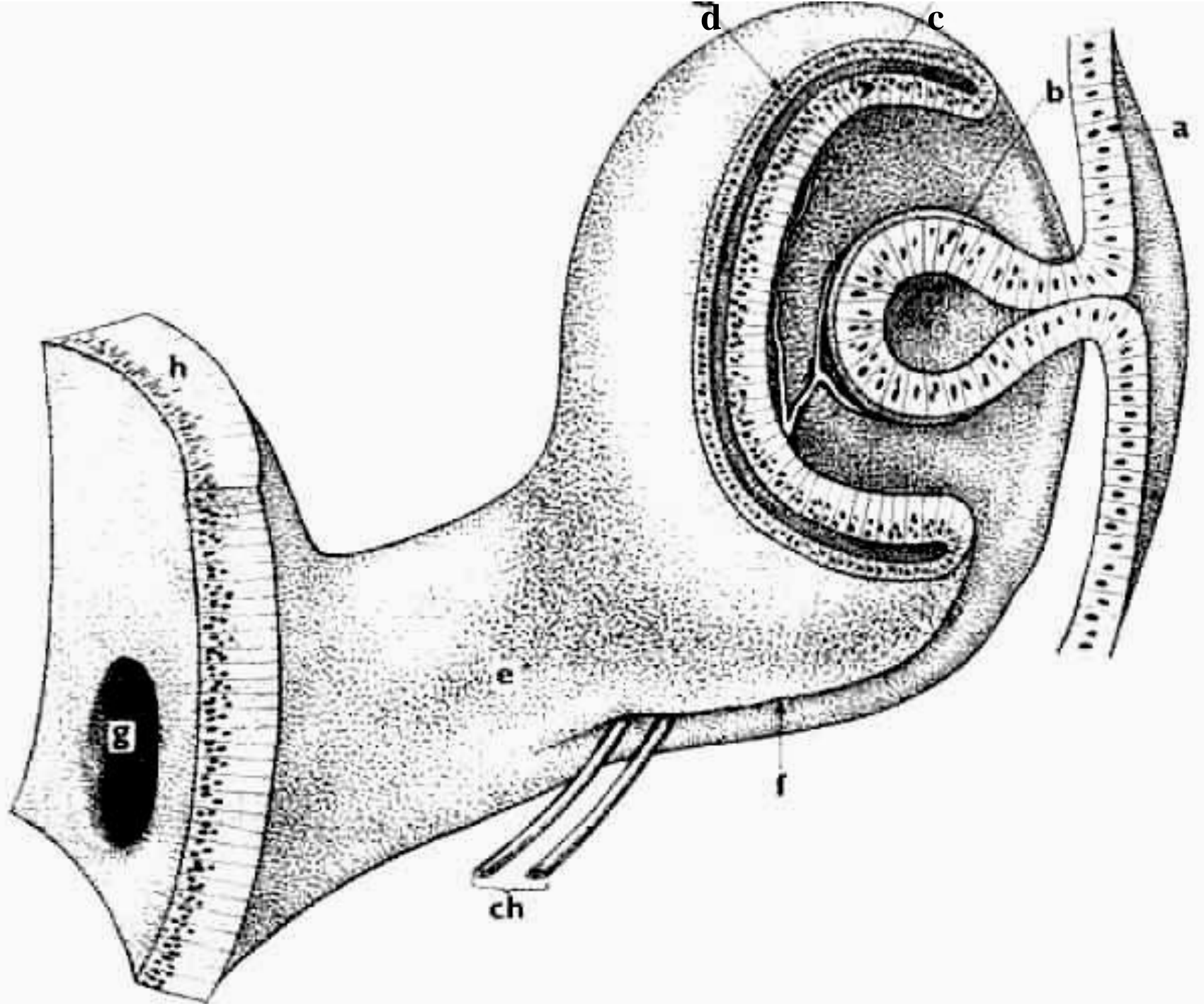
Surface ectoderm

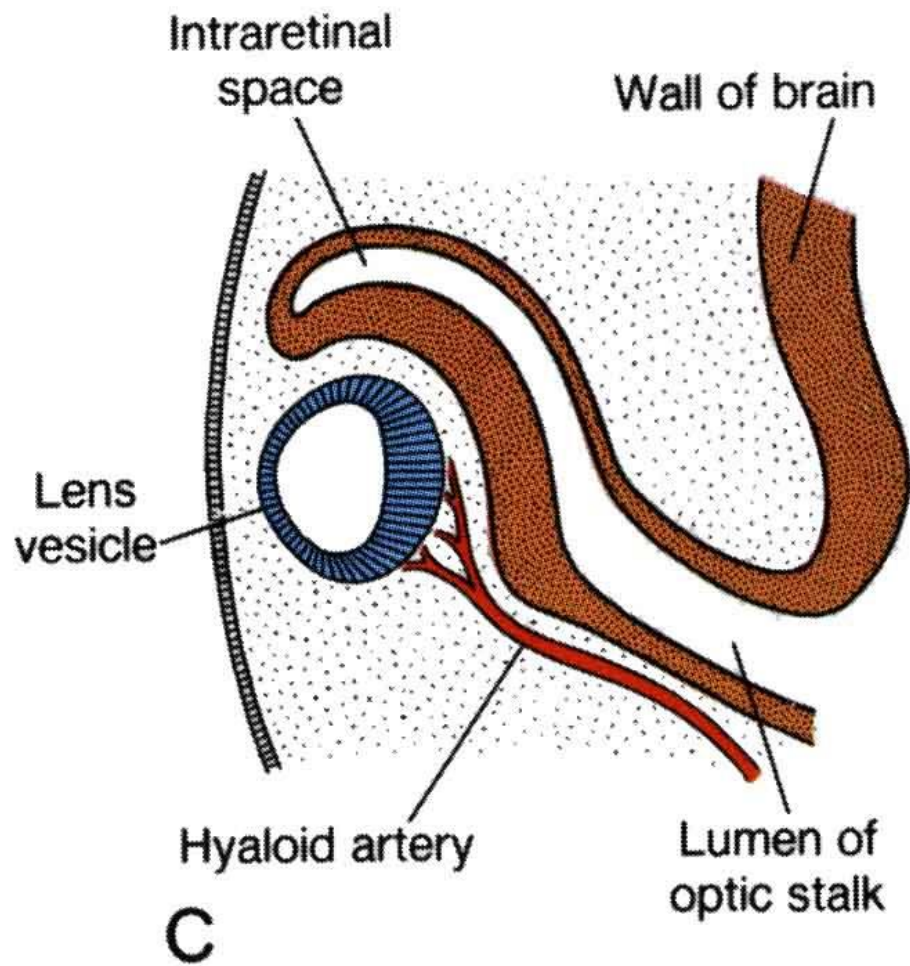
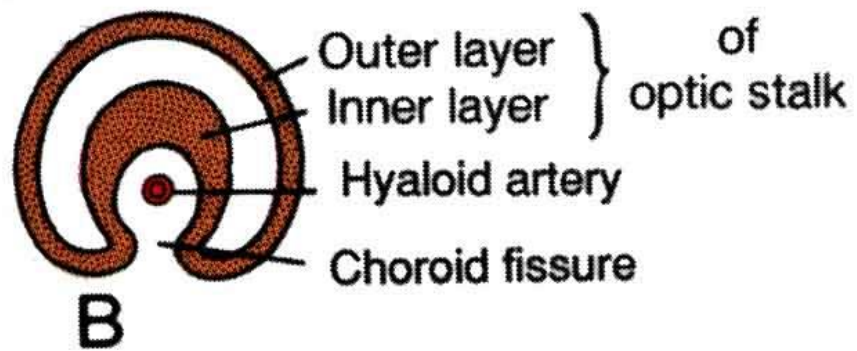
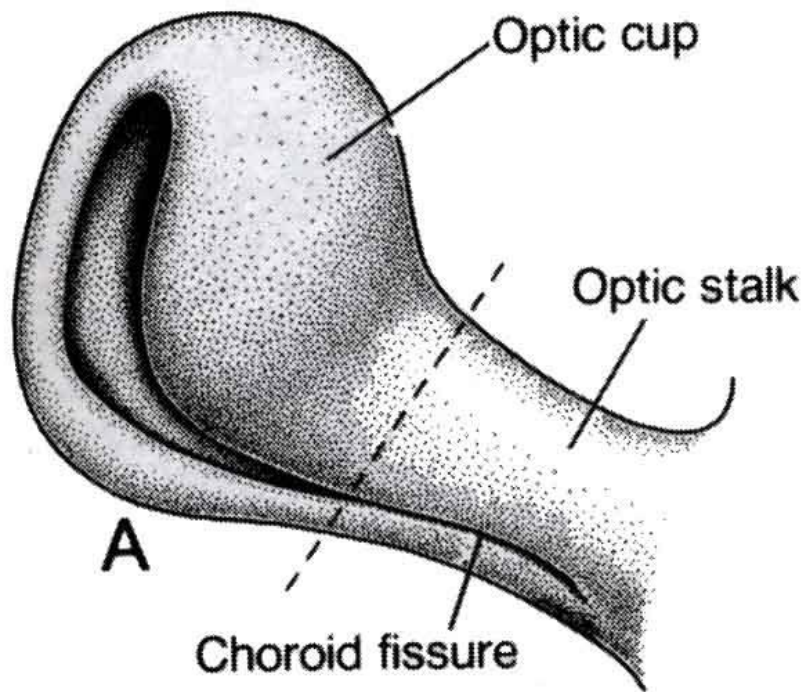
Lens pit
(invaginated lens placode)

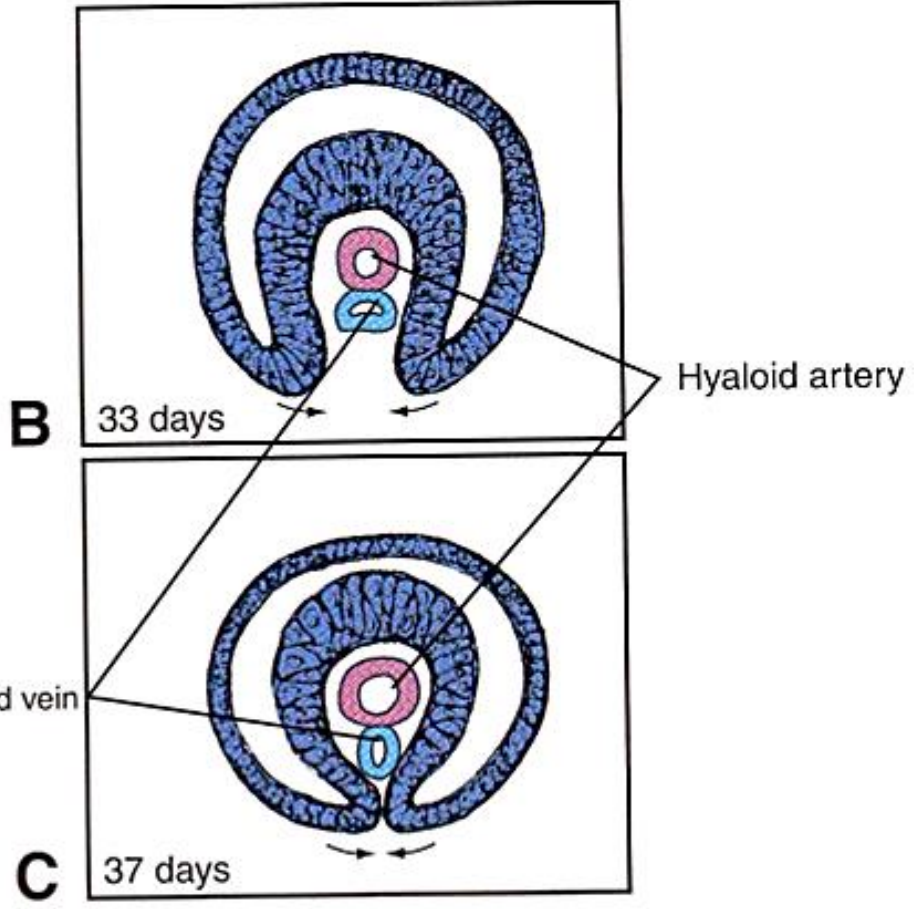
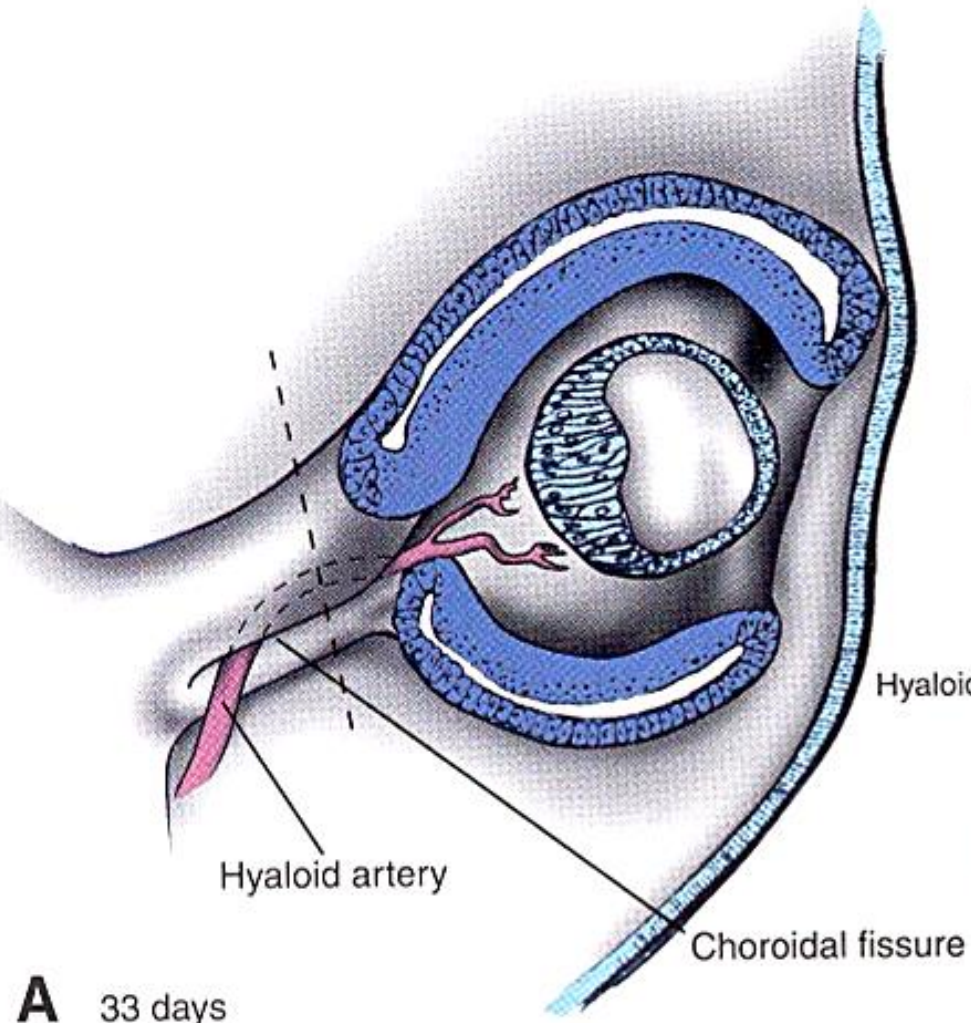
Inner layer of optic cup
(primordium of neural
layer of retina)

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

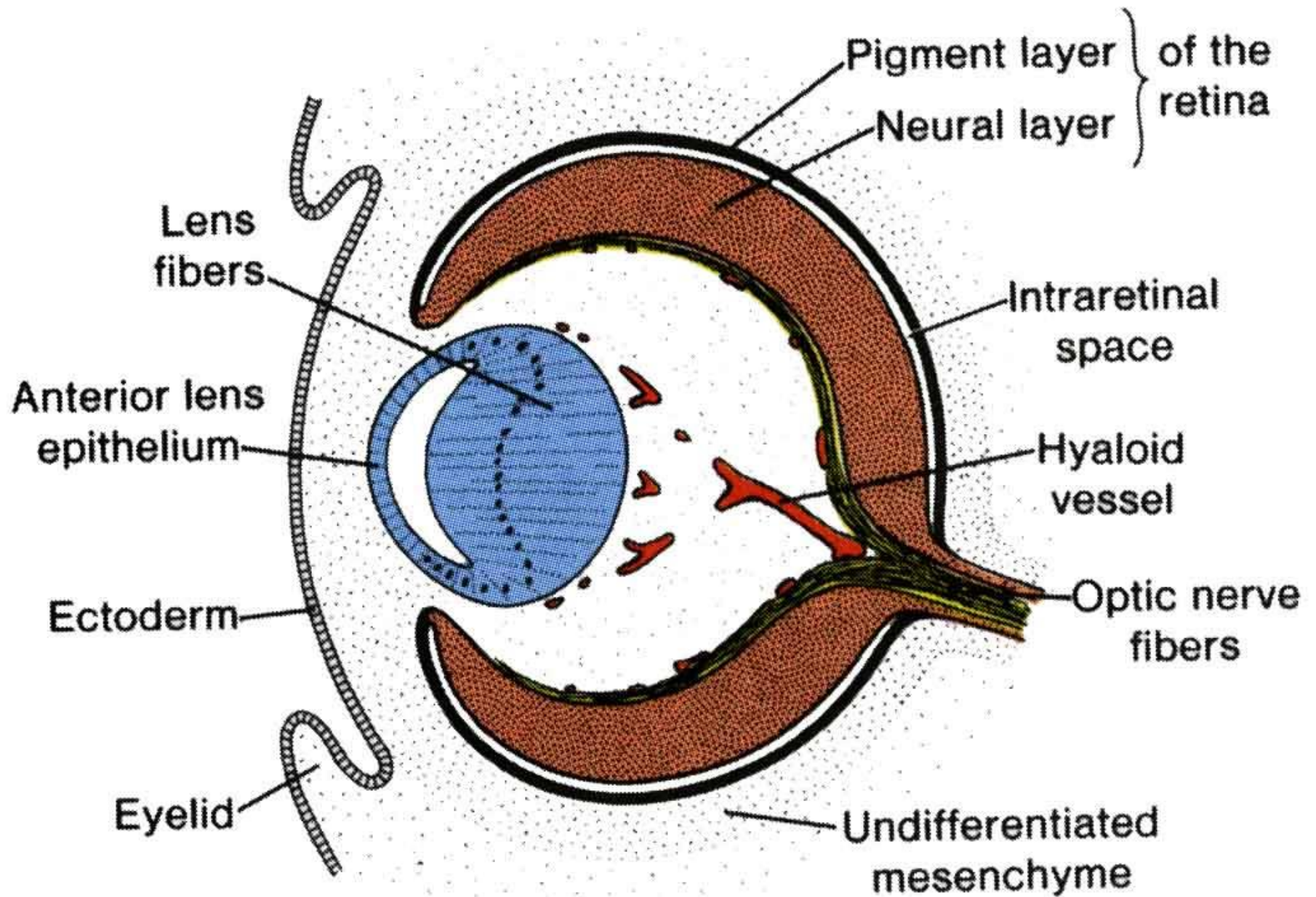
Lens fibers

Iris

Vitreous body

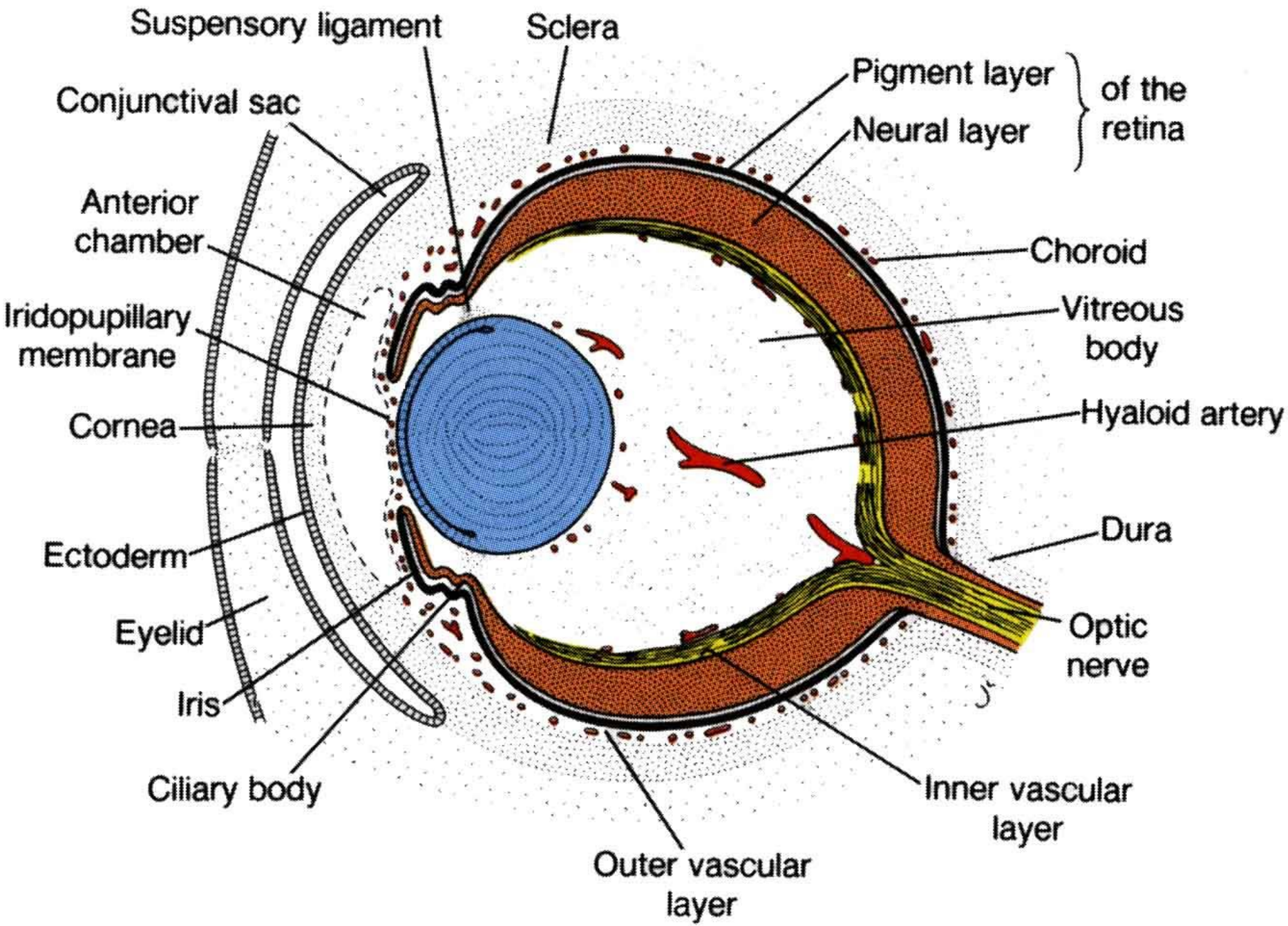
Sclera

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

