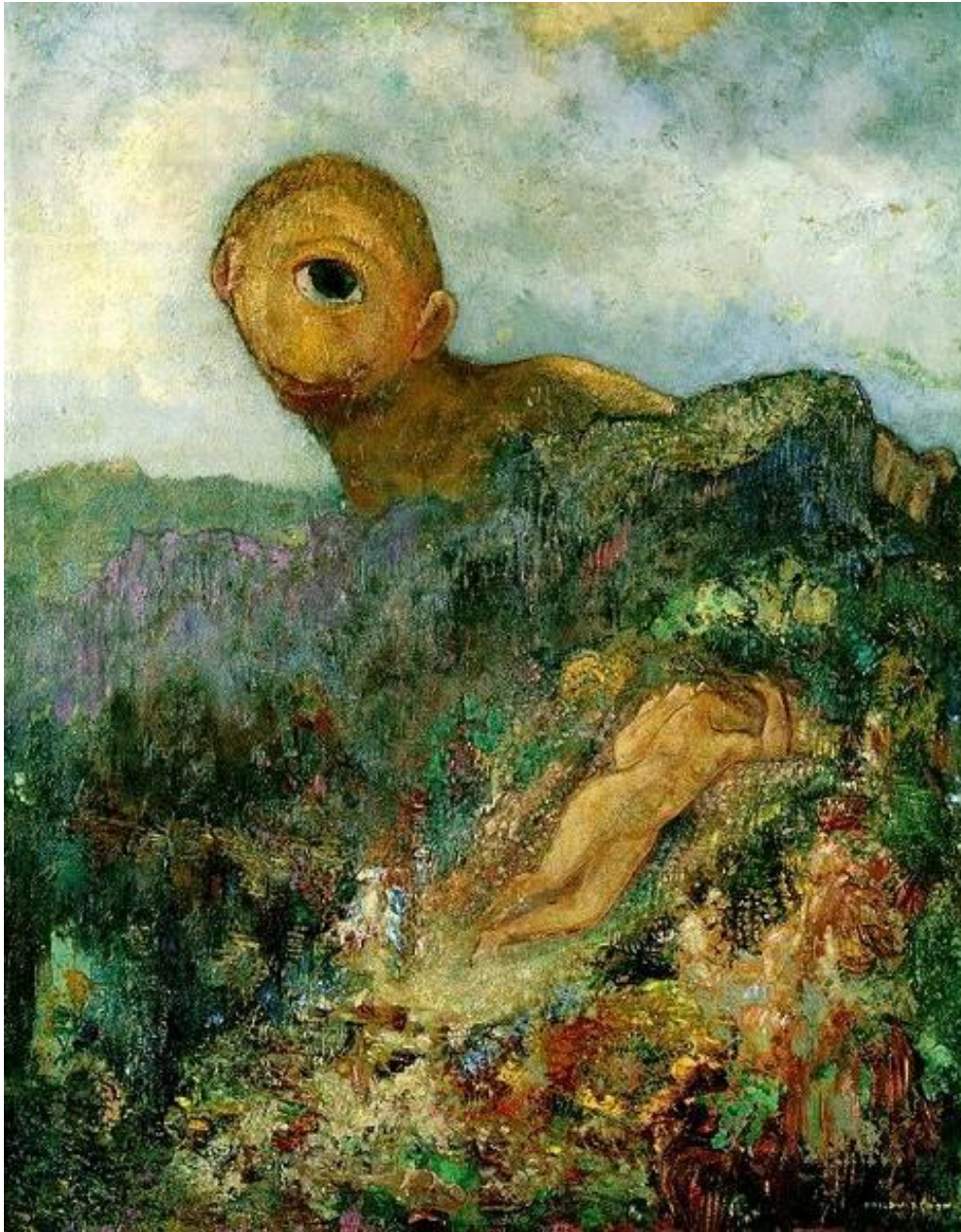


Visual system and accessory visual structures

Organum visuale et structurae oculi accessoriae

David Kachlík



Odilo Redon (1840-1916)



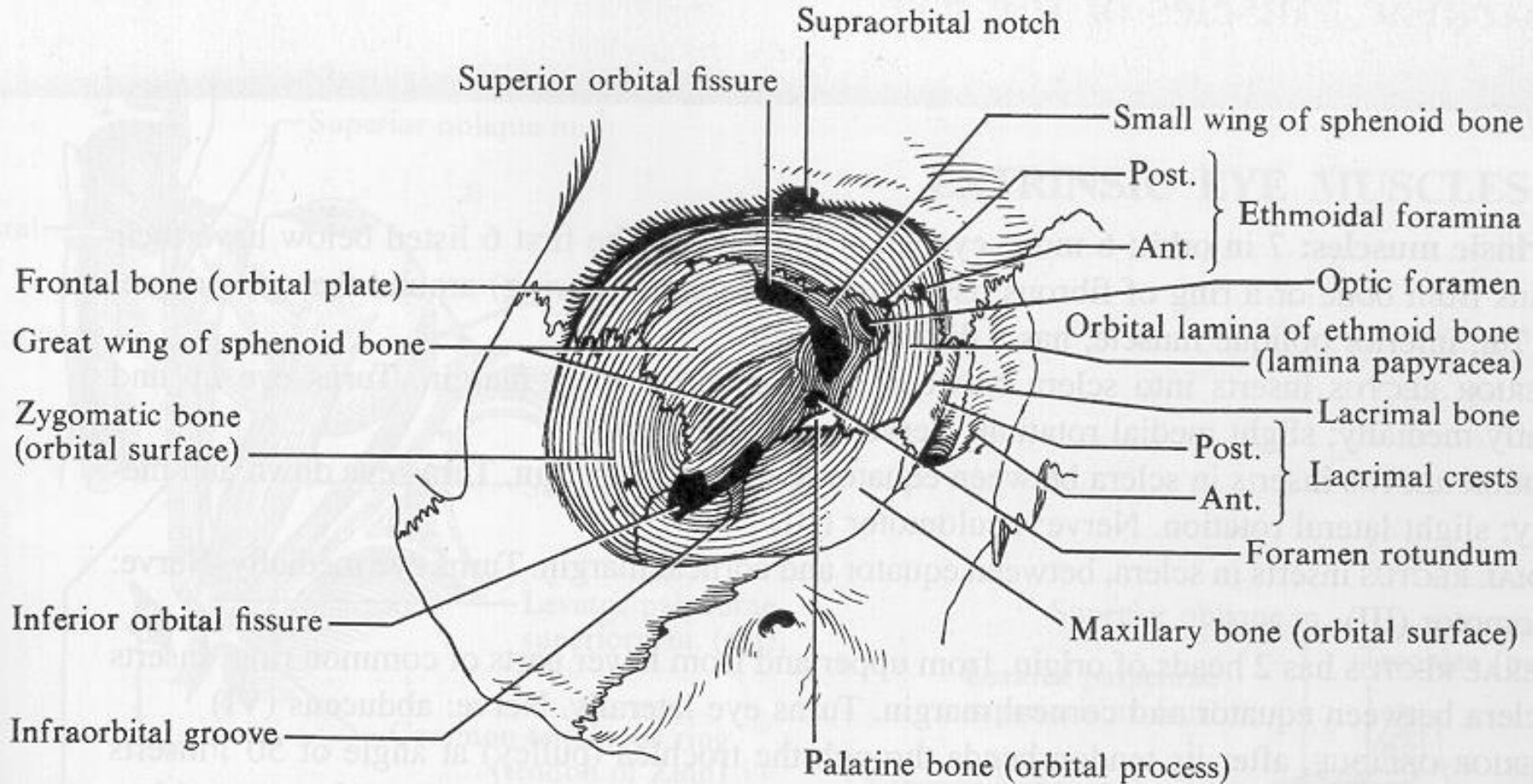
Henri Jean Gaspard Redon
(1899-1974)



Orbita = *Orbit*

- tetrahedral pyramid tilted dorsally
- 4 osseous walls
- aditus orbitae → apex orbitae
- 10 openings + their content
- septum orbitale – closes the aditus orbitae
- m. orbitalis *Mülleri* – smooth muscle in the fissura orbitalis inferior
- contents: eyeball, oculomotor muscles, fat pad and related structures

Orbita – osseous walls



Orbita – osseous walls

- cranially: pars orbitalis o. frontalis (fovea trochlearis + spina trochlearis, incisura/foramen frontalis/supraorbitalis, fossa glandulae lacrimalis), ala minor o. sphenoidalis (fissura orbitalis sup.)
- medially: processus frontalis maxillae (fossa sacci lacrimalis), os lacrimale, lamina orbitalis o. ethmoidalis (foramen ethmoidale ant. et post.), ala minor o. sphenoidalis
- laterally: facies orbitalis o. zygomatici (foramen zygomaticoorbitale), facies orbitalis alae majoris o. sphenoidalis

Orbita – osseous walls

- caudally: facies orbitalis o. zygomatici, facies orbitalis corporis maxillae (sulcus et canalis infraorbitalis, fissura orbitalis inf.), processus orbitalis o. palatini
- aditus orbitae → apex orbitae
- orbita is divided by theoretical planes into 3 levels

Orbita – related structures

- medially: cellulae ethmoidales (behind very thin lamina orbitalis ossis ethmoidalis)
- caudally: sinus maxillaris
- cranially: fossa cerebri anterior
- dorsally: sinus cavernosus + fossa pterygopalatina

Visual system

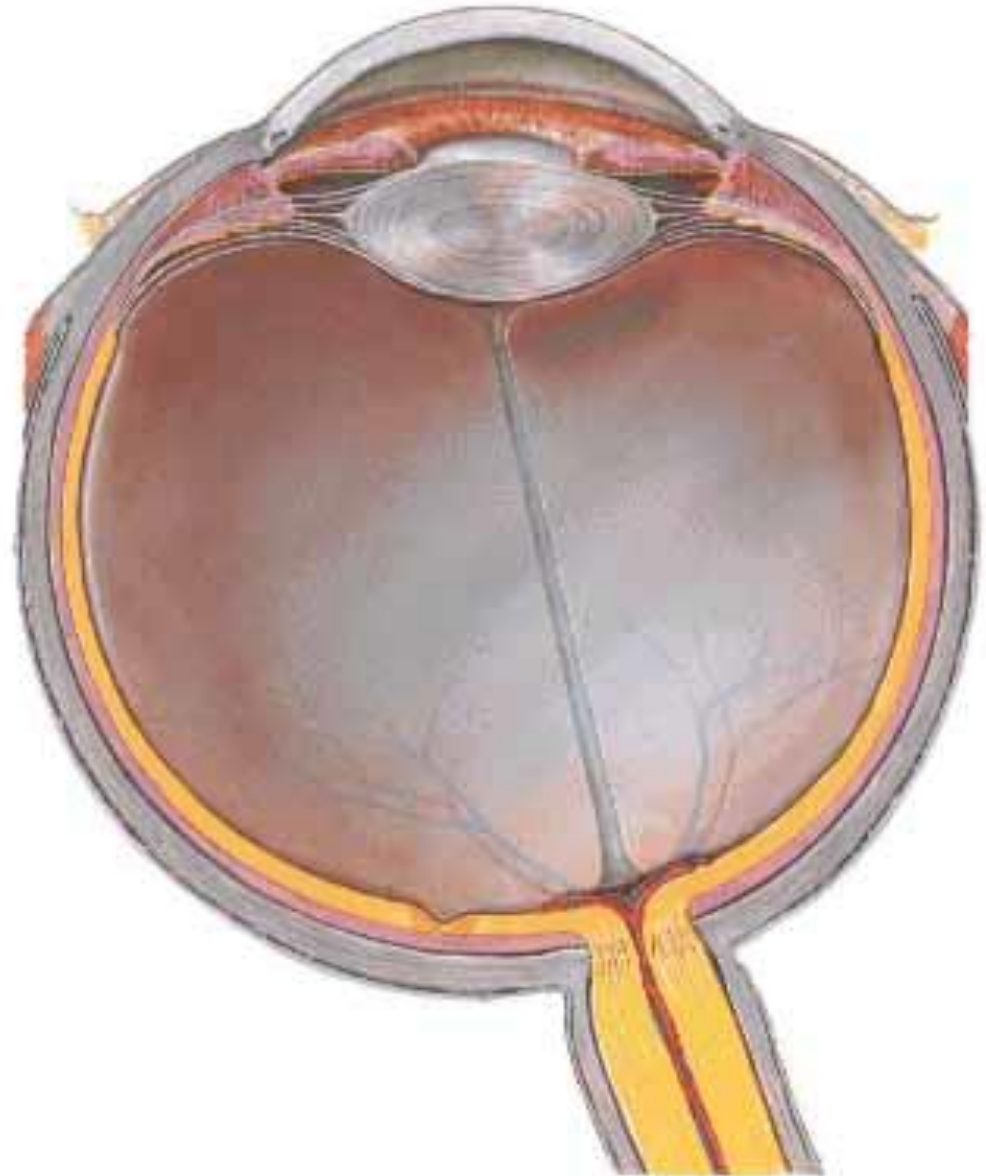
- bulbus oculi = eyeball
- structurae oculi accessoriae = related structures of the eye
- topography: regio orbitalis
- development

Eyeball

Eyeball

Horizontal section

- tunica fibrosa (externa)
- tunica vasculosa (media)
- tunica interna (nervosa)
- corpus vitreum (*vitreous body*) + lens
- segmentum anterius + posterius

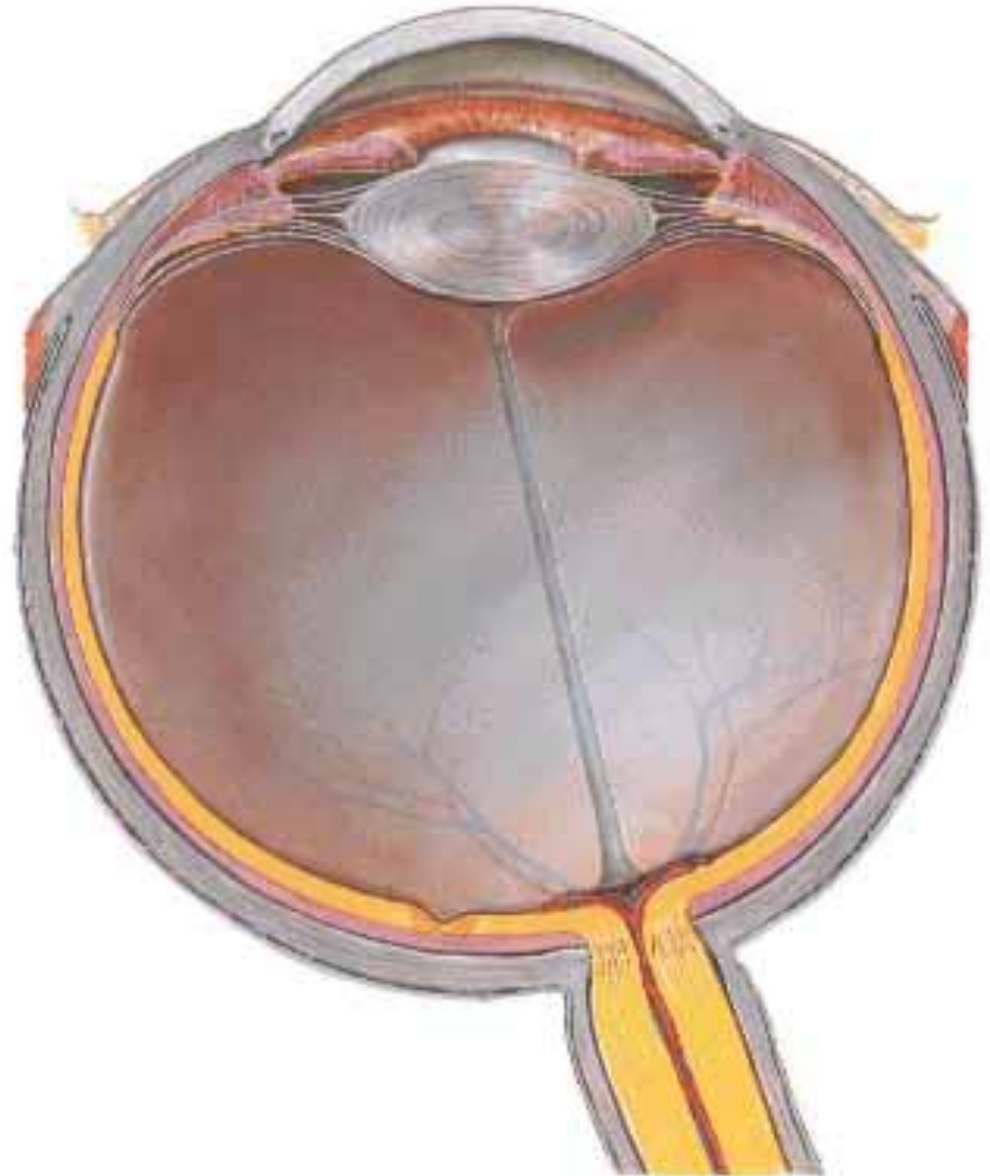


Eyeball

- polus anterior + posterior
- equator *versus* meridiani
- axis bulbi externus + internus
- axis opticus (= „linea visus“)

Eyeball

Horizontal section



Tunica fibrosa (externa)

- sclera
- cornea

Tunica fibrosa (externa)

Sclera

- 5/6 of the eyeball surface
- untransparent layer of dense connective tissue, less elastic fibers and fibroblasts
- thickness: 0,4 mm (at equator) → 1 mm (dorsally)
- tendons of 6 extraocular muscles insert into the outer layer
- forms a protective envelope of deeper layers and a fixed support for insertion of extraocular muscle tendons

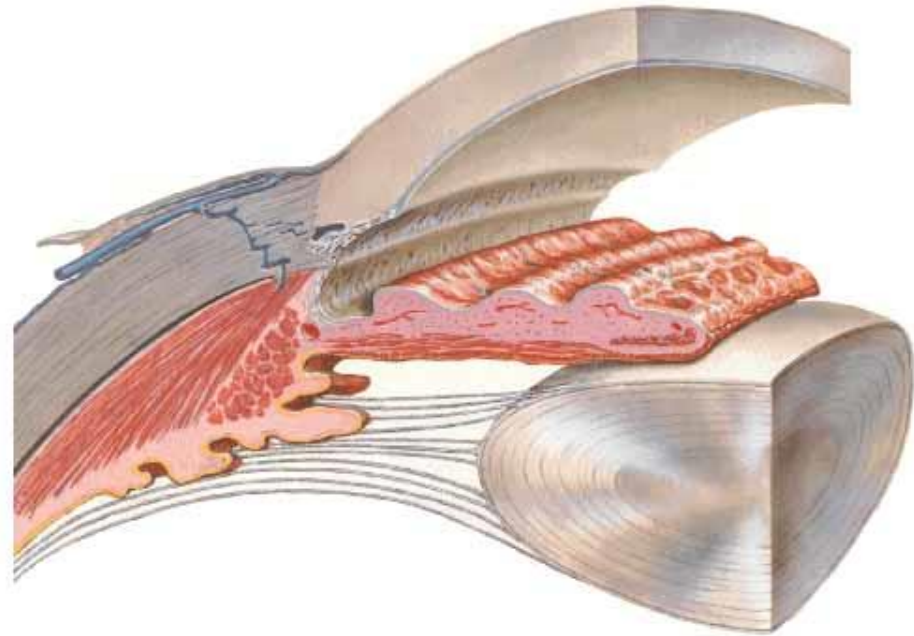
Tunica fibrosa (externa)

Sclera

layers:

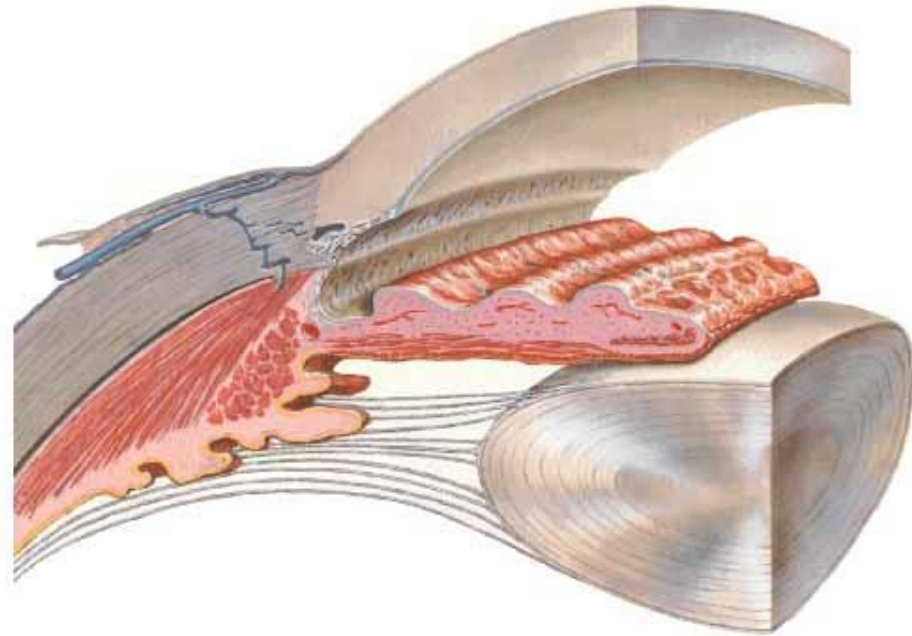
- **lamina episcleralis**
 - thin layer of loose connective tissue connects the eyeball with vagina bulbi, contains vessels
- **substantia propria sclerae**
 - dense network of thick collagen fibers
- **lamina fusca sclerae (= lamina suprachoroidea)**
 - fibroblasts and melanocytes

Tunica fibrosa (externa) Sclera

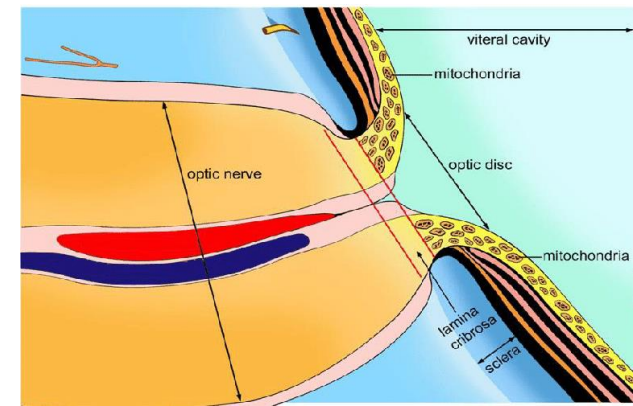


- **reticulum trabeculare / ligamentum pectinatum anguli iridocornealis (Fontana's spaces)**
 - connective tissue with spaces between camera anterior and sinus venosus sclerae
- **calcar sclerae**
 - process of sclera projecting between sinus venosus sclerae and corpus ciliare
- **sinus venosus sclerae (canalis Schlemmi)**
 - oval (on section) circular canal for humor aquosus drainage

Tunica fibrosa (externa) Sclera

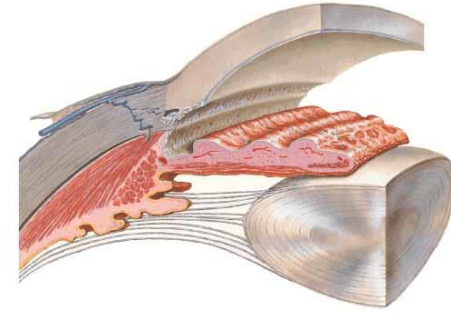


- **sulcus sclerae**
 - shallow groove at corneoscleral junction (limbus corneae)
 - insufficiently cleaned during blinking („dead space“) → potential spread of infection to cornea
- **lamina cribrosa sclerae** – dorsally
 - exit of n. opticus fibers
- **anulus scleralis**
 - fibrous ring around the exit of n. opticus, visible on eye fundus around discus n. optici (blind spot) in ophthalmoscopy (fundoscopy)





Tunica fibrosa (externa) Cornea



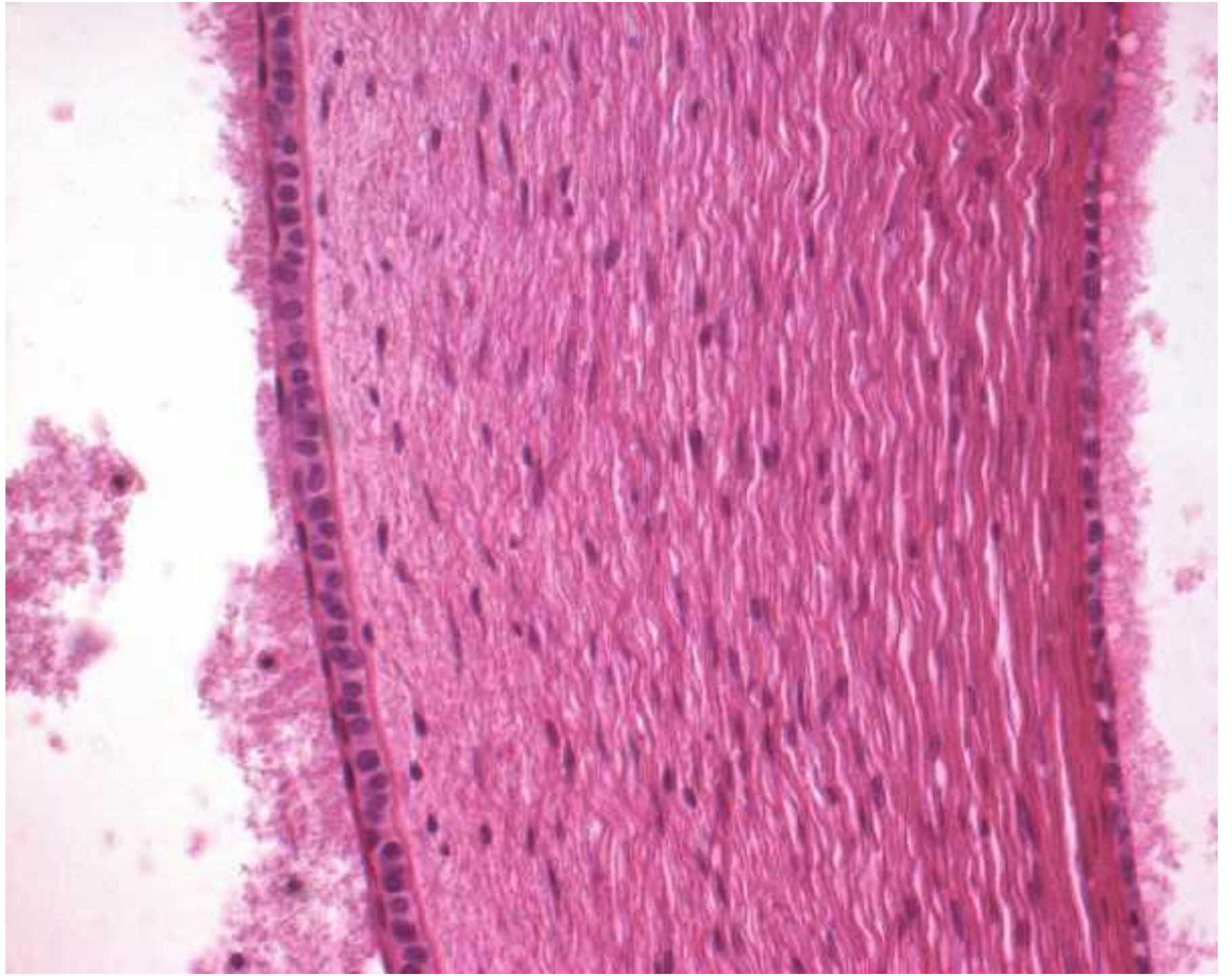
- perfectly transparent, ventrally convex
- physiological astigmatism – vertically 11 mm and horizontally 12 mm (up to 0.5 diopter)
- optical (refractive) power about +43 diopters
- avascular (neither blood nor lymph), fed by diffusion from scleral and conjunctival capillaries, from humor aquosus and tears
- contains 78% of water, collagen and keratansulfate
- **limbus corneae (corneoscleral junction)** – wedge-shaped margin connecting to sclera
- **vertex corneae** – thinnest and ventralmost spot of cornea (555 μm thick)

Tunica fibrosa (externa)

Cornea – layers

5 layers

- epithelium anterius corneae
 - stratified squamous non-keratinizing epithelium
- lamina limitans anterior
 - *Bowman's* membrane
- substantia propria corneae
- lamina limitans posterior
 - *Descemet's* membrane
- epithelium posterius corneae
 - simple squamous epithelium
 - clinically „endothelium“



Tunica fibrosa (externa) – cornea

Epithelium anterius corneae

- stratified squamous non-keratinizing epithelium
 - usually 5 layers, 70 μm thick
- large regeneration ability (6-day cycle), at margins dendritic Langerhans' cells
- free nerve endings within epithelium anterius
 - from branches of n. V1
- stratum superficiale
 - flattened cells have microvilli on apical surface
- stratum intermedium
 - contains cells always overlapping two basal cells below
- stratum basale
 - cuboid cells with basal lamina connected by hemidesmosomes with deeper lamina limitans anterior

Tunica fibrosa (externa) – cornea

Other layers

- lamina limitans anterior *Bowmani* – 12 μm
 - dense layer of collagen fibers without fibroblasts
- substantia propria – 500 μm
 - 200-250 layers of arranged collagen lamellas
 - fibroblasts with branched processes
 - macrophages, neutrophils, lymphocytes
 - only 1% of passing light is dispersed
 - injury causes a scar → corneal turbidity
- lamina limitans posterior *Descemeti*
 - thick basal membrane of epithelium posterius
 - 3-10 μm – thickens with age

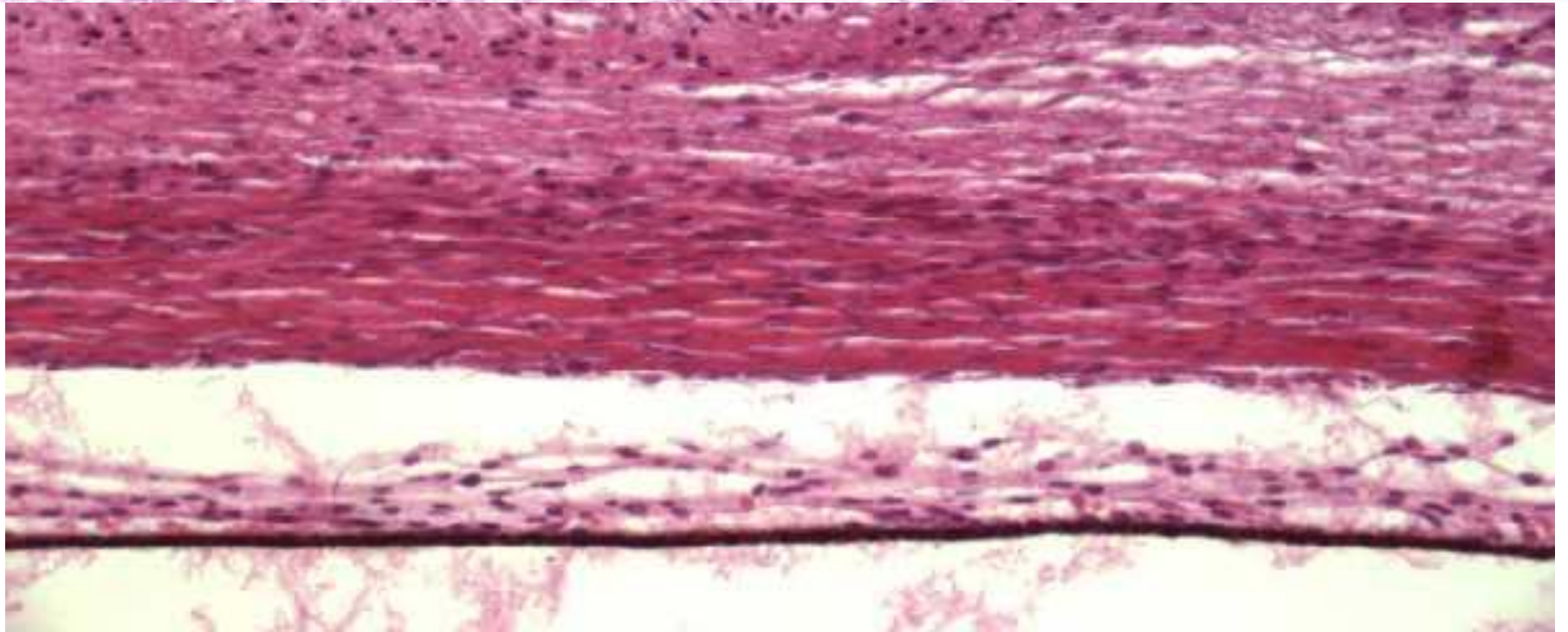
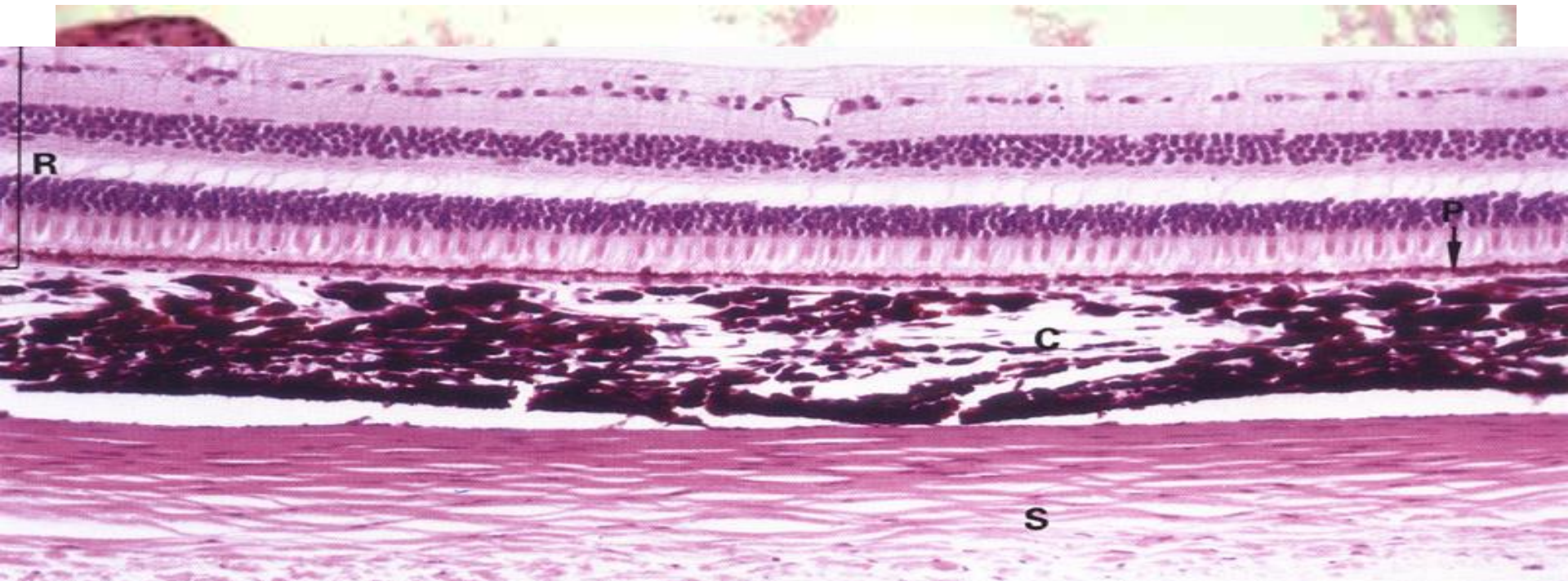
Tunica vasculosa (media) = Uvea

- *choroidea* = choroid
- *corpus ciliare* = ciliary body
- *iris* = iris

Tunica vasculosa (media)

Choroidea

- lamina suprachoroidea (= lamina fusca sclerae)
- spatium perichoroideum
- lamina vasculosa *Halleri* (choroid stroma)
 - large vessels, connective tissue, smooth muscle cells, nerves
- lamina choroidocapillaris
 - capillaries
- complexus basalis choroideae = *Bruch's* membrane
 - BM of pigmented epithelium and capillaries + connective tissue

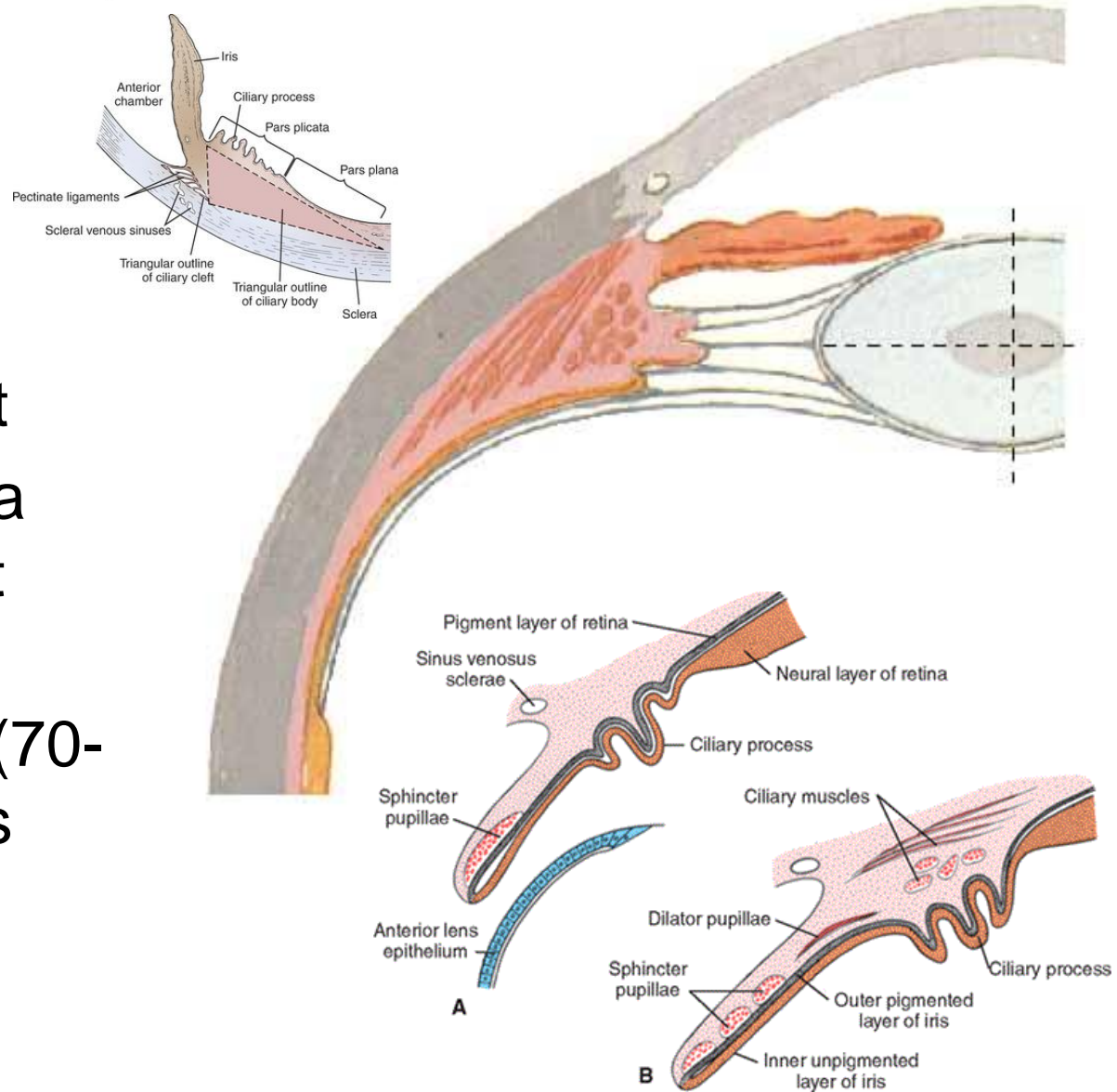


Tunica vasculosa (media) – choroidea
Complexus basalis choroideae
(*Bruch's membrane*)

- lamina basalis vasis capillaris choroideae
- stratum fibrosum externum choroideae
- stratum elasticum choroideae
- stratum fibrosum internum choroideae
- lamina basalis epithelii pigmentosi choroideae

Tunica vasculosa (media) Corpus ciliare

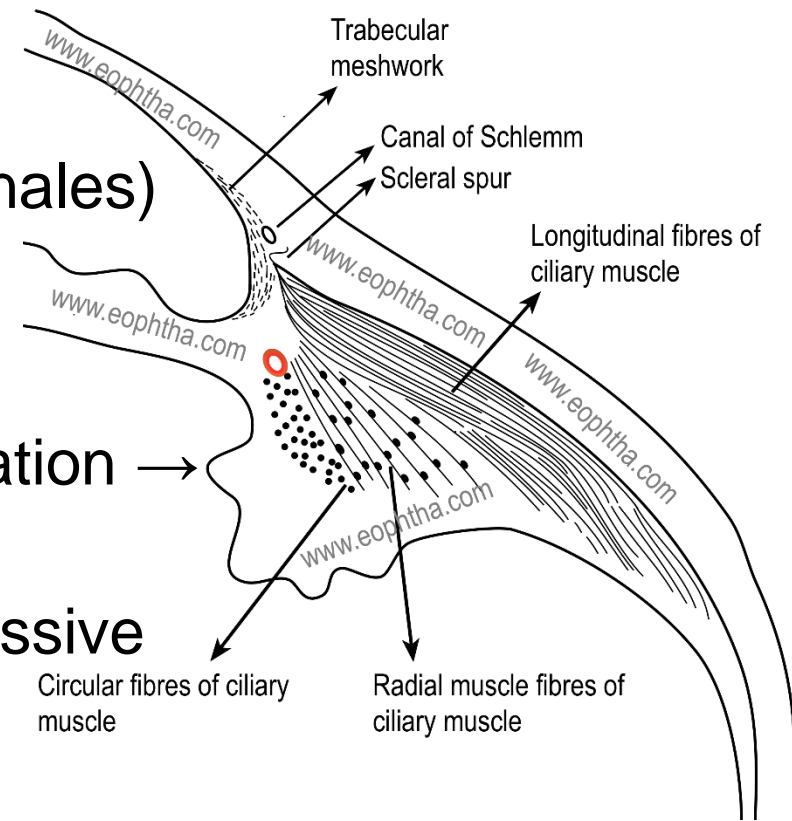
- thick anular ring
- triangular section
- pars plana (anulus ciliaris, orbiculus ciliaris) = outer part
- pars plicata (corona ciliaris) = inner part
- fan-shaped higher processus ciliares (70-80) + plicae ciliares
- zonula ciliaris – fixation of lens



Tunica vasculosa (media)

Corpus ciliare

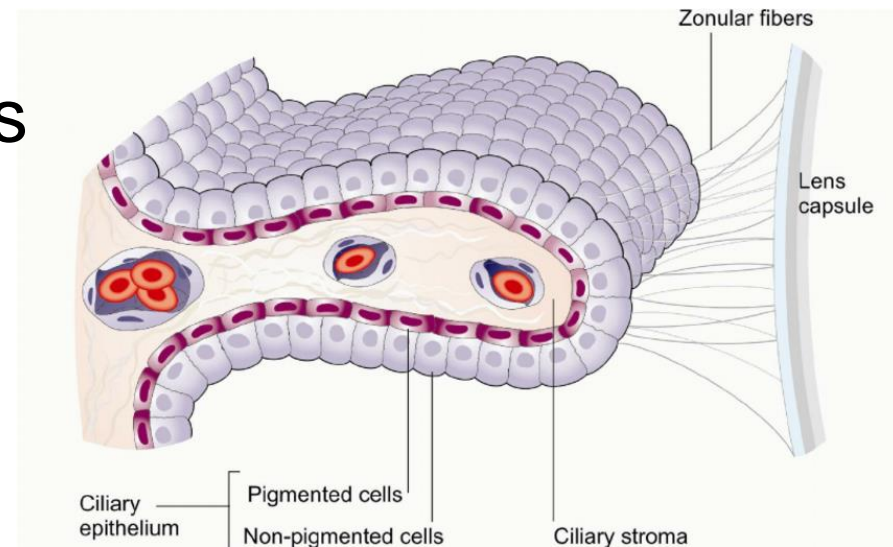
- lamina supraciliaris (corresponds to lamina suprachoroidea)
- *smooth* musculus ciliaris
 - fibrae meridionales (= longitudinales)
 - fibrae radiales
 - fibrae circulares
 - **parasympathetic** → accommodation → **focus at near**
 - (focus at distant provided by passive elasticity of the choroid)
- stroma
 - vessels

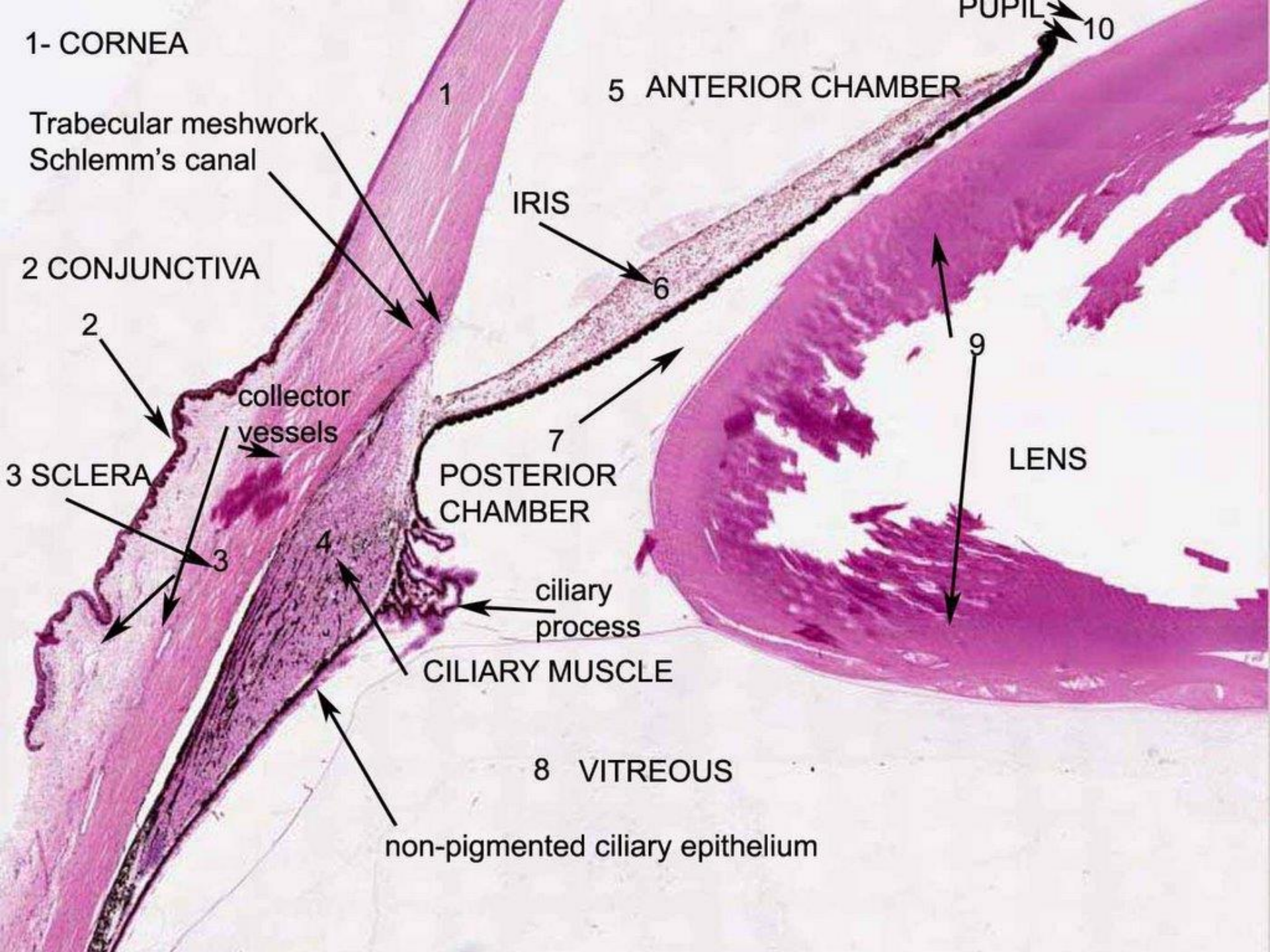


Tunica vasculosa (media)

Corpus ciliare

- lamina basalis (corresponds to Bruch's membrane)
- epithelium ciliare (pars ciliaris retinae)
 - epithelium pigmentosum (corresponds to pigmented epithelium of retina)
 - ciliary canal – production of **humor aquosus**
 - epithelium nonpigmentosum (corresponds to sensory epithelium of retina)
- covered by lamina limitans interna retinae
- insertion of zonula ciliaris (suspensory apparatus of lens)









Tunica vasculosa (media) Iris

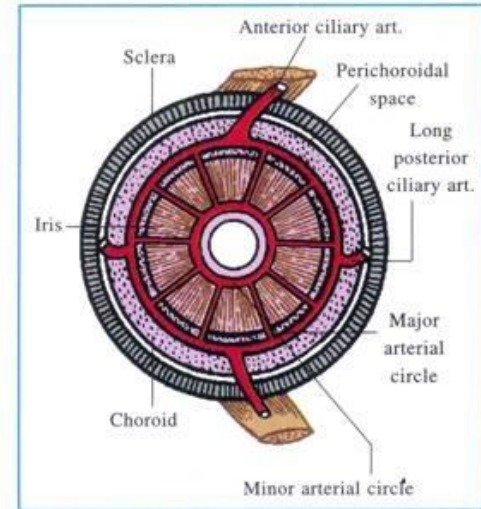
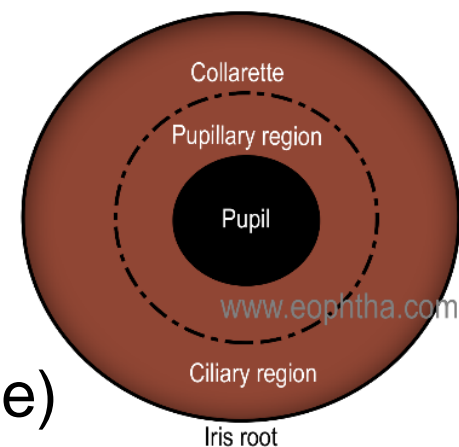


Fig. 9.26. Arterial supply of iris.

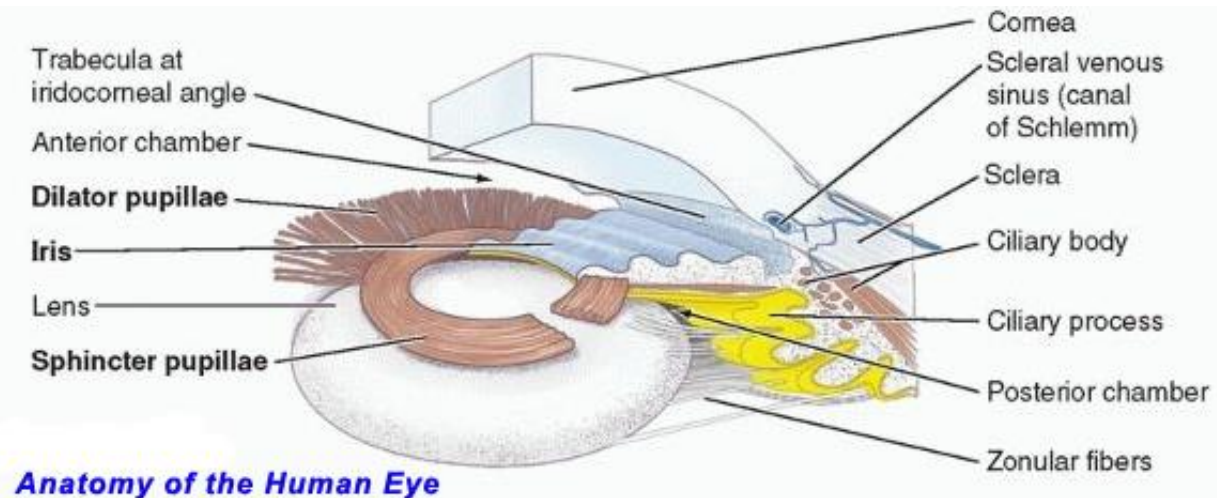
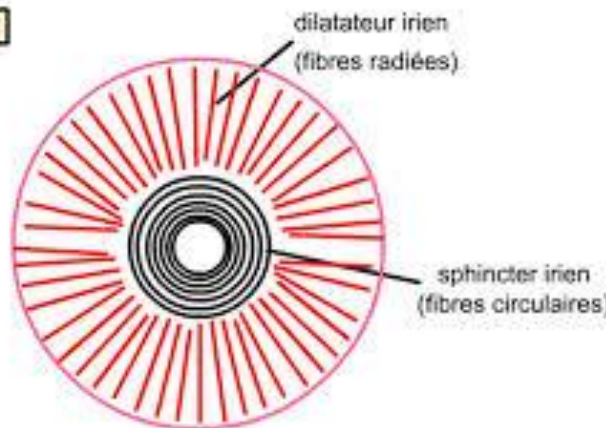
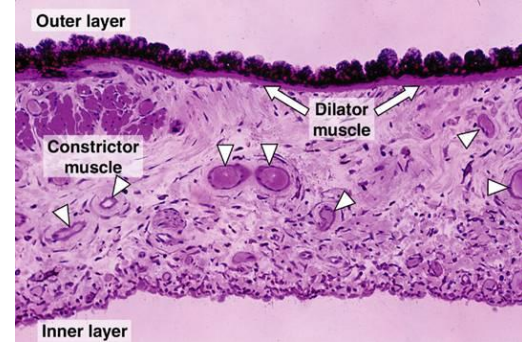


- thin flat anular ring – diameter 21 mm
- functions as diaphragm in pupillary reflex
- contains two smooth muscles
- margo ciliaris (outer) + pupillaris (inner)
- anulus iridis major + minor (contain circulus arteriosus iridis major + minor)
- **pupilla** (pupil) – circular opening (2.5-7 mm wide)
- facies anterior – plicae iridis circulares et radiantes
 - zona ciliaris (cryptae iridis at catella)
 - catella („collarette“) – remnants after membrana pupillaris attachment
 - zona pupillaris (1,5 mm wide, cryptae pupillares)
- facies posterior

Tunica vasculosa (media)

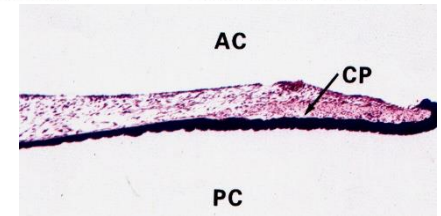
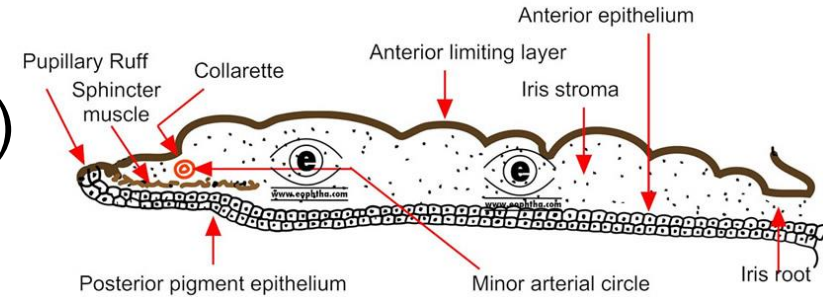
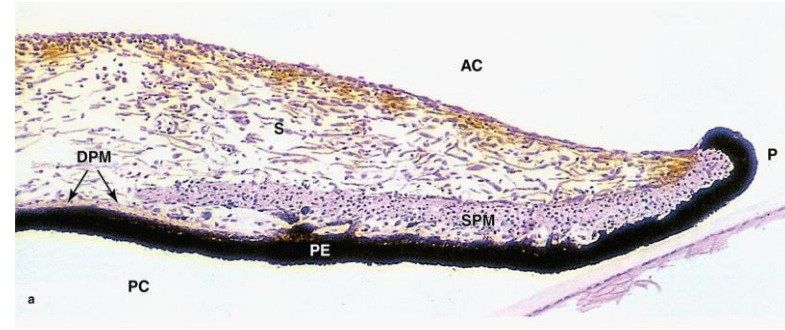
Muscles of iris

- m. sphincter pupillae
 - parasympathetic (n.III → ggl. ciliare)
 - **miosis** (circular shape)
- m. dilatator pupillae (dilator muscle)
 - sympathetic (ggl. cervicale superius)
 - **mydriasis** (fan-shaped)



Tunica vasculosa (media)

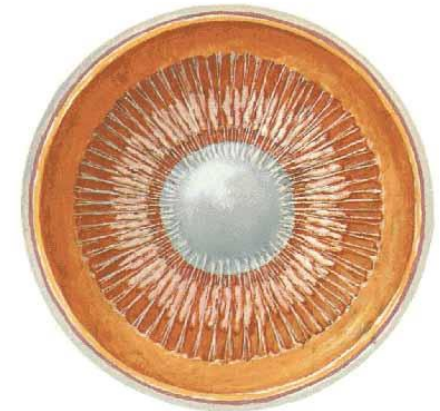
Layers of iris



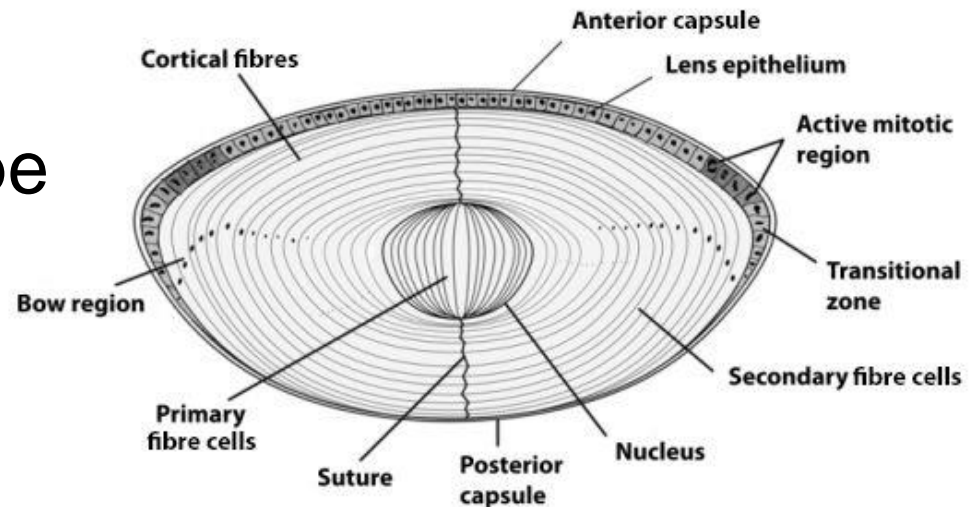
- facies anterior
 - no epithelial cover (*stratum limitans anterior*) = transformed stroma
 - fibroblasts + melanocytes (color)
 - „pigment frill = pupillary ruff“
- stroma iridis
 - *stratum anterius nonvasculosum*
 - contains m. sphincter pupillae
 - *stratum posterius vasculosum* – both arterial circles
 - macrophages (*cellula congregata Koganei*)
- epithelium iridicum – 2 layers
 - epithelium nonpigmentosum – contains m. dilatator pupillae (myoepithelial cells)
 - epithelium pigmentosum – cylindric cells

Lens

- transparent biconvex avascular
- serves to focus
- 15-20 diopters
- facies anterior + posterior
- polus anterior + posterior
- axis, equator
- radii (sutures of Y-shape and inverted Y-shape)
- zonula ciliaris *Zinni*
 - fibrae zonulares
 - spatia zonularia



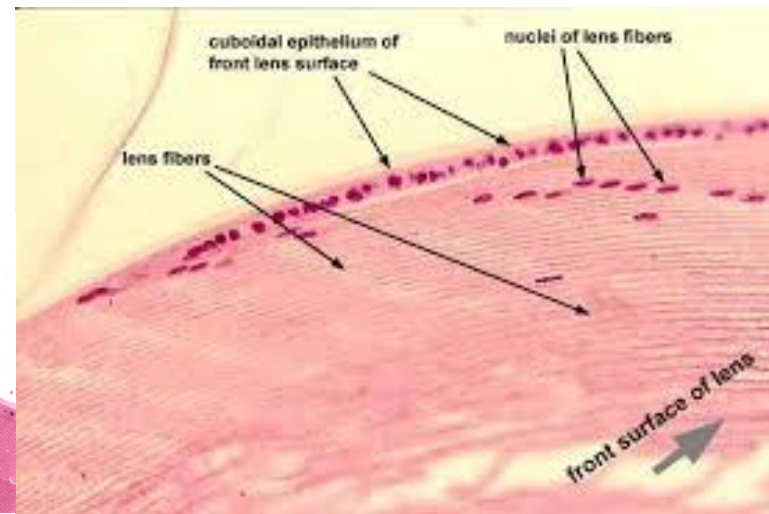
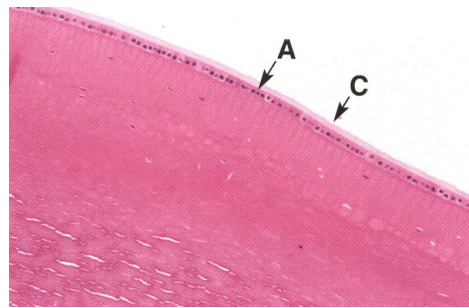
Bulb of eye: anterior segment viewed from behind



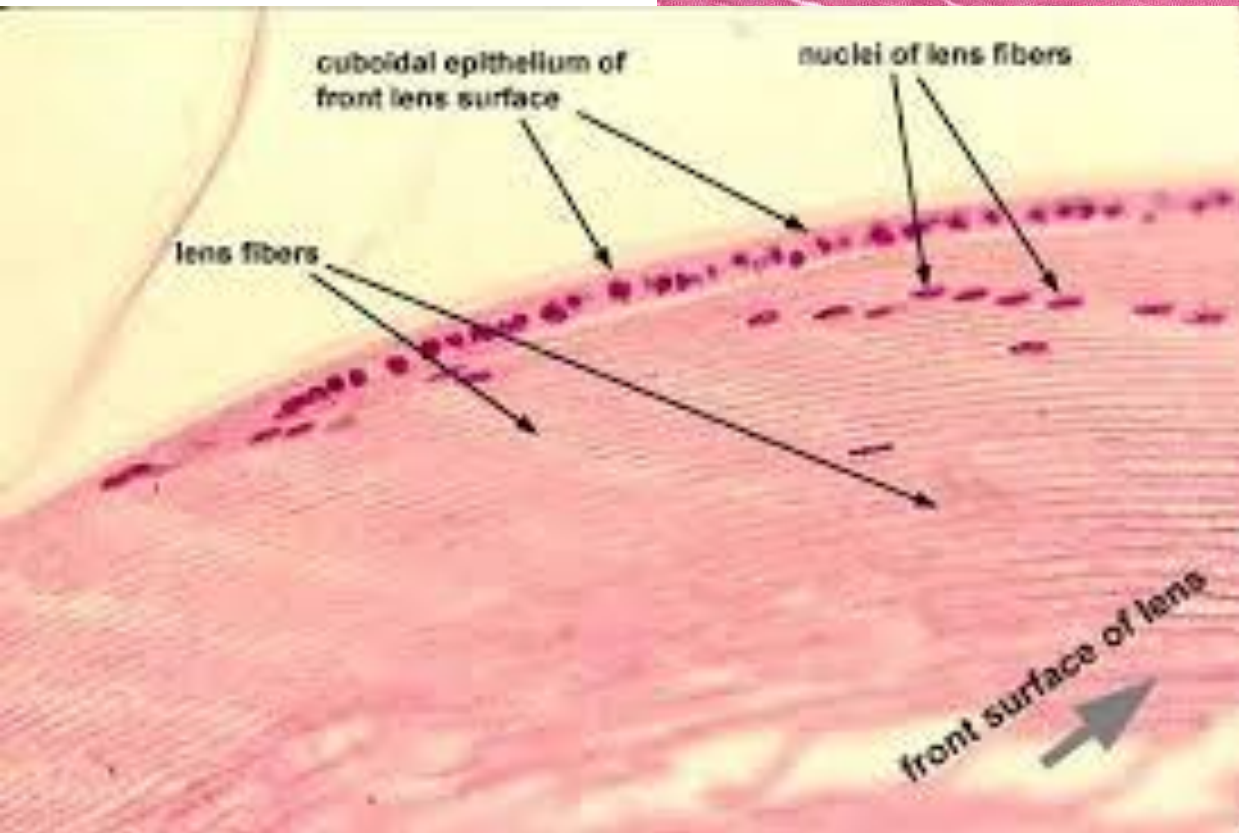
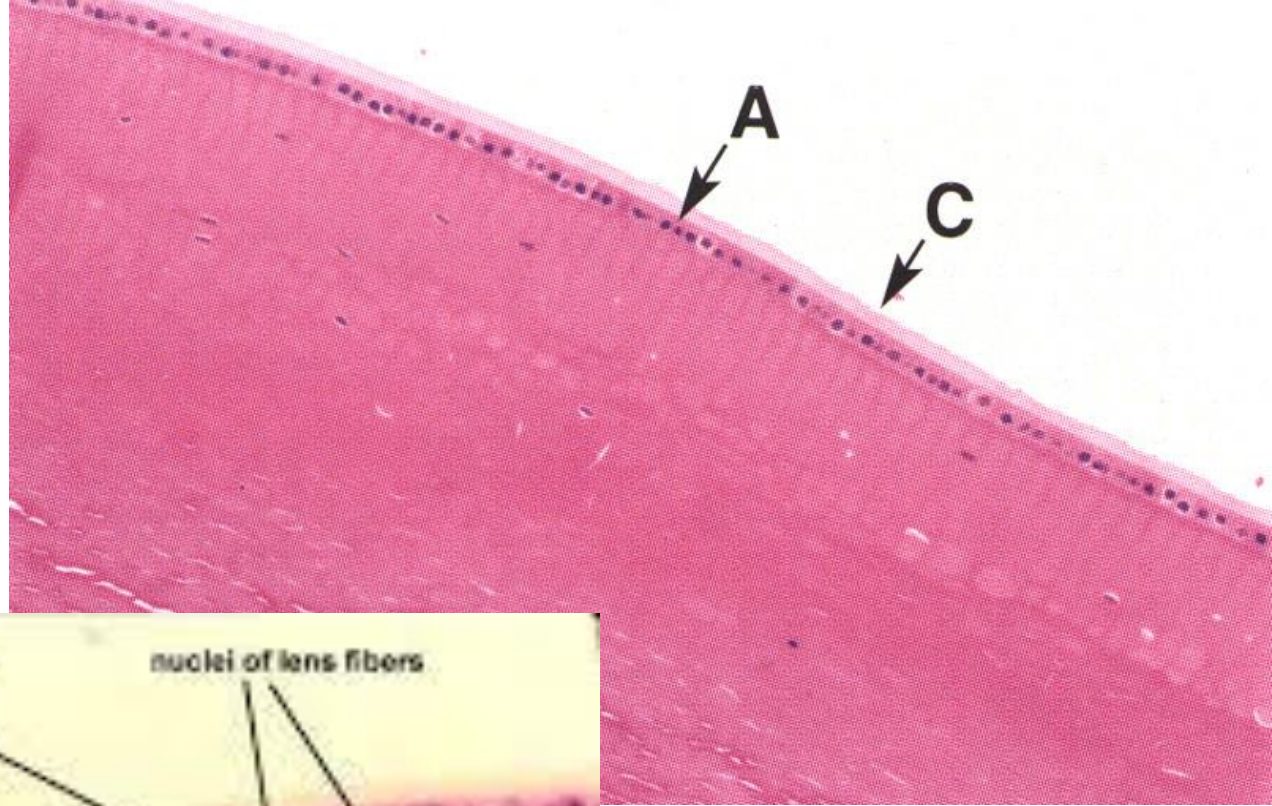
cataract → replacement with artificial = *pseudophakia*

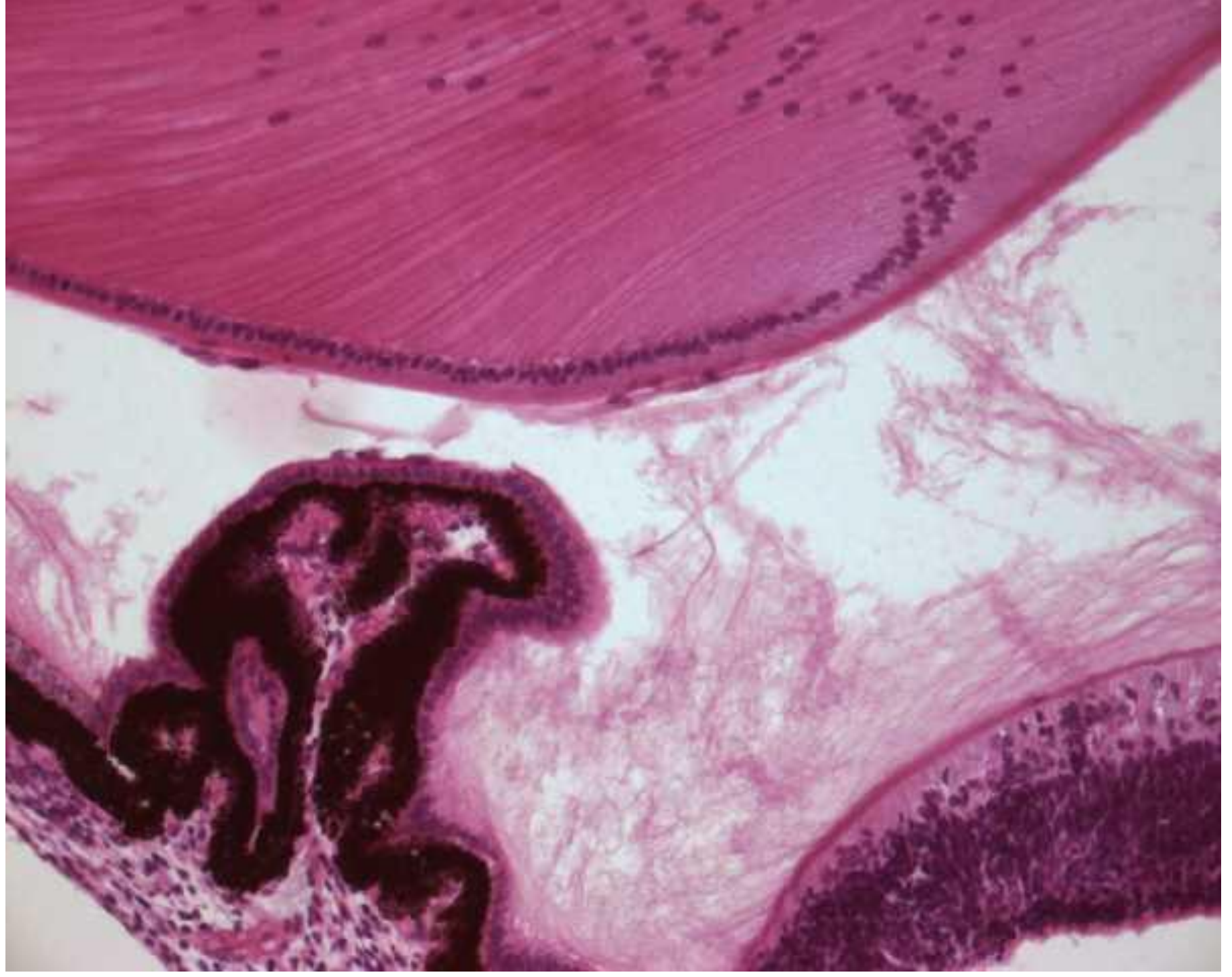
Lens

- capsula lentis – similar to lamina basalis
- epithelium lentis – simple cuboid
 - only on facies anterior
- substantia lentis
 - cortex – contains elongated hexagonal eosinophilic cells (fibrae) with organelles and nucleus
 - nucleus – cellular fibers without organelles and nucleus
 - cells contain specific proteins (filensin, crystallines)
- diameter 9-10 mm
- thickness 3.7-4,4 mm
- 69% of water



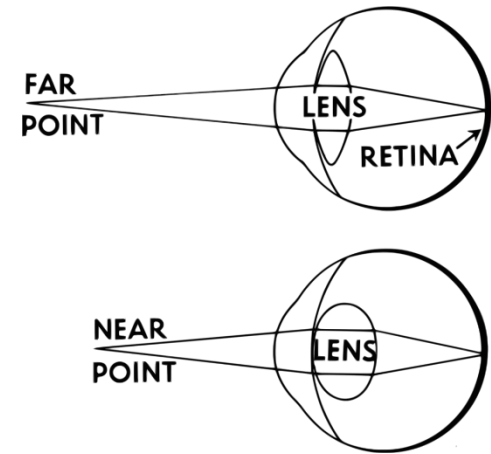
Lens





Focusing = Accommodation of lens

- focusing on a near object
 - maximum to 6.5 cm in young eye
 - contraction of m. ciliaris
 - fibrae zonulares relax
 - lens is enlarged
 - concomitant contraction of m. sphincter pupillae (= **miosis**)
- focusing on far / distant object
 - basic state of eye
 - vessel tone maintains fibrae zonulares tight
 - lens is flattened
 - from accommodated state performed by contraction of m. dilatator pupillae (= **mydriasis**)



Corpus vitreum = Vitreous body

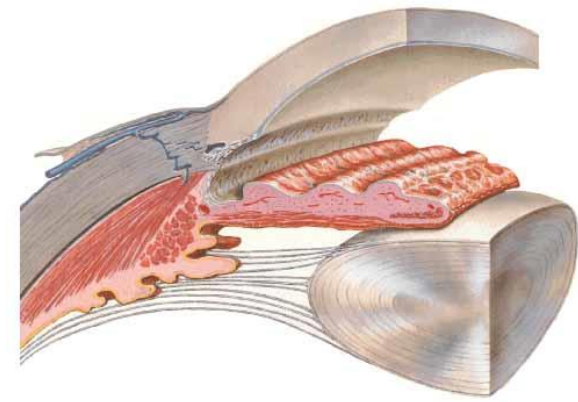
- **membrana vitrea** – collagen envelope
- **stroma vitreum** – sparse web of collagen fibers and hyalocytes (which produces in only prenatally)
- **humor vitreus** – 4 ml, 98% of water, hyaluronic acid
- hyalocytes are of monocyto-macrophage origin
- it *does not* regenerate ! – in injury it leaks and is replaced by humor aquosus
- canalis hyaloideus *Cloqueti* – remnant of fetal arteria hylaloidea
- fossa hyaloidea
- *maintains internal eyeball pressure, press retina to choroid, after loss → **retinal detachment (amotio)***

Humor aquosus = Aqueous humor

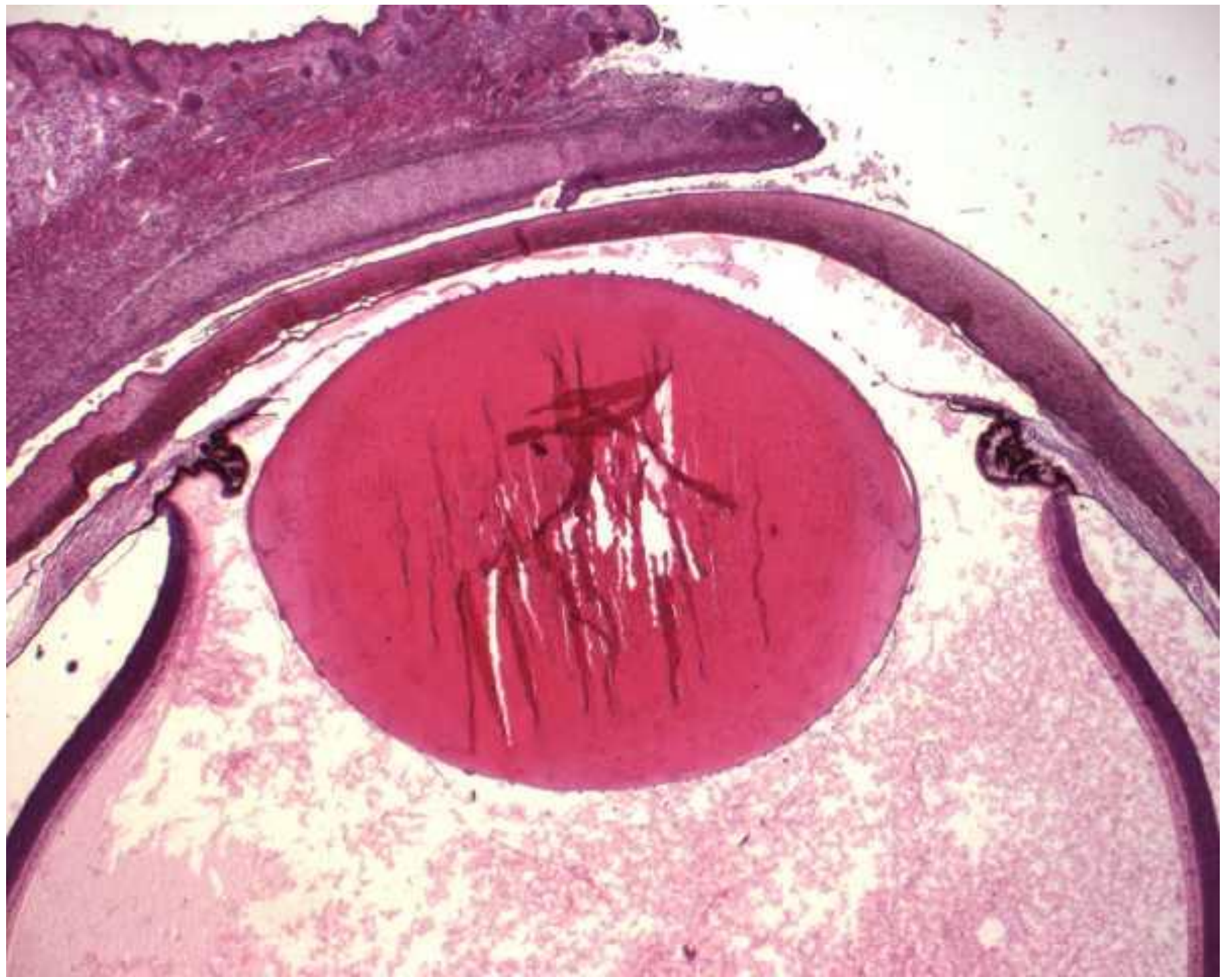
- produced by corpus ciliare
 - absorbed in angulus iridocornealis
 - 0.2-0.3 ml of transparent colorless fluid
 - daily production: 3 ml
 - composition: 0.7-1.2% NaCl, traces of urea and glucose (0.1%), no proteins
 - substitutes lymph
 - intraocular pressure 14-17 mmHg
- ↑ intraocular pressure → compression of retina → ***glaucoma***

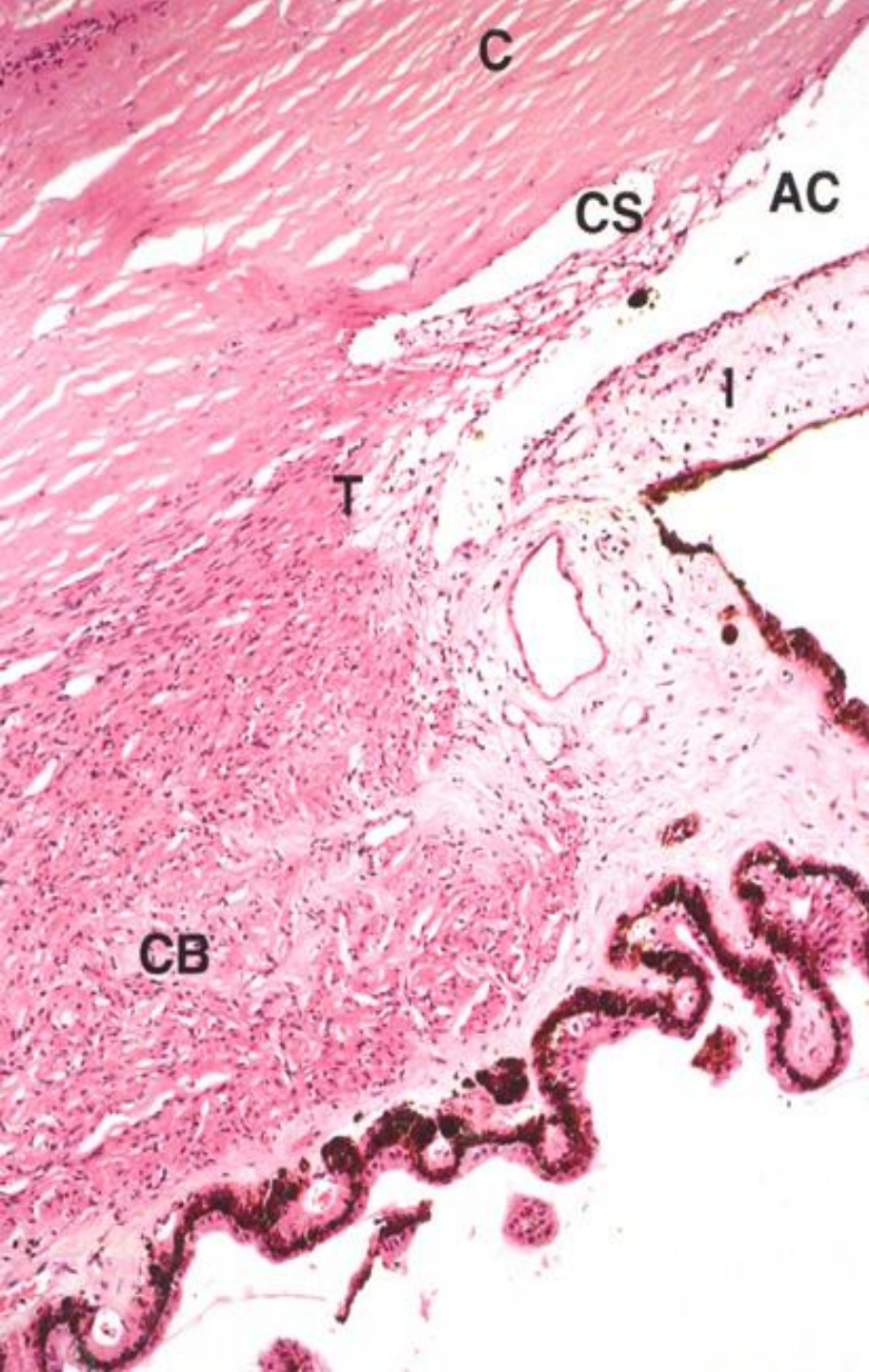
Camerae bulbi

Chamber of eyeball



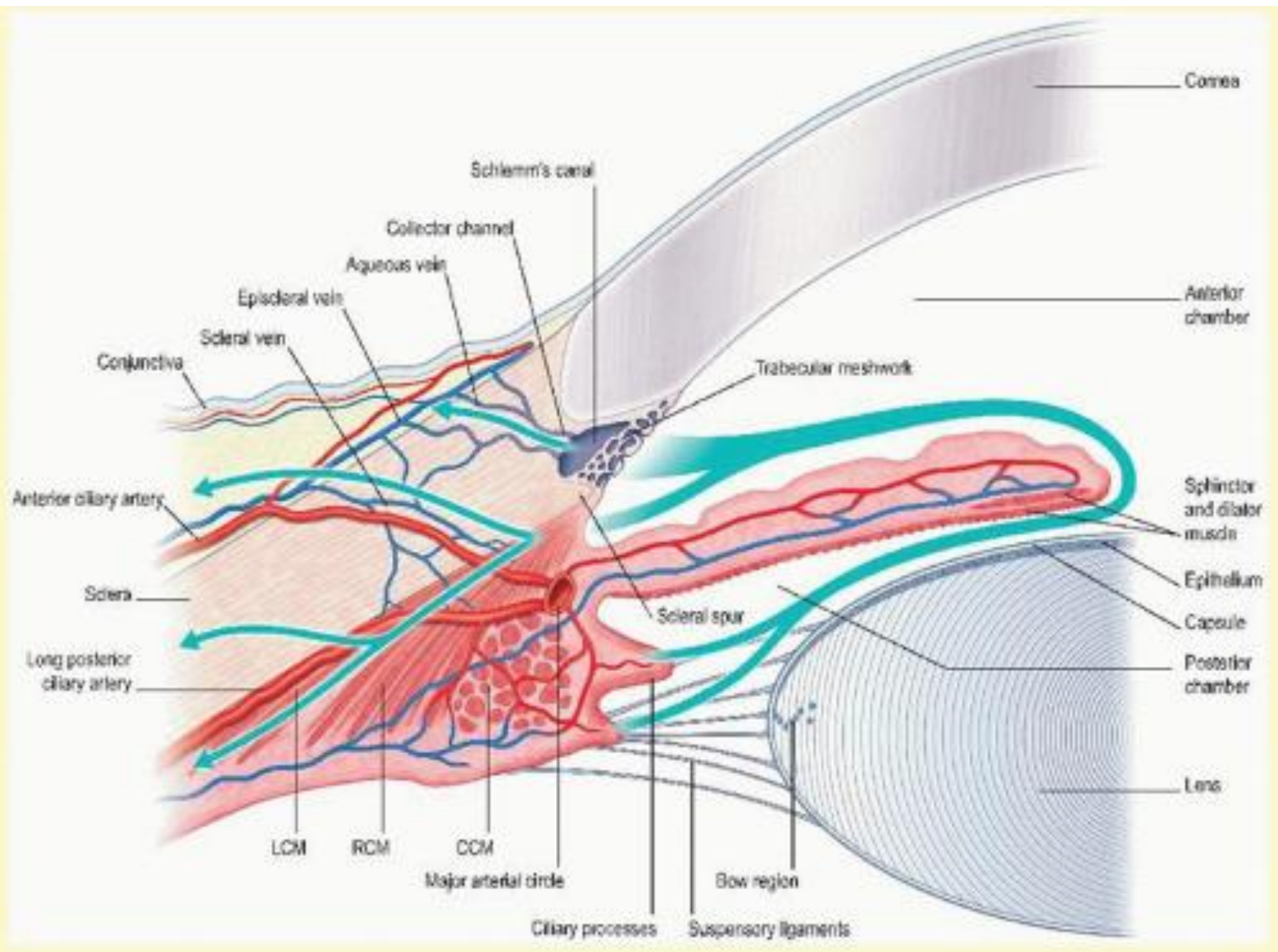
- **camera postrema s. vitrea** = vitreous chamber
 - between corpus ciliare, lens and retina
 - contains corpus vitreum
 - spatium retrozonulare
- **camera posterior** = posterior chamber
 - between iris, corpus ciliare, lens
 - produces and contains humor aquosus
- **camera anterior** = anterior chamber
 - between cornea and iris
 - angulus iridocornealis
 - contains and absorbs humor aquosus





Angulus iridocornealis Iridocorneal angle

- at corneoscleral junction (limbus corneae)
- trabecular network in its posterior wall = spatia anguli i.c. = *Fontana's spaces*
- No direct communication with sinus venosus sclerae (Schlemm's canal)
- absorption of humor aquosus
- maintenance of intraocular pressure
- *!!! no administration of parasympatholytic drugs in glaucoma !!!*



Cesta toku komorového moku

production: corpus ciliare (ciliary canal)

→ camera posterior

→ pupilla

→ camera anterior

→ angulus iridocornealis

→ spatia anguli iridocornealis (Fontana's spaces)

→ sinus venosus sclerae (Schlemm's canal)

→ venulae acquosae

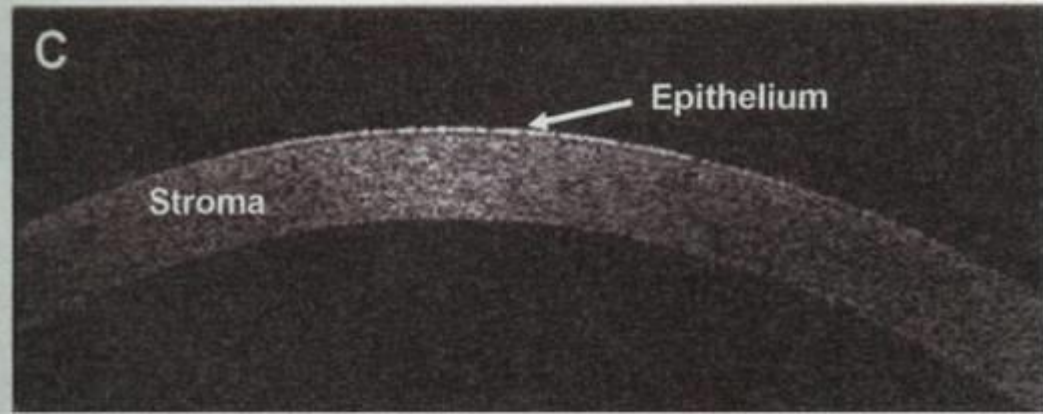
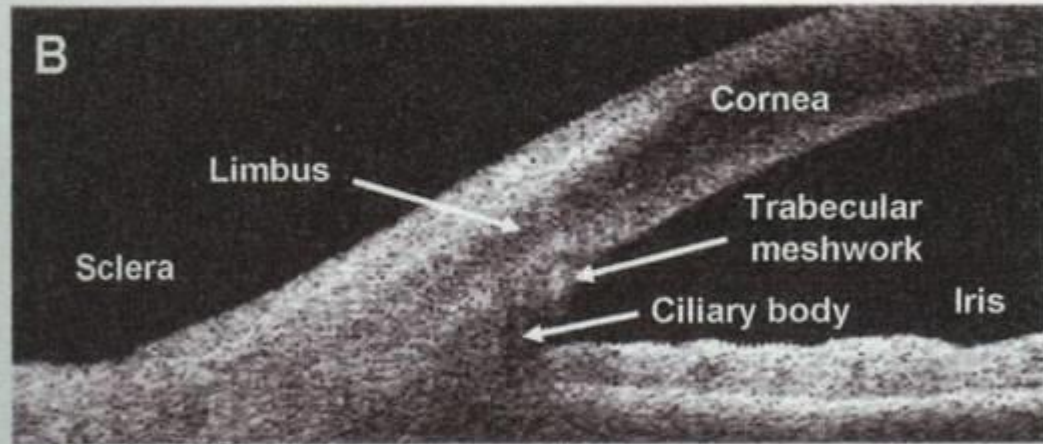
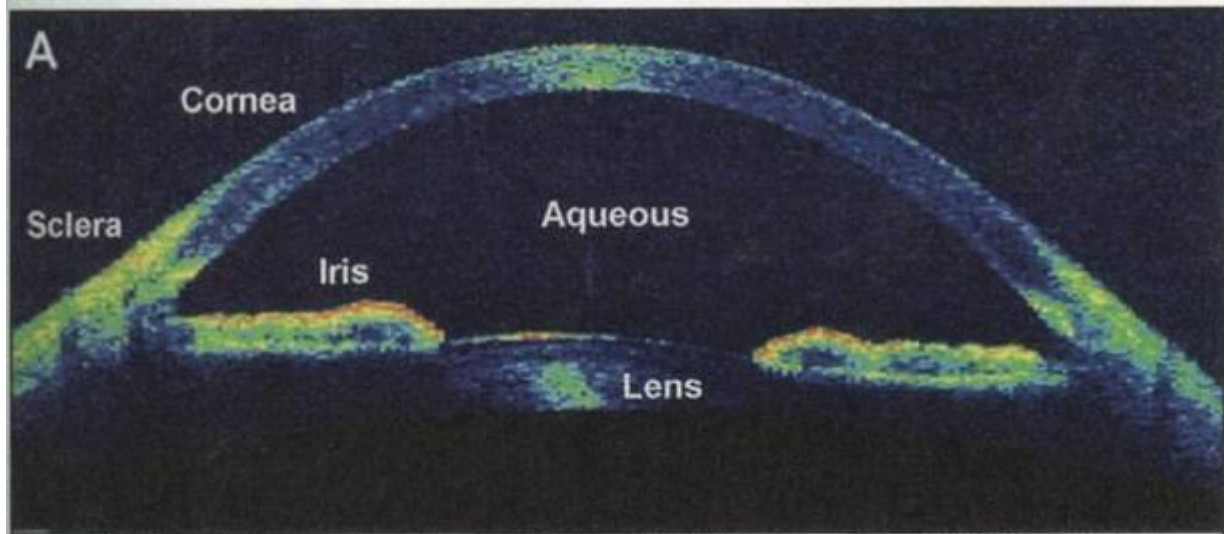
→ vv. episclerales (+ vv. sclerales)

→ larger eyeballs veins (vv. ciliares anteriores, vv. conjunctivales)

OCT

Optic
coherent
tomograph

*measurements
of light
reflection*



Section of eyeball layers

