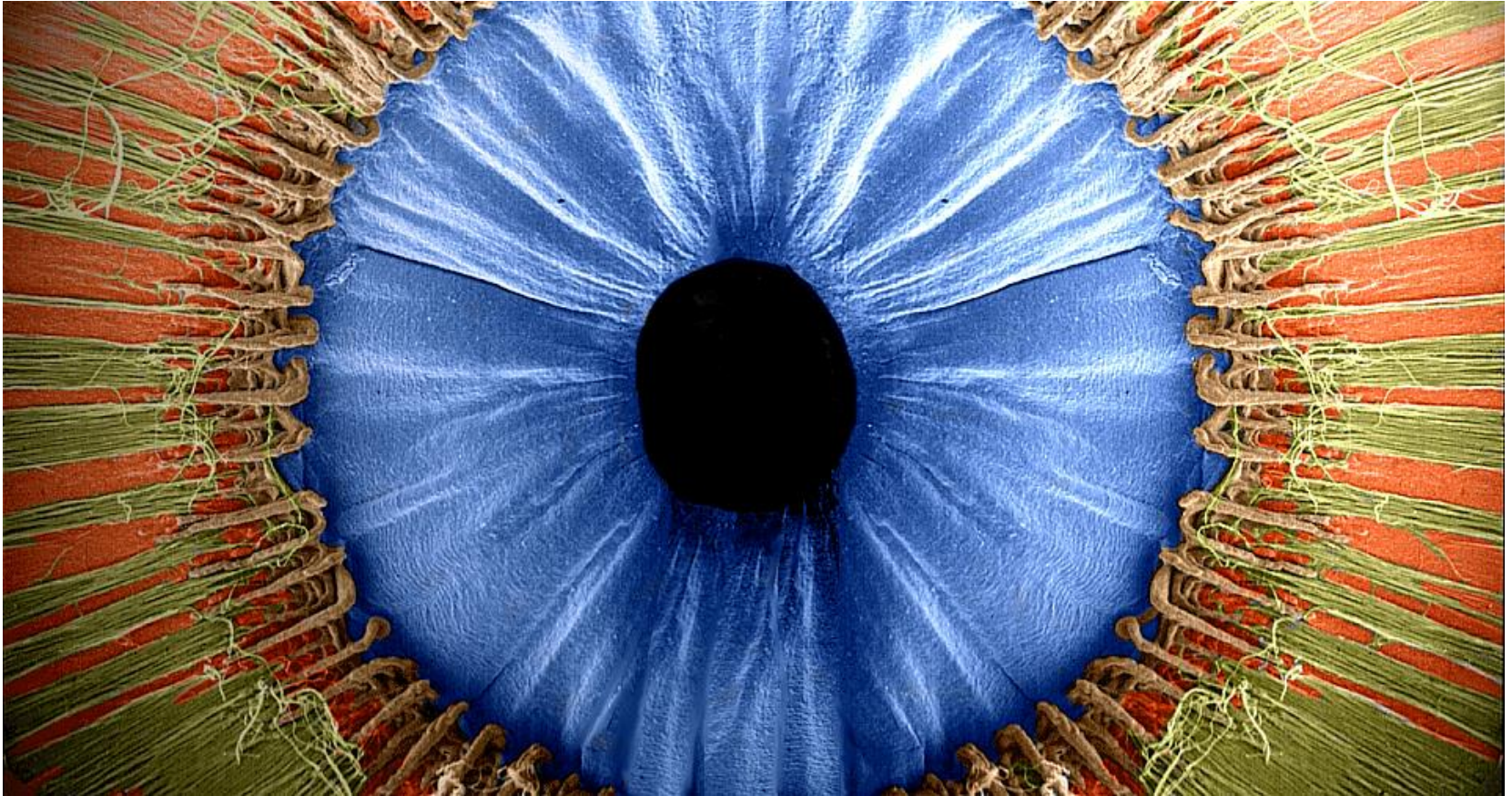


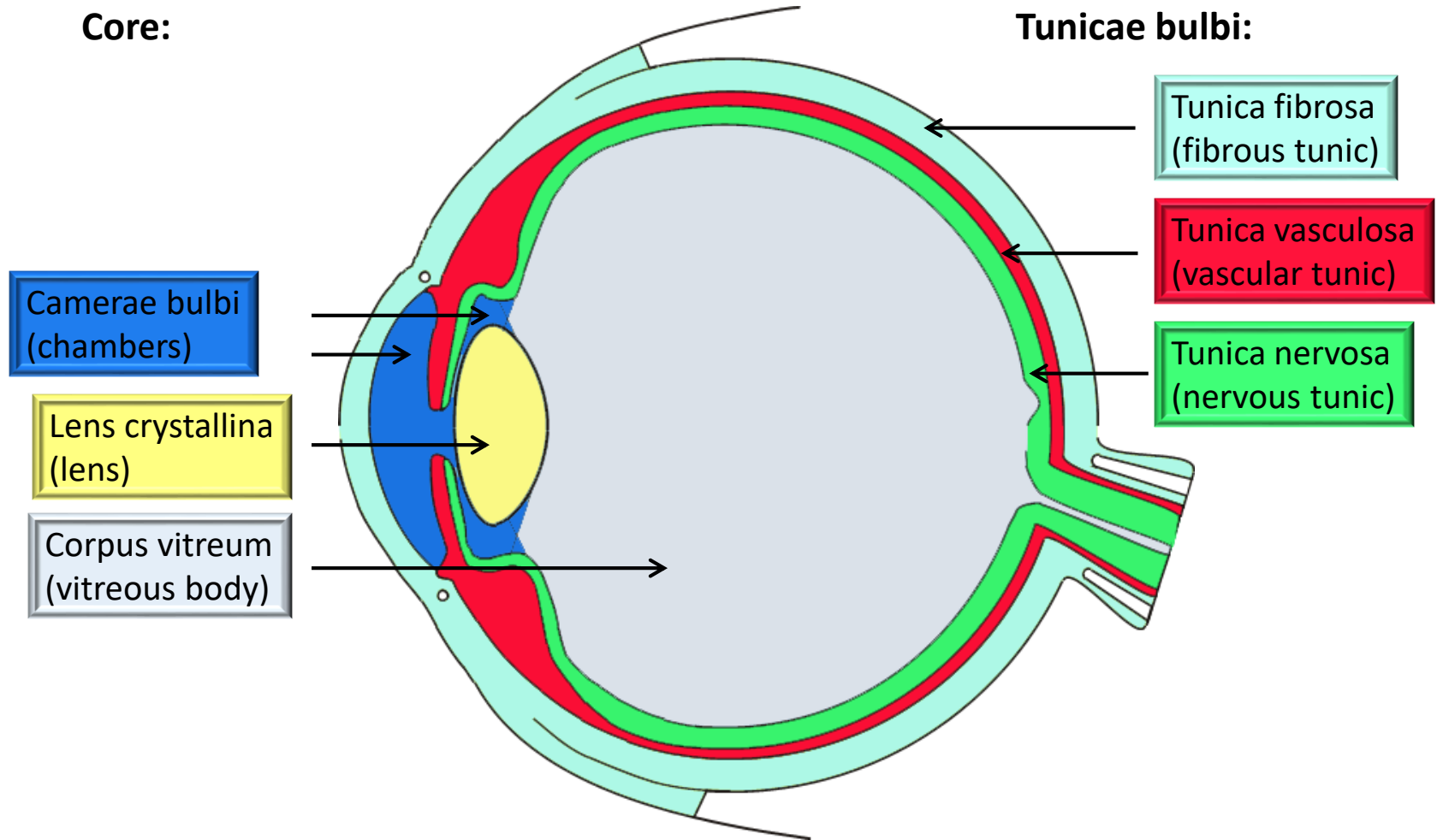
The eye

(lens, vitreous body, chambers, accomodation)



Zsuzsanna Tóth, PhD
Semmelweis University,
Department of Anatomy, Histology- and Embryology

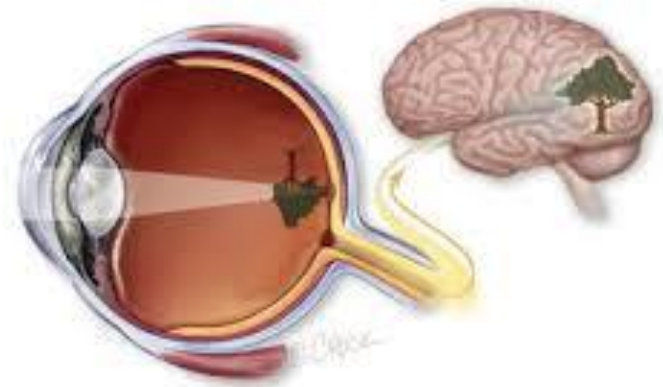
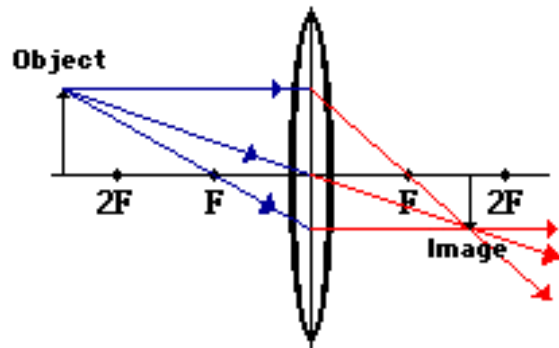
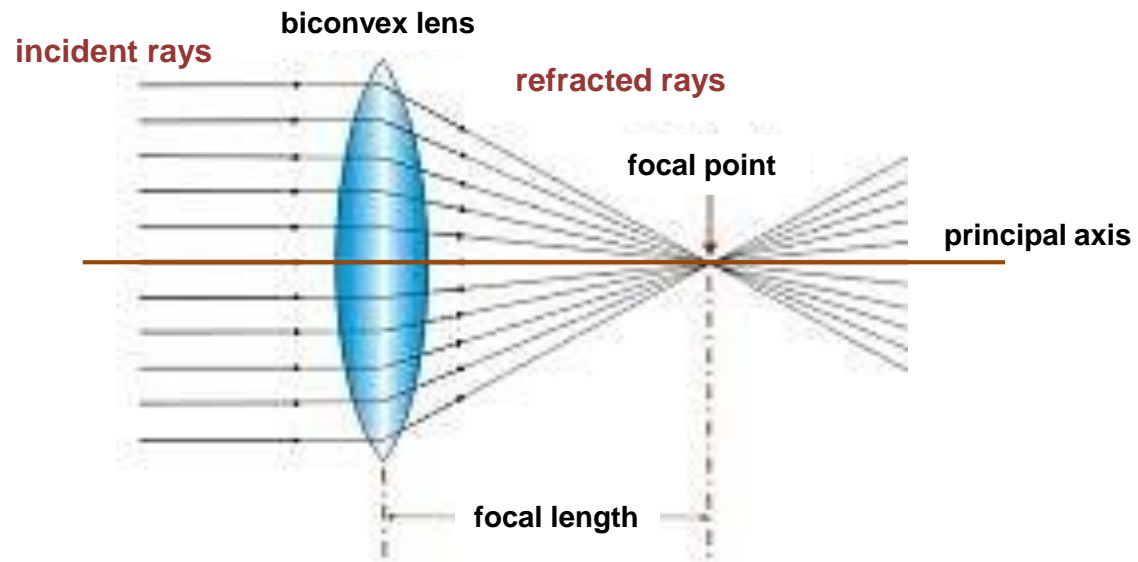
Parts of the eye



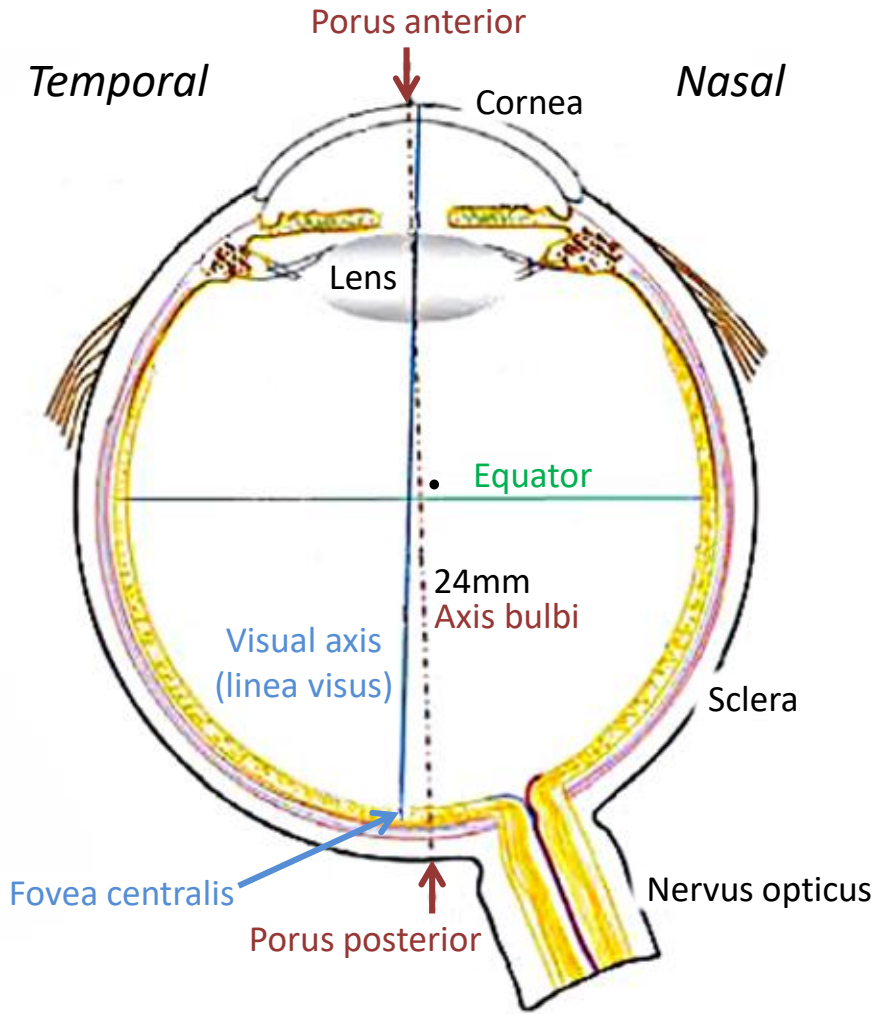
Sagittal

From prof. Ágoston Szél

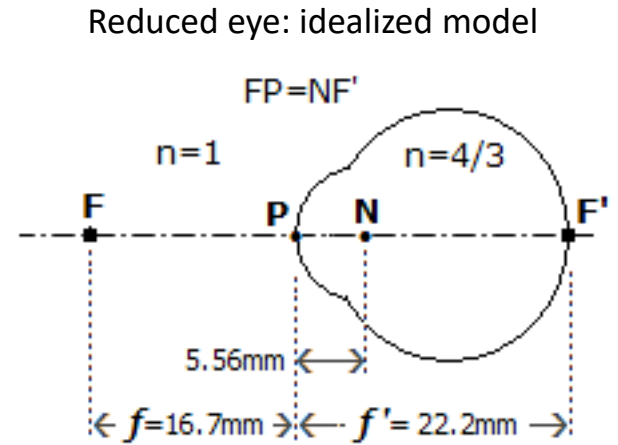
Formation of the image



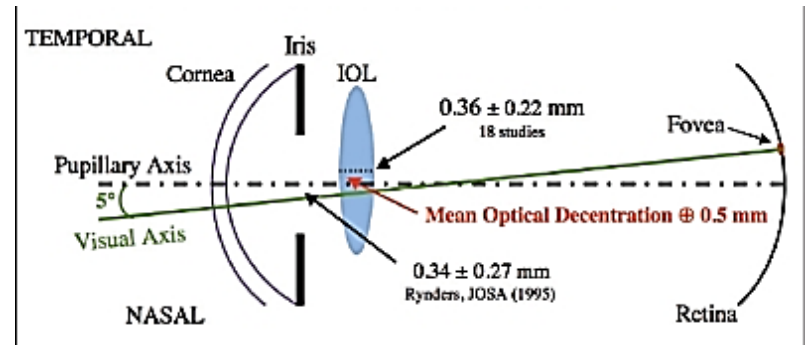
Bulbus oculi-decentralized optical system



Axis bulbi externus and interus



F: focal point, P: principal point, N: nodal point



Optical axis (linea visus) :

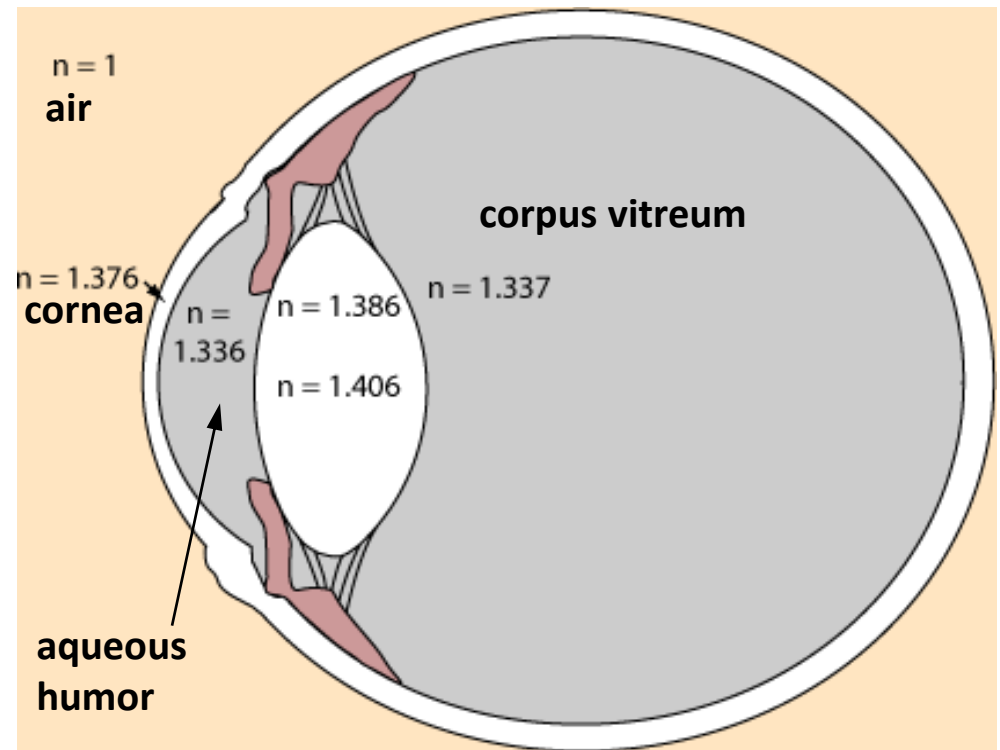
an imaginary line passing from the midpoint of the visual field to the fovea centralis.

Optical elements of the eye

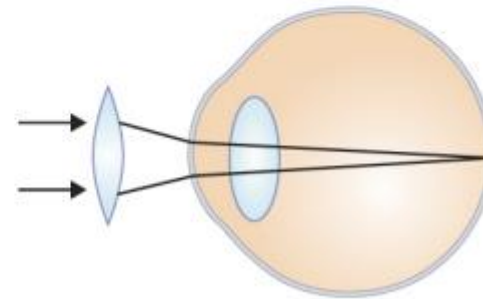
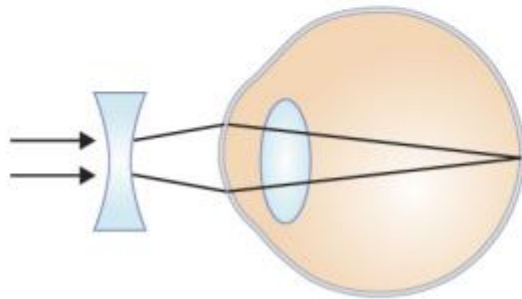
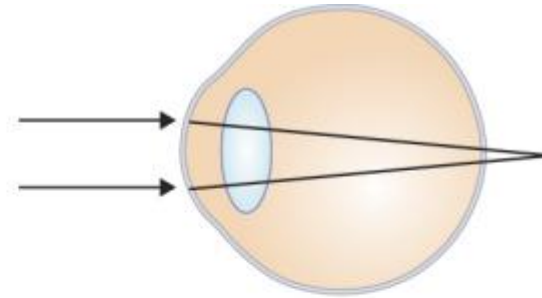
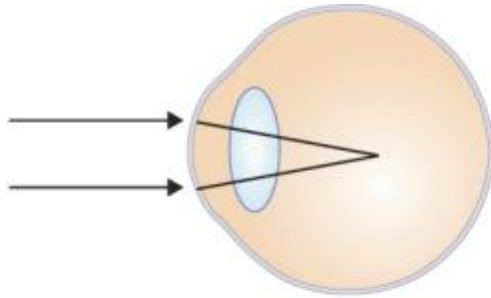
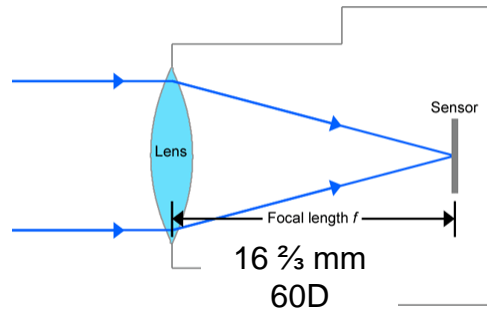
$$\text{Refractive Index} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

N determines bending of light rays.

1. Cornea: provides 80% of refracting power of the eye, air/cornea interface, tears!
2. Aqueous humor.
3. Crystalline lens: provides 20% of refracting power
4. Vitreous body.



Refractive errors of the eye

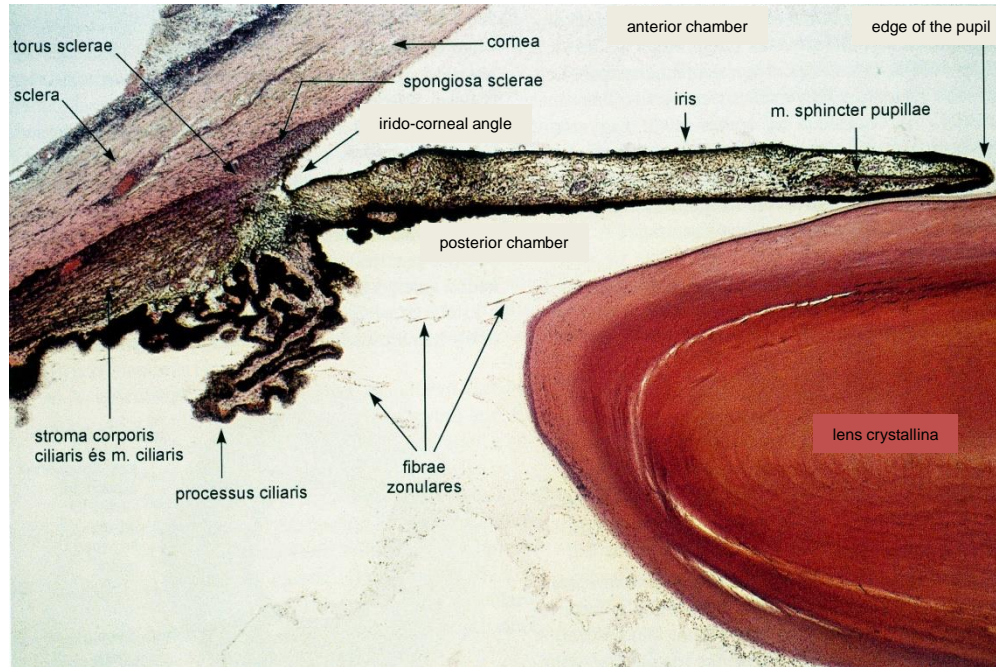
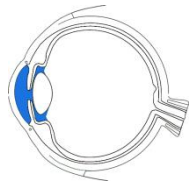


myopia - nearsightedness

hypermetropia-farsightedness

$$\text{Diopter (D, 1/m)} = 1 / \text{focal length (m)}$$

Chambers of the eye, corneoscleral junction

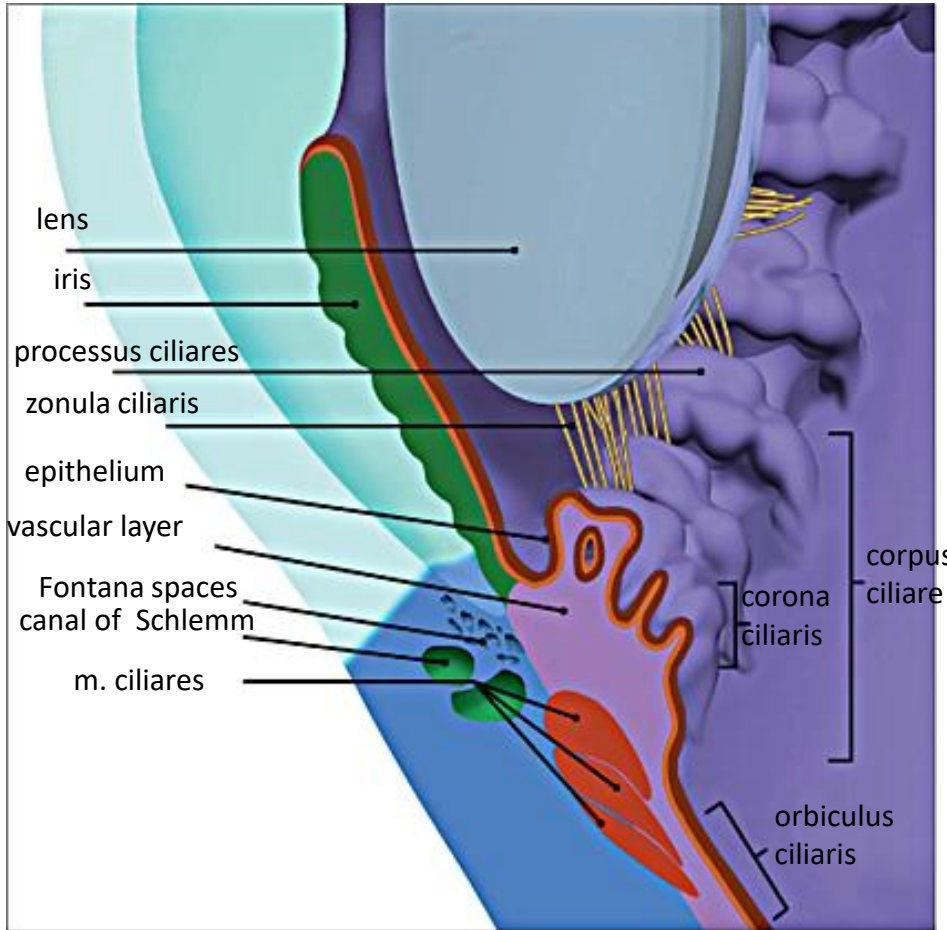


- Camera anterior bulbi:
 - innermost surface of cornea (endothel), iris, lens in the pupil
- Spongiosa sclerae:
 - at the irido-corneal angle, spongy structure, a trabecular meshwork of connective tissue covered by endothelial cells, meridional muscles of the ciliary body partly originate here
- Torus sclerae (scleral spur):
 - a thickening of the sclera,
 - insertion point for the trabeculae,
 - place of origin for ciliary muscles and the pectinate ligaments of iris.
- Camera posterior bulbi:
 - behind the iris extending to the vitreous body, (corona ciliaris, fibrae zonulares, lens).

The chambers communicate.



Ciliary body



Ciliary muscles:

- oblique (Brücke), radial, circular (Müller) muscles
- parasympathetically innervated,
- in mammals it is a smooth muscle
- melanocytes, elastic tissue
- role in accommodation and drainage of aqueous humor

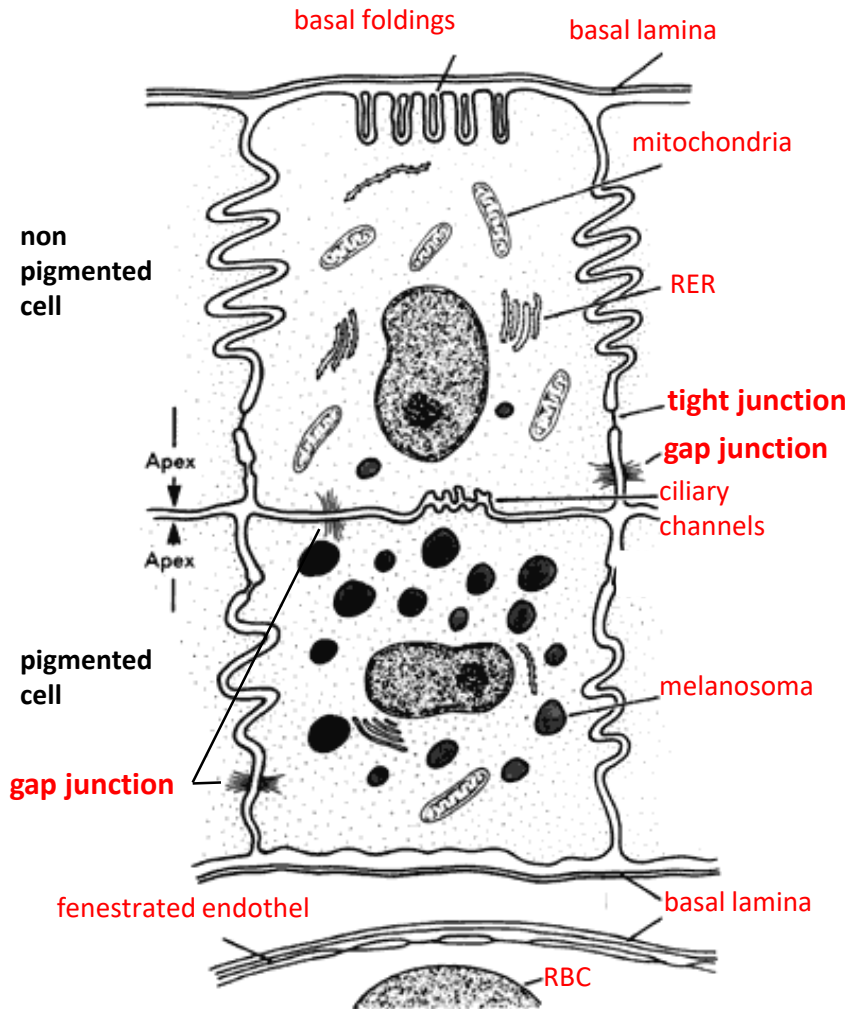
Vascular layer:

- continuous with the vascular lamina of the choroid,
- fenestrated capillaries
- production of aqueous humor

Epithelium:

- pars ciliaris retinae,
- double layered columnar cells
- secretion of aqueous humor

Epithelium ciliare – aqueous humor



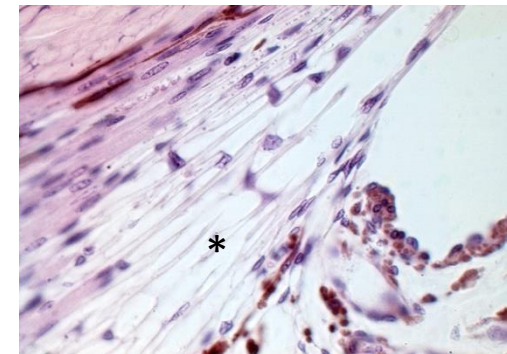
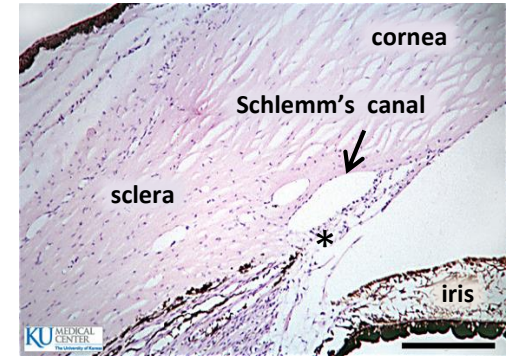
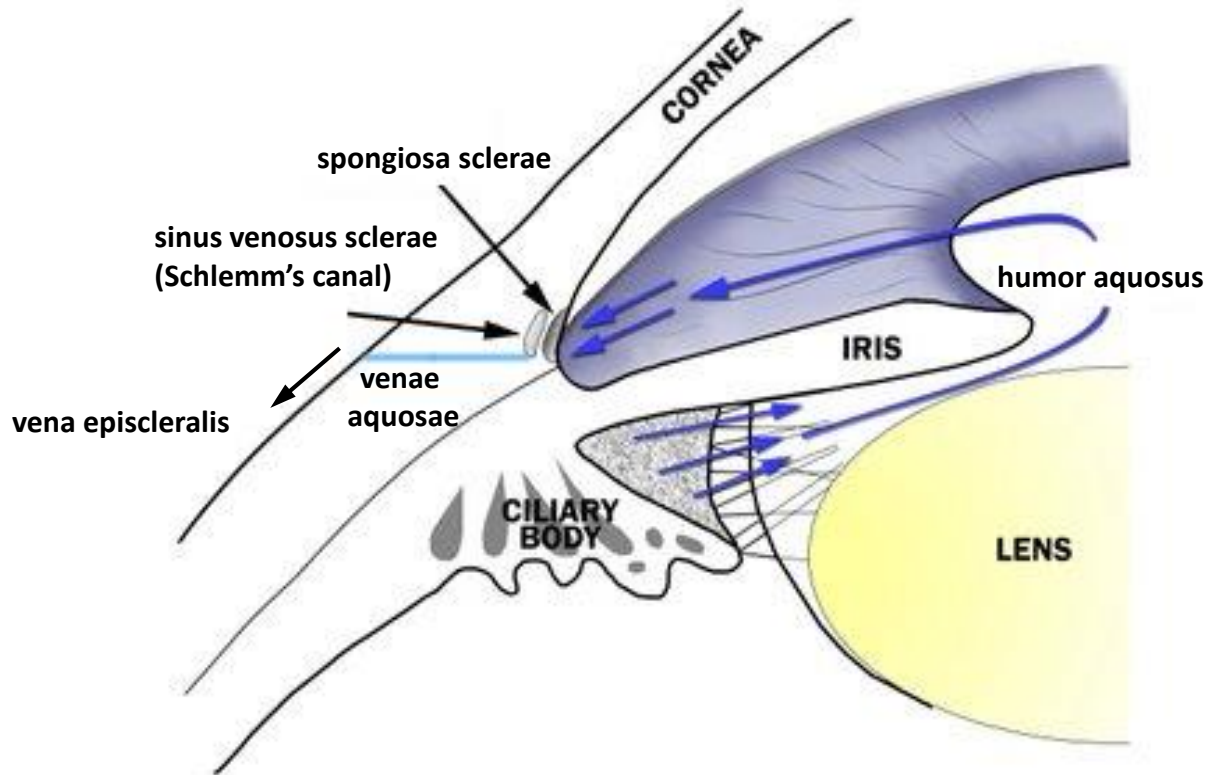
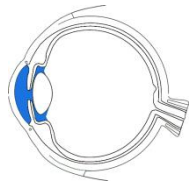
Structure:

- typical of secretory epithelia
- basal laminas, tight junctions between NPE cells:
blood-aqueous barrier

Aqueous humor:

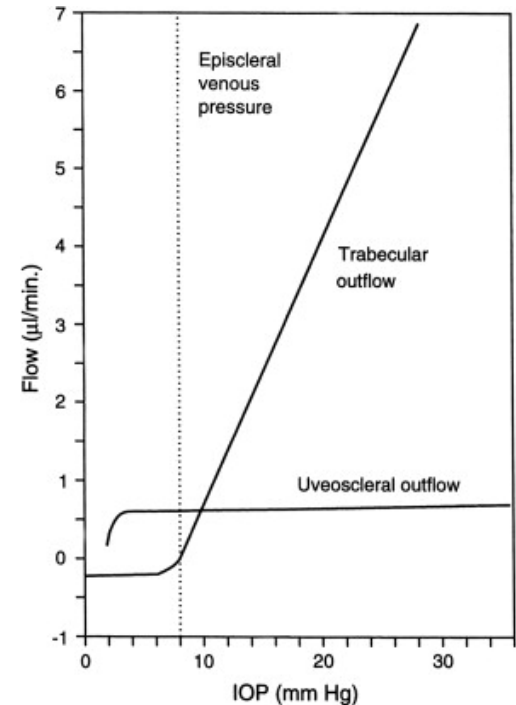
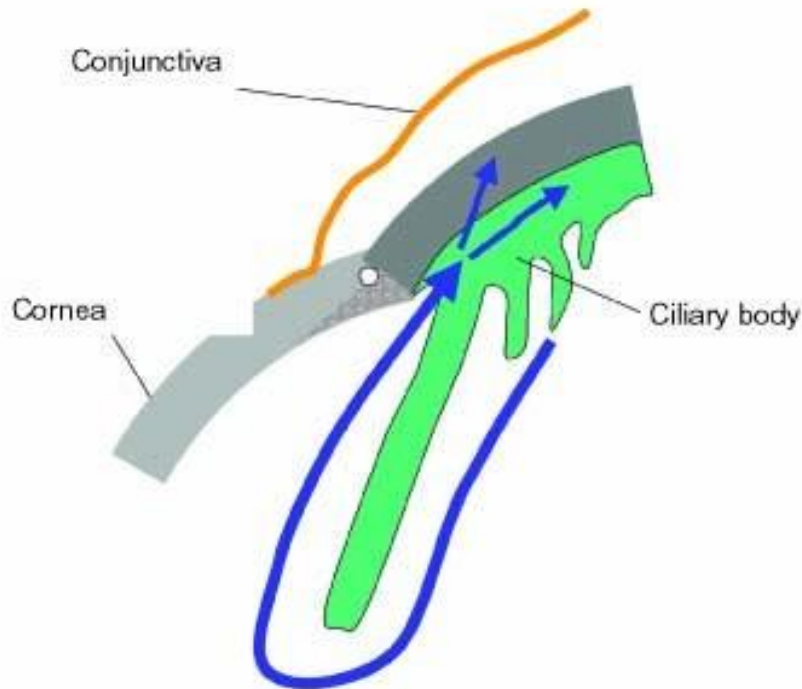
- an ultrafiltrate of blood,
- NaCl is actively secreted ,
- water follows the NaCl movement,
- maintains the intraocular pressure ,
- provides nutrition for the cornea, lens, vitreous body, retina,
- relative composition to the plasma:
 - lower protein and glucose content,
 - higher amino acid, lactate, ascorbic acid content,
- there is a slight divergence of light rays passing from the cornea

Flow of the aqueous humor – conventional pathway



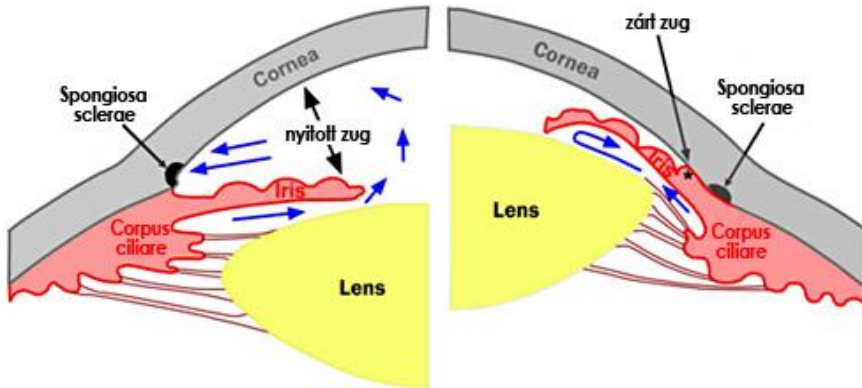
- The composition is changing during the flow (metabolic demands, waste).
- Dynamics of the production and the outflow rate has to be in balance to maintain the intraocular pressure.

Flow of the aqueous humor – non-conventional or uveoscleral outflow



- Not a distinct pathway, the aqueous humor leaves the anterior chamber through, around, and between tissues (ciliary body, sclera).
- Accounts for 30% of the total outflow at the age of 25-30, then it is less prominent.
- Prostaglandin analogues - increase the uveoscleral outflow. Primary choice in the treatment for glaucoma!

Increase of the intraocular pressure- glaucoma



- optic nerve damage, irreversible blindness
- 70 million people worldwide

1. Primary, open-angle (chronic) glaucoma:

clogging of the drainage canals, develops slowly by age, symptoms and damage are usually not noticed in time, both eyes are affected.

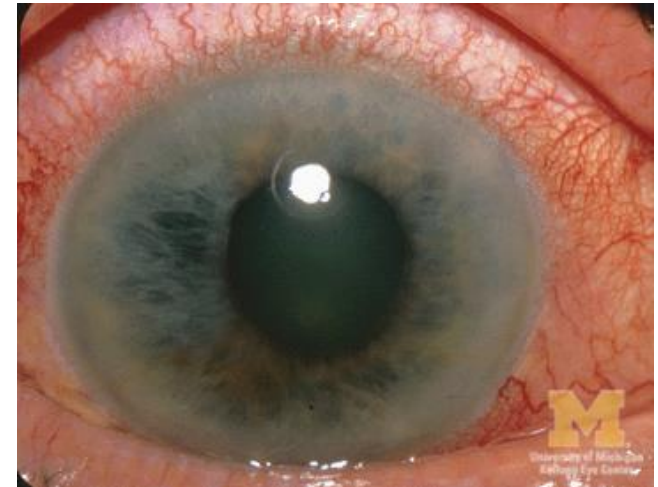
2. Primary, angle-closure glaucoma (acute) glaucoma:

a sudden rise in intraocular pressure, anatomically narrow angle between the iris and cornea, closure happens for a stimulus that opens the pupil (eye drops, drugs, darkness), immediate medical attention is needed, runs in families, one eye is affected usually.

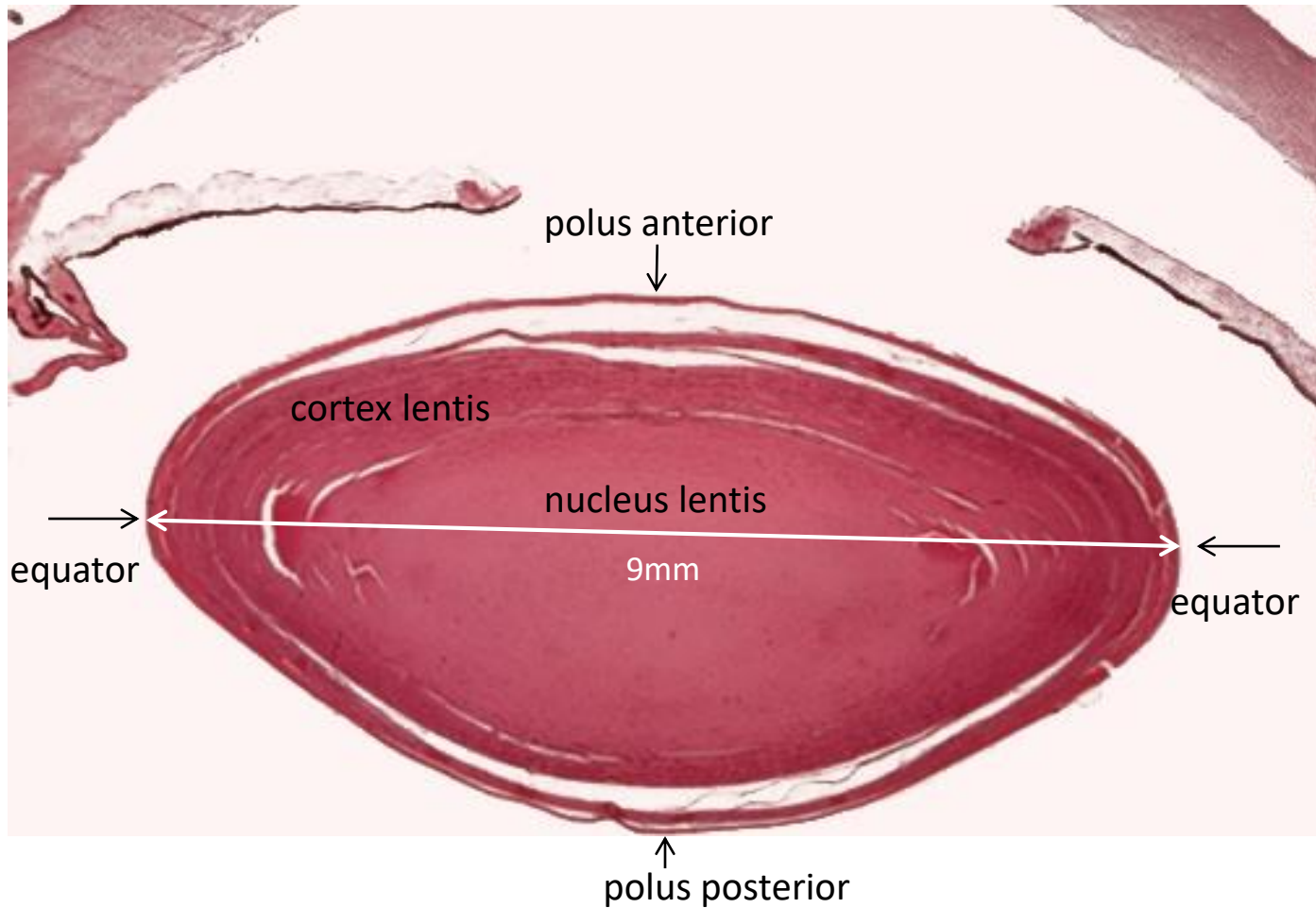
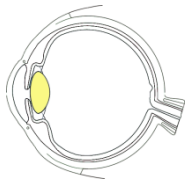
3. Congenital glaucoma: incorrect development of the eye.

4. Secondary glaucoma: trauma, inflammation, steroid treatment

Acute glaucoma

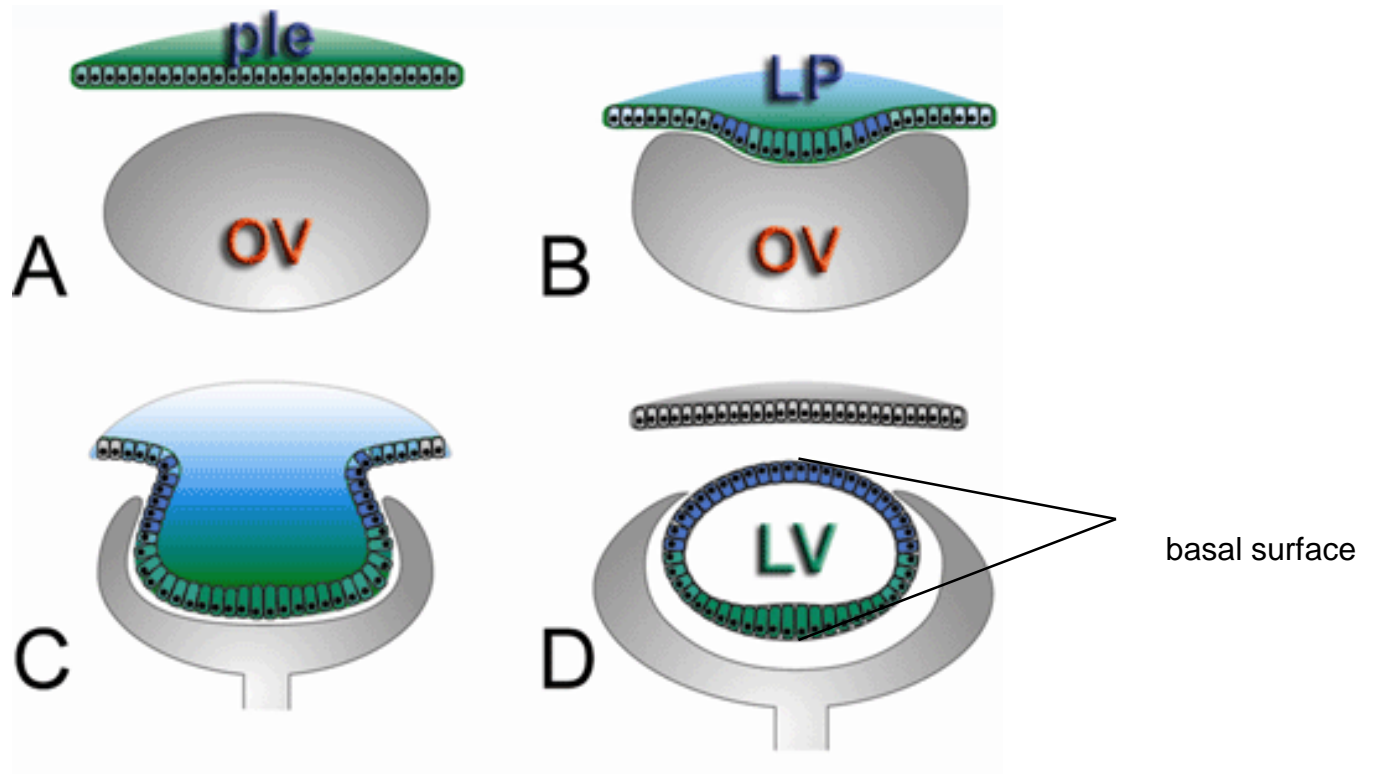
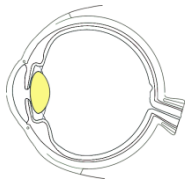


Lens crystallina



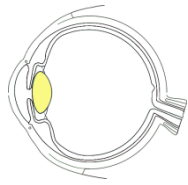
- Elastic, biconvex elliptical structure.
- Continues to grow throughout a person's lifetime.
- Avascular.
- Held in place by the zonular fibers.
- Becomes more rigid by age-presbiopia.

Lens development I.

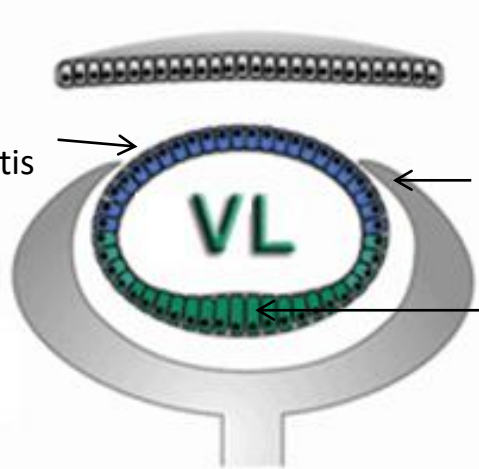


OV: optic vesicle,
LP: lens placode
Ple: presumptive lens epithelium
LV: lens vesicle

Lens development II.



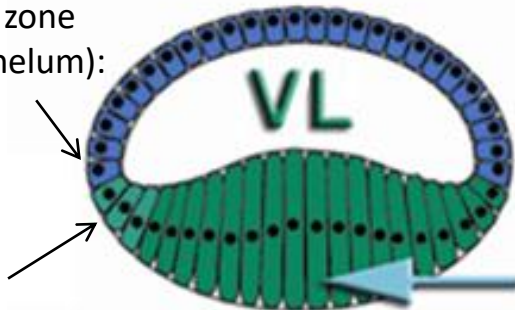
- anterior wall:
→ epithelium lentis



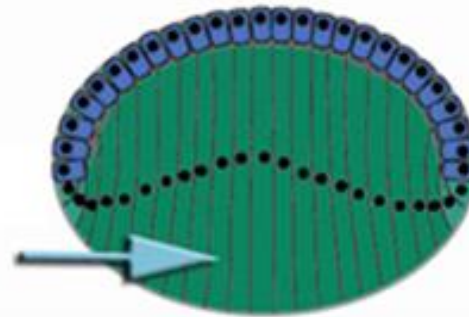
Optic vesicle

- posterior wall:
elongation → primary lens fibers
(at embryonic age)

- germinative zone
(equatorial epithelium):



- elongative zone
- (outer cortex):
→ secondary lens fibers,
produced throughout life

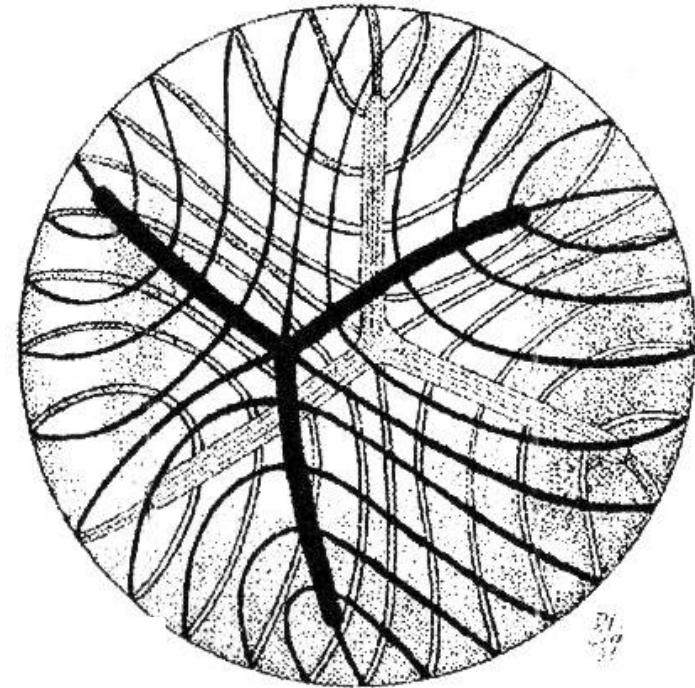
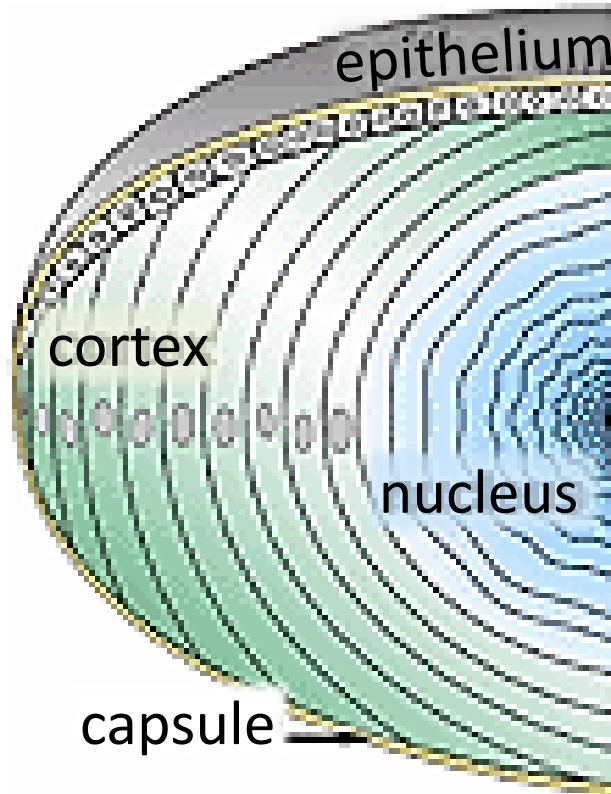
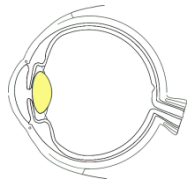


- maturation zone (deep cortex):
loss of nuclei and intracellular organelles,
crystalline accumulation



- matured fibers (inner
core or nucleus)

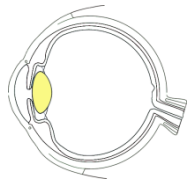
Structure of the lens



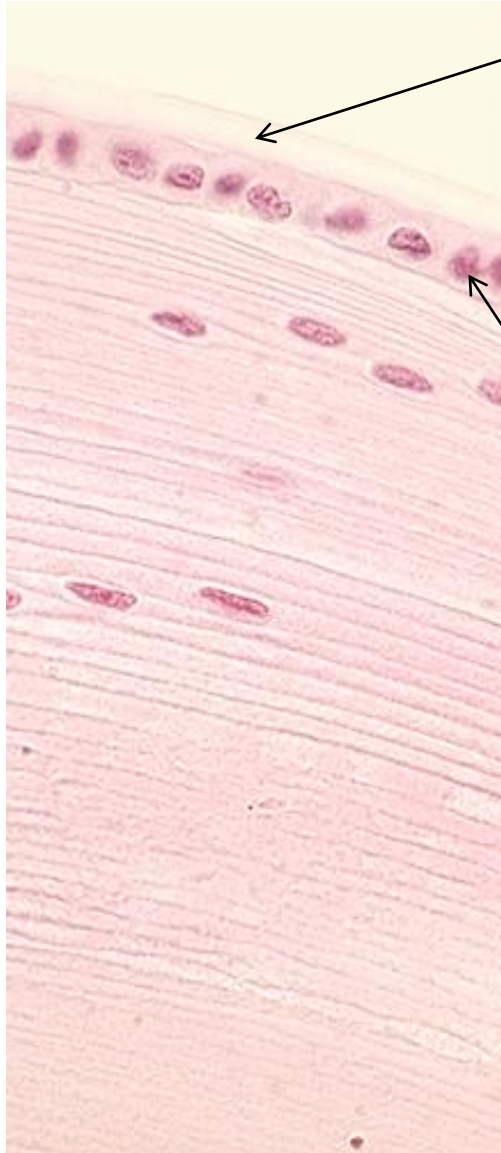
- continuous growing,
- fibers have nuclei only in the cortex,
- Secondary fibers are not long enough:
 - elliptical shape
 - lens sutures

Lens sutures:

- anterior and posterior radii lentis,
- ends of the opposite side fibers interdigitate,
- resemble a the letter "Y" in embryonic lenses ,
- becomes increasingly complex later



Lens-histology



Lens capsule:

- anteriorly it is thicker till the equator
- produced by the lens epithelium,
- a thick basal lamina (10-20 μ m),
- collagen IV, proteoglicans, fibronectin, laminin,
- zonular fibers are inserted to it

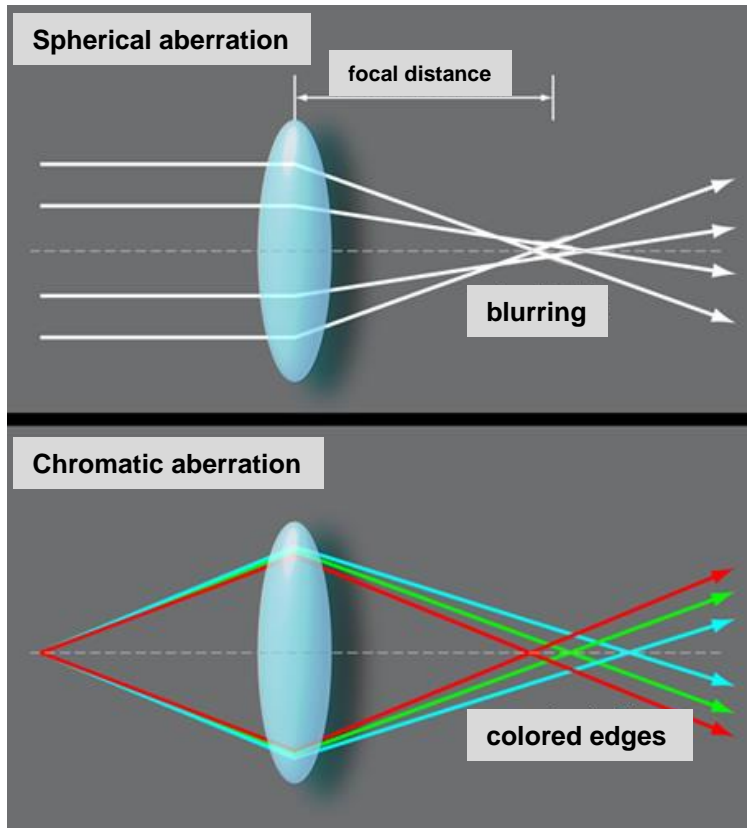
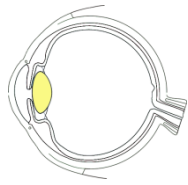
epithelium anterius-lens epithelium:

- a single layer of cuboidal cells on the anterior surface
- apical surfaces are in connection with the lens fibers
- germinative zone at the equator-lifetime

fibrae lentis-lens fibers:

- 7-10 mm long, develop from epithelial cells
- primary or secondary
- densely packed concentric lamellae - „onion like”
- cell organells only in younger fibers in the outer cortex,
- cytoplasm is filled with crystallins (α , β , γ , 90%)

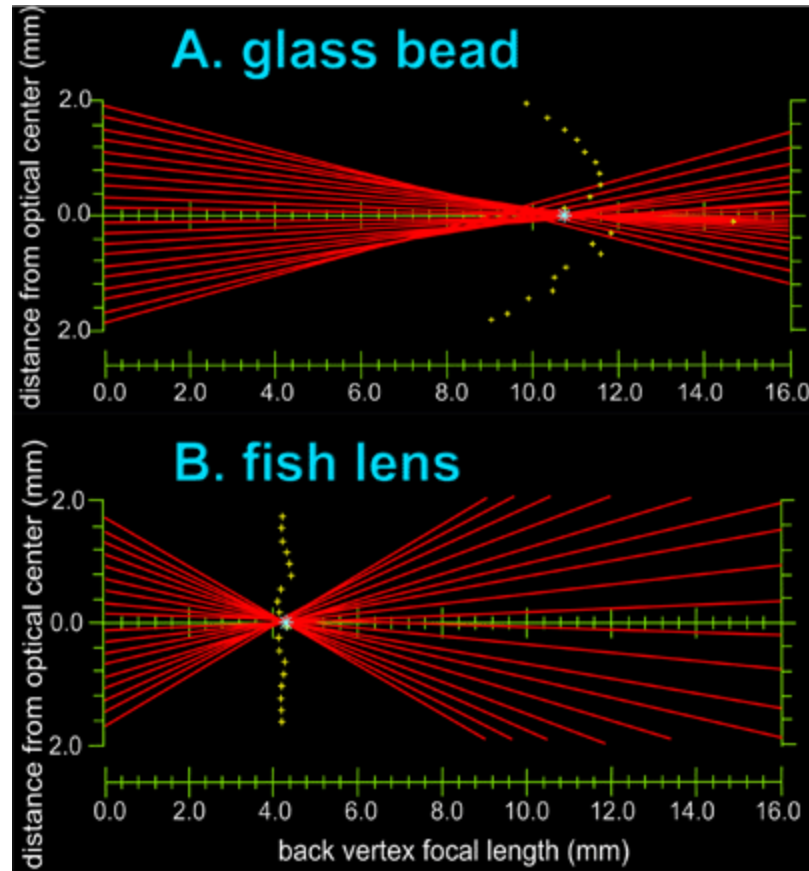
Optical aberrations



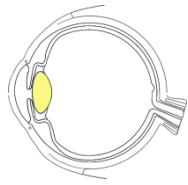
Corrections:

1. The pupil covers the edges of the lens (average pupil size: 4mm, lens diameter: 9mm).
2. Crystallins increase the refractive index of the lens and have a decreasing concentration gradient from the centrum to the periphery. The lens has a variable refractive index.

Laser polarimetry of the refractive plane



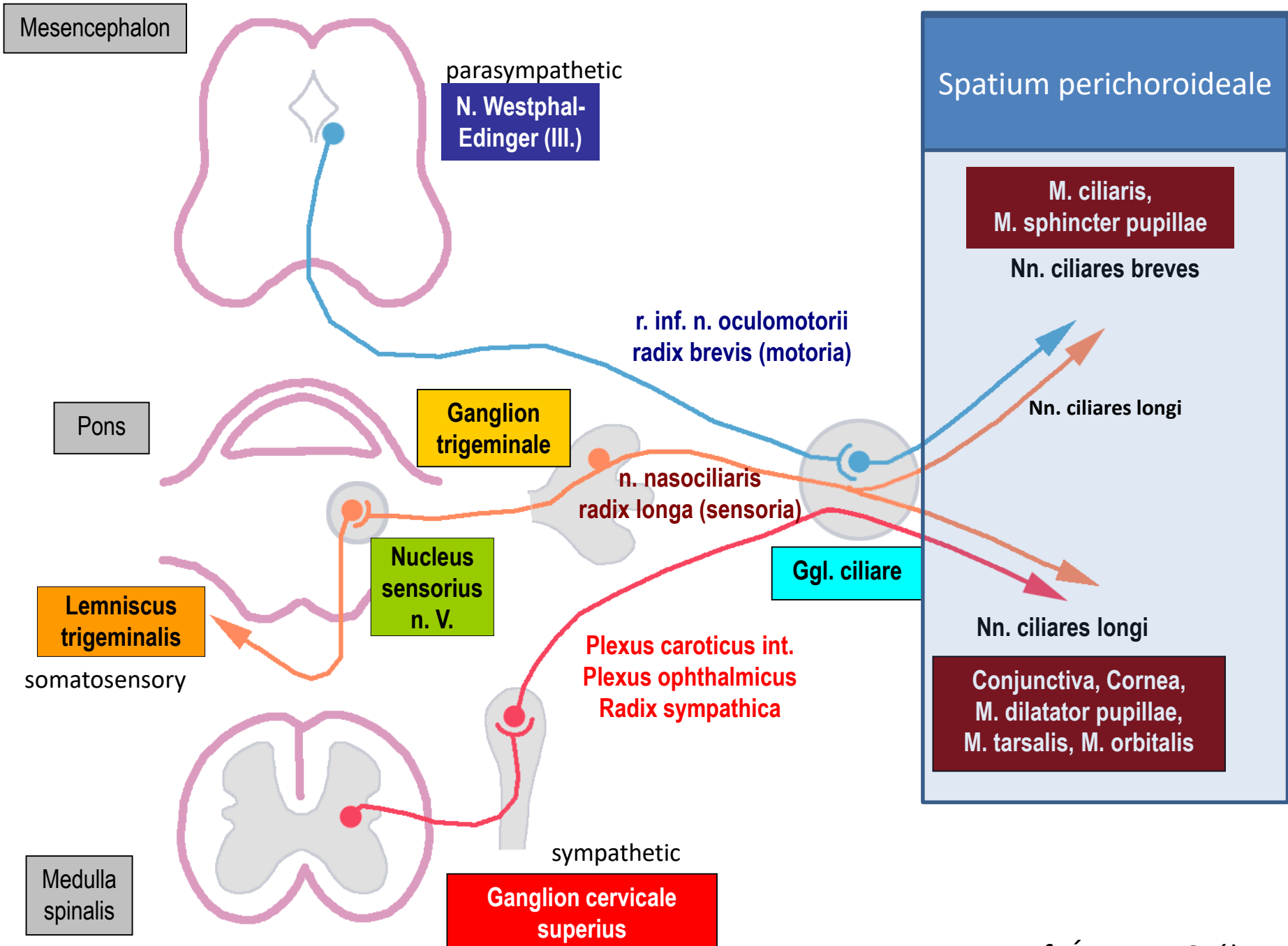
Cataract



cataracta=water fall (greek)

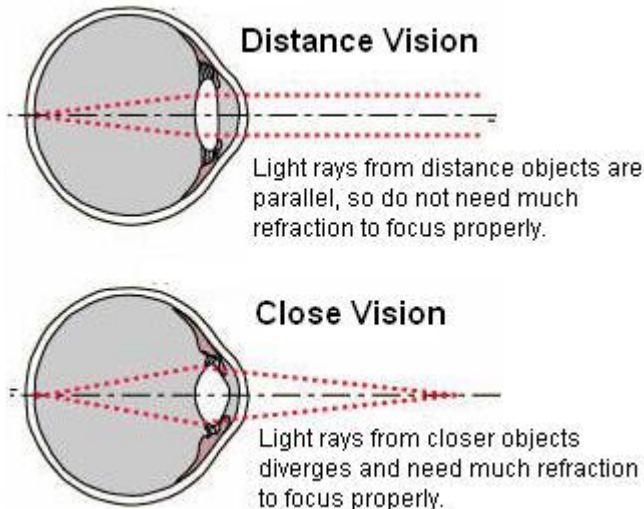


- lens of the eye becomes darkened or opaque
- after 60 it has an increasing prevalence
- crystallins aggregate, ion and water concentrations change
- risk factors: diabetes, UV exposure, steroid treatment, family history
- surgical replacment with plastic lens

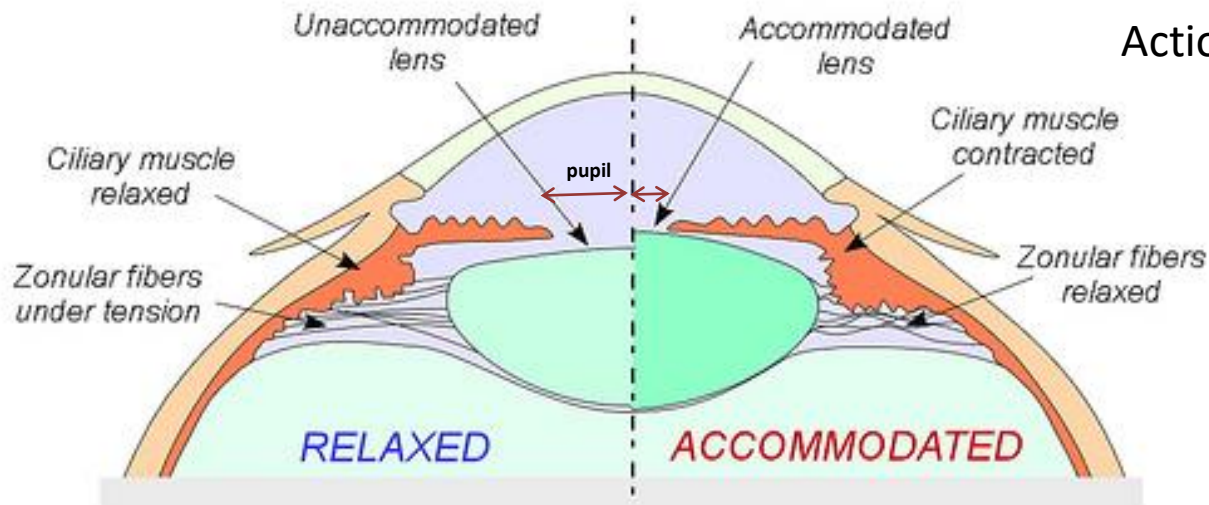
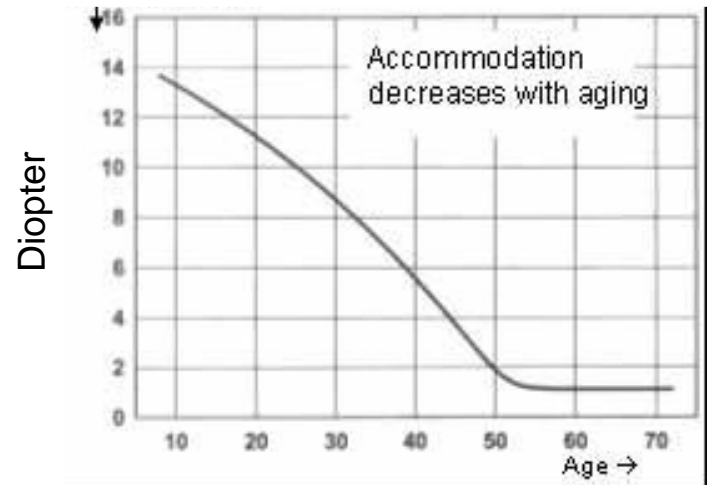


From prof. Ágoston Szél

Accomodation



Amplitude of accomodation with age



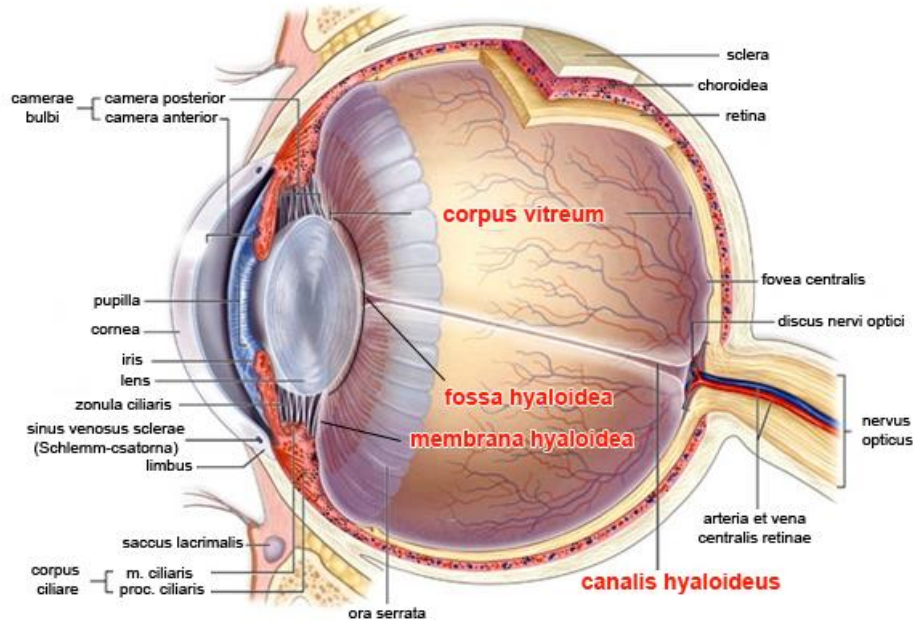
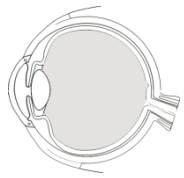
ACCOMMODATION IN THE NORMAL EYE

Actions during accomodation:

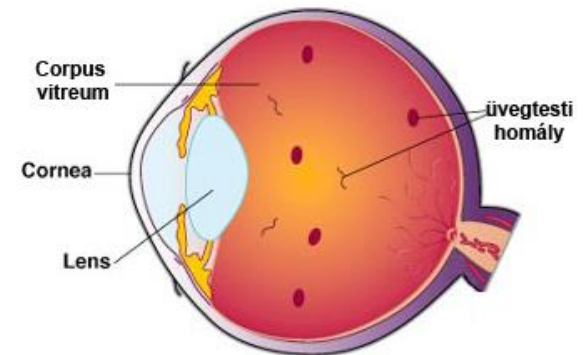
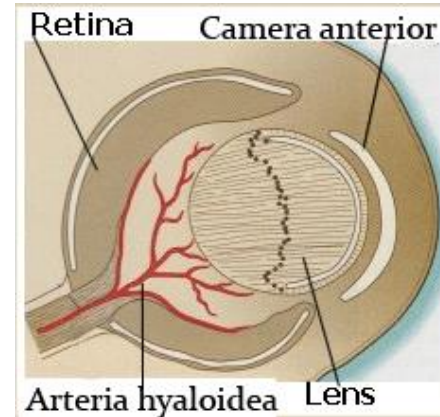
1. Pupil constiction (paraszimp.)
2. Ciliary muscle contract (parasymp.)
3. Convegence of m. rectus medialis



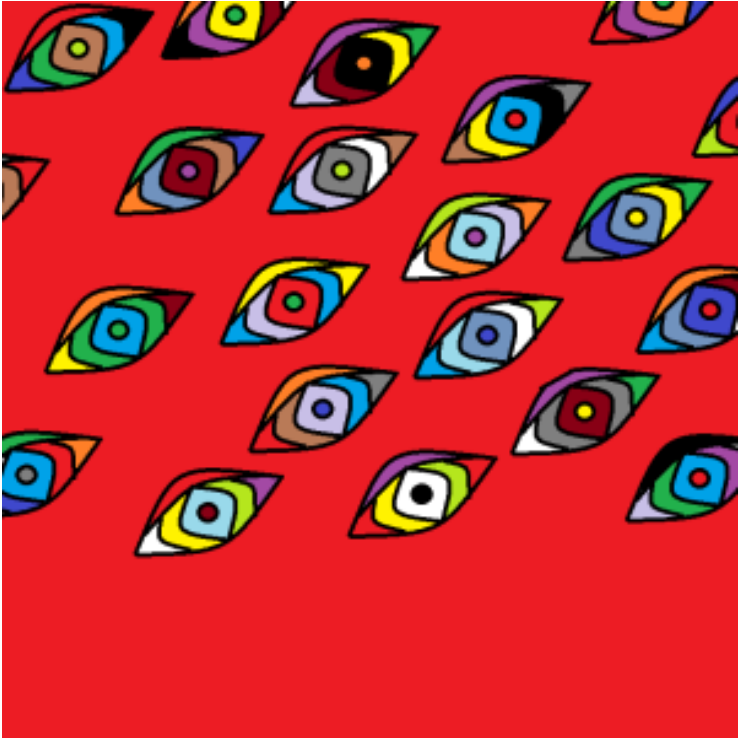
Corpus vitreum-Vitreous body



Development of the eye, 6th week



- Occupies the vitreous chamber behind the lens.
- Jelly like, transparent:
 - 98% water (humor vitreus) and hyaluronate,
 - 2% stroma vitreum - collagen.
- Membrana hyaloidea: anteriorly only, hyalocytes-hyaluronate and collagen production.
- Canalis hyaloideus: developmental remnant- hyaloid artery.
- Floaters: dark moving spots in the field of vision. Inhomegenities in the vitreous body.



Picasso: Eyes



Dali: Eye