Augenentwicklung

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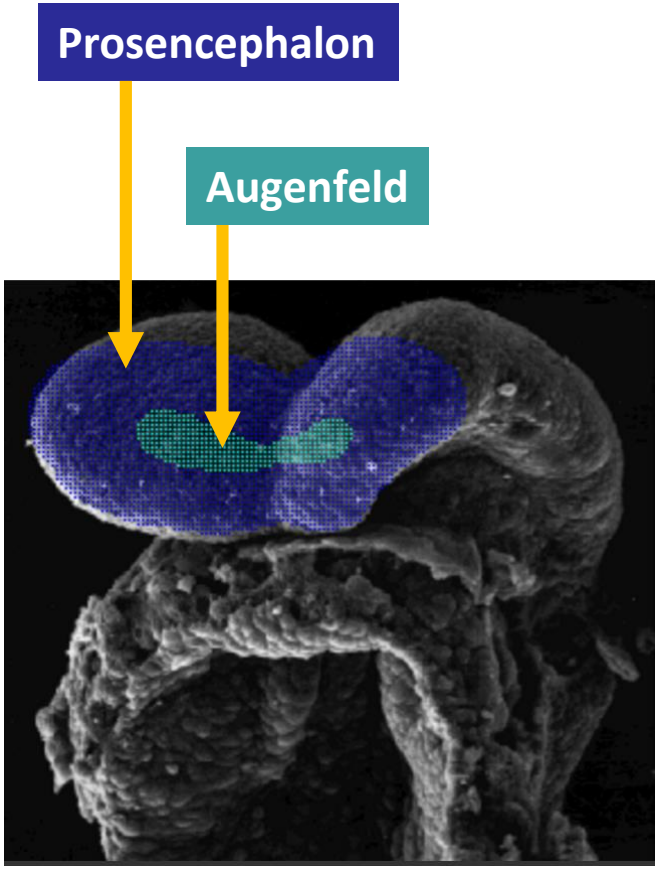
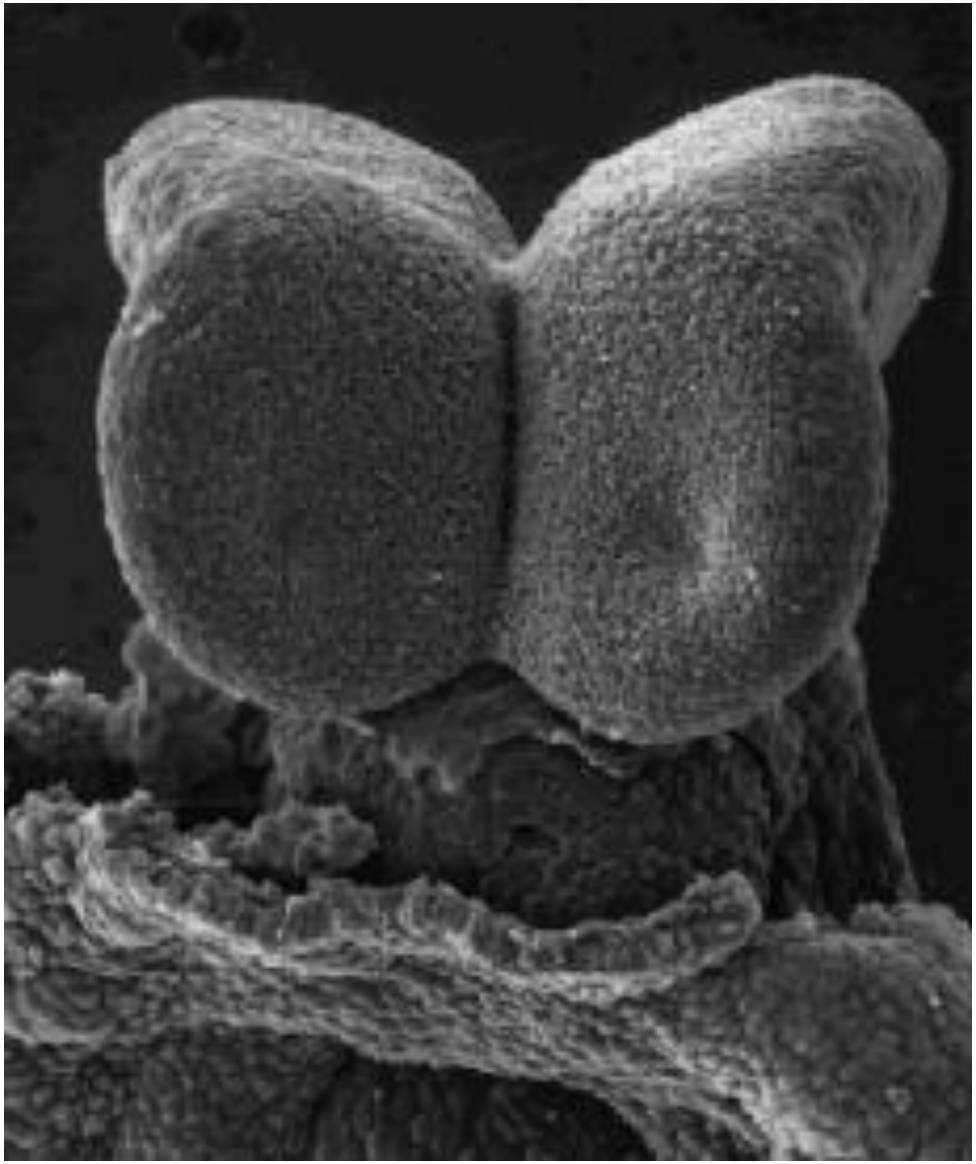
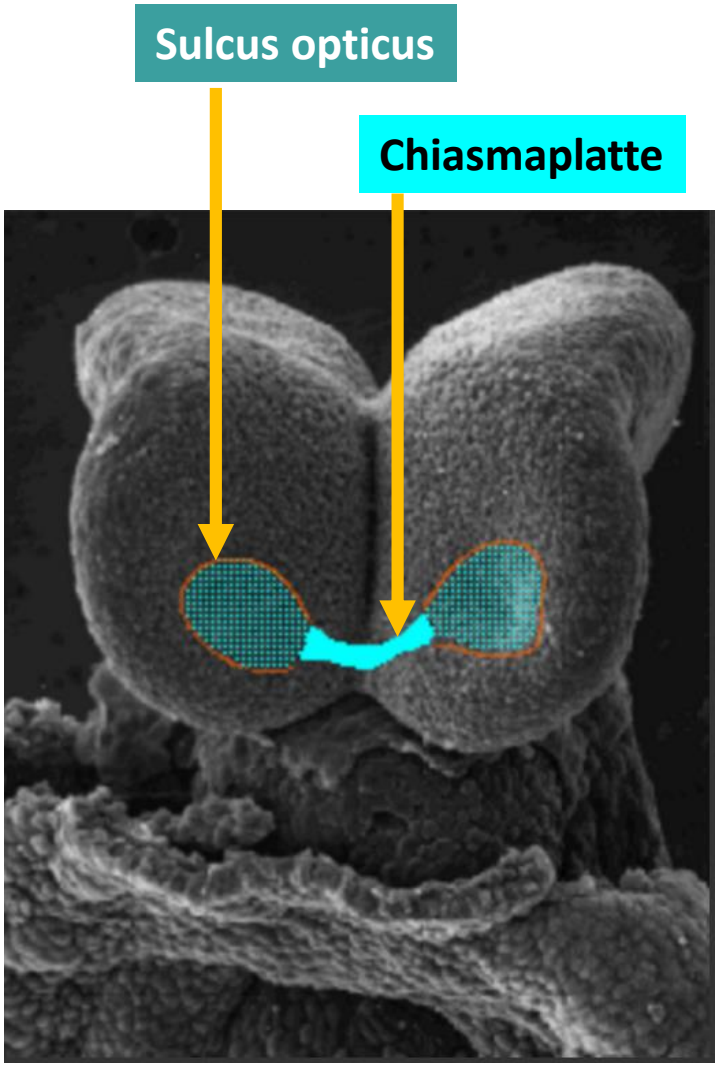
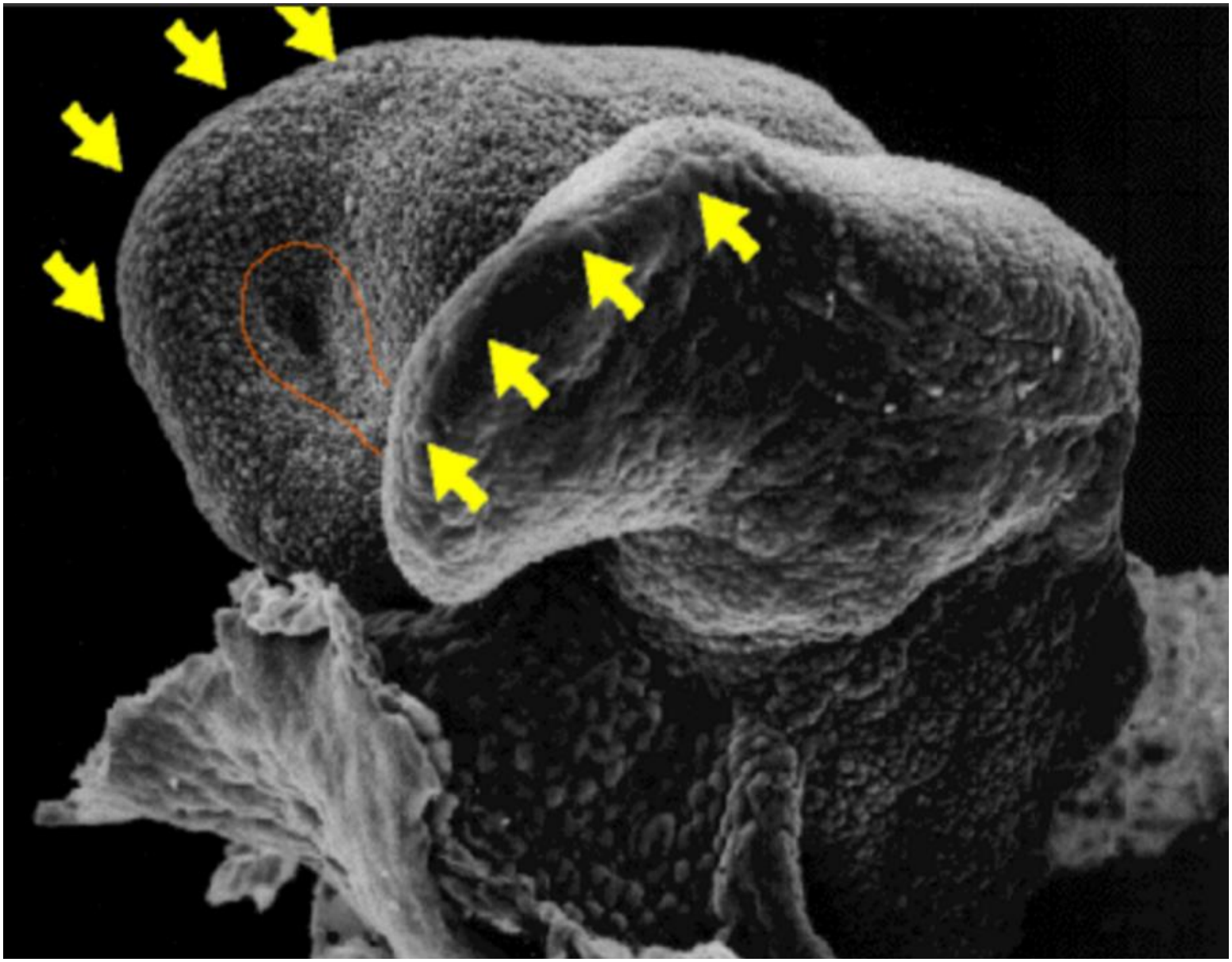


Während der dritten Embryonalwoche erscheinen im späteren Diencephalon die Augenfelder.

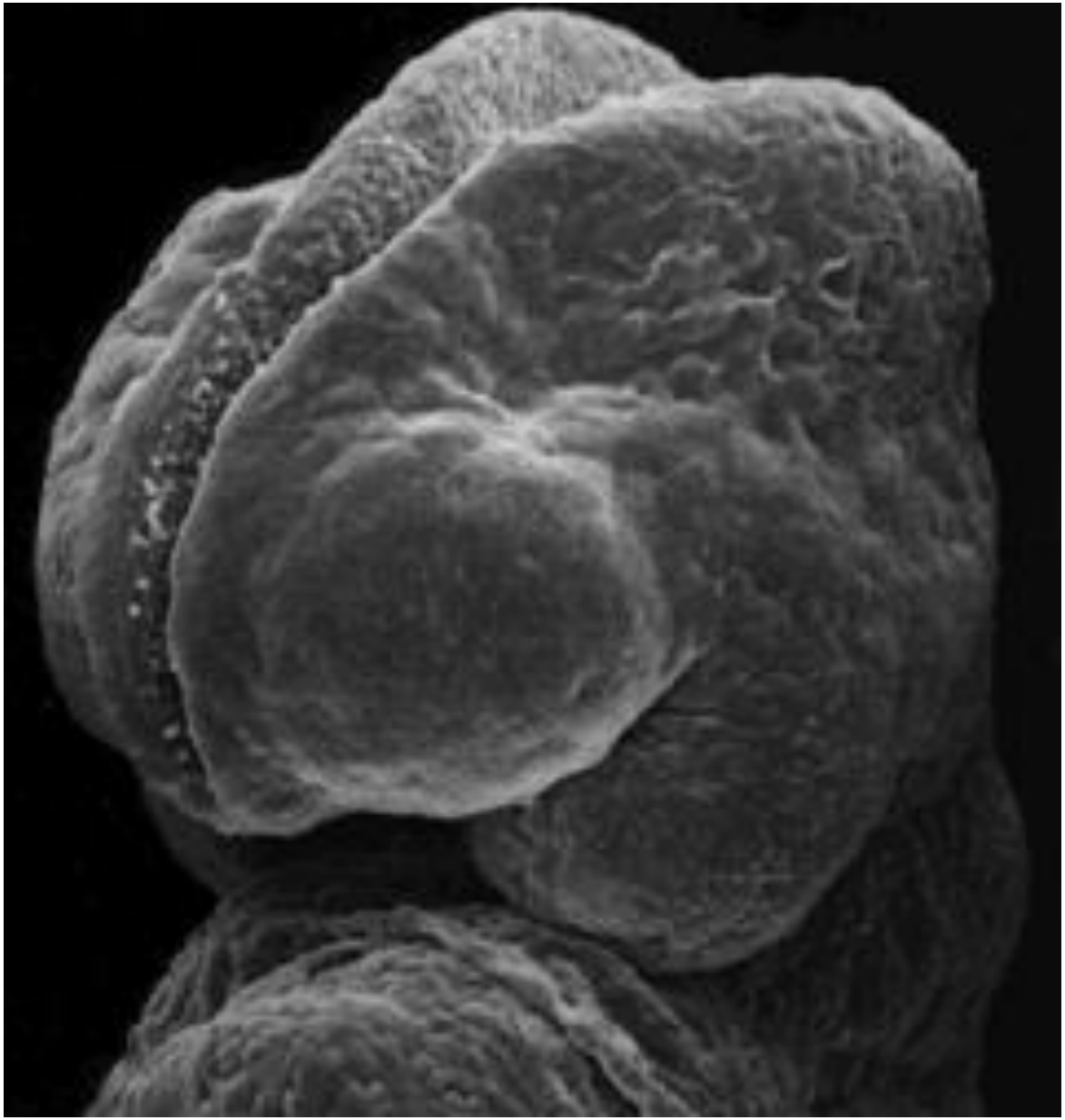


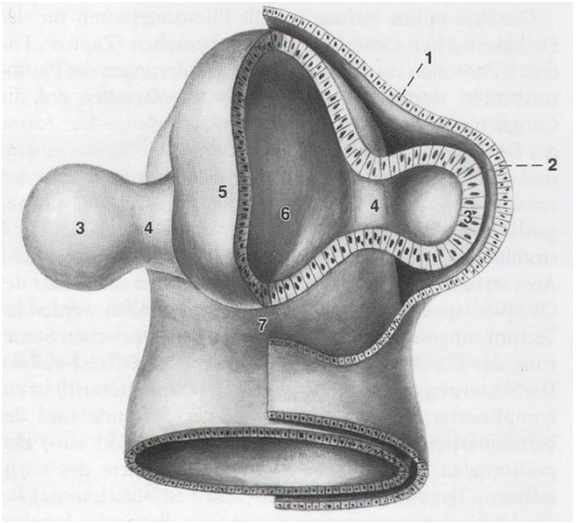


Die ektodermalen Zellen vertiefen das Augenfeld durch Proliferation zum Sulcus opticus.

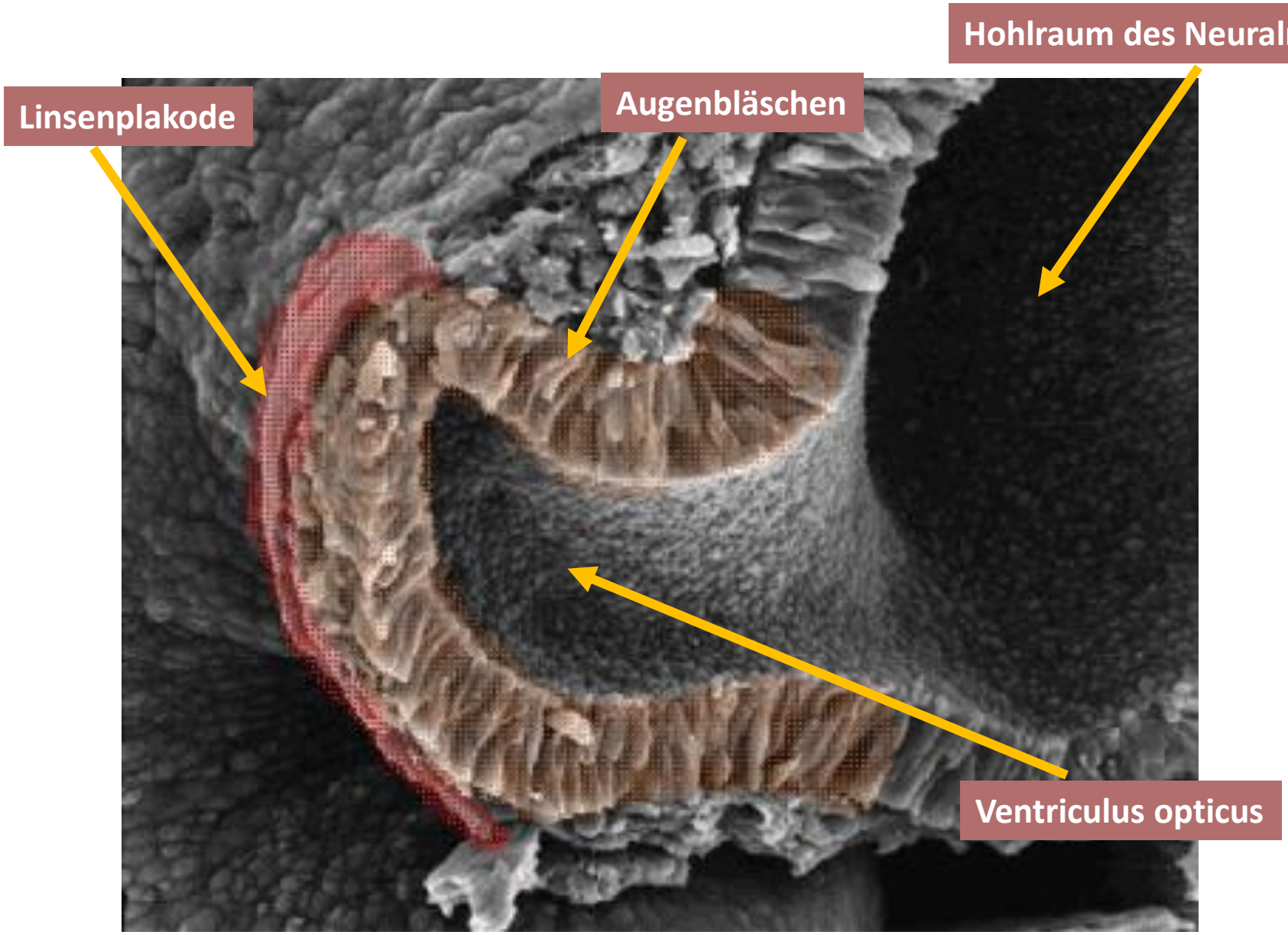


Durch Faltung des Neuroporus anterior verschließt sich das Neuralrohr.

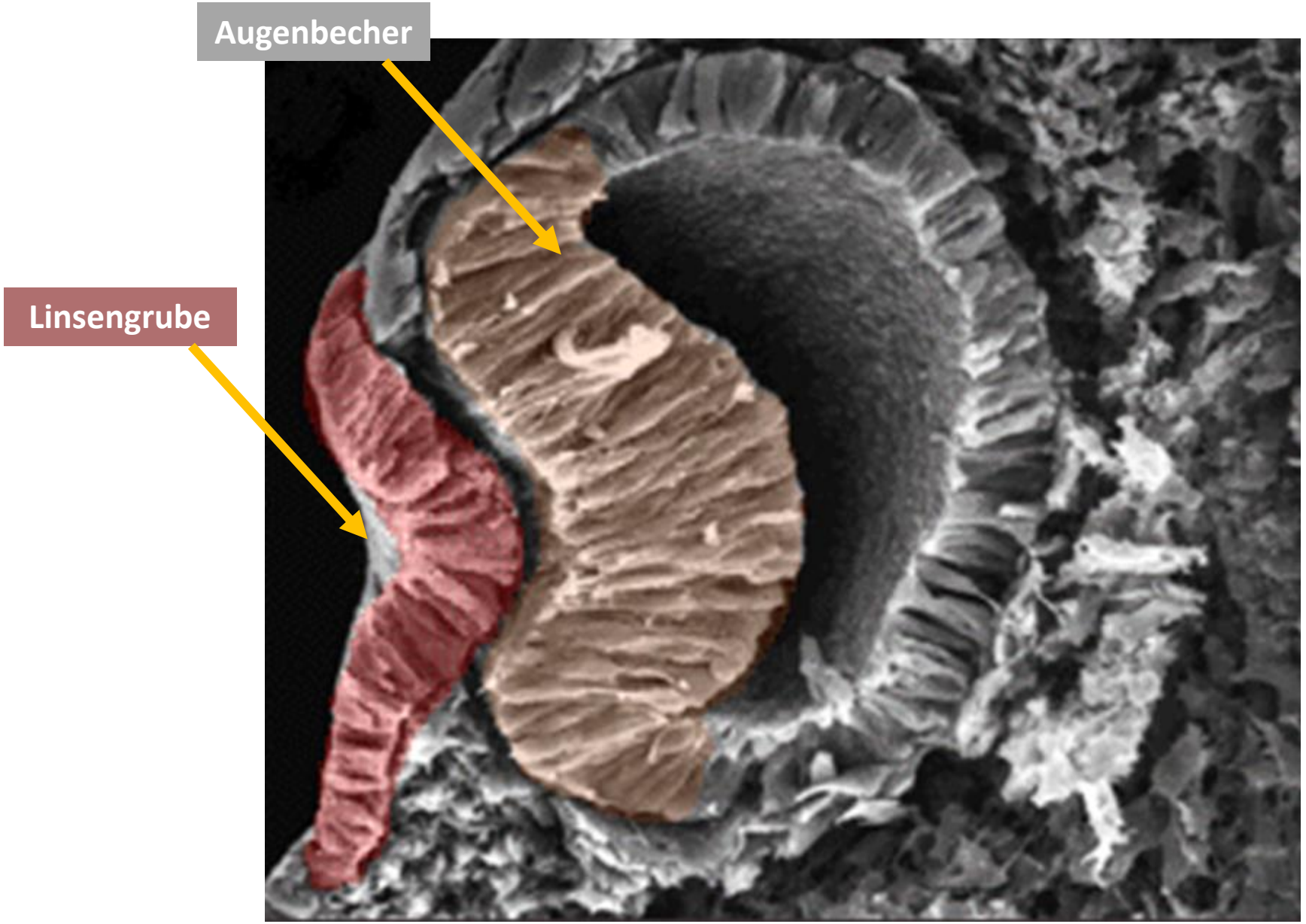




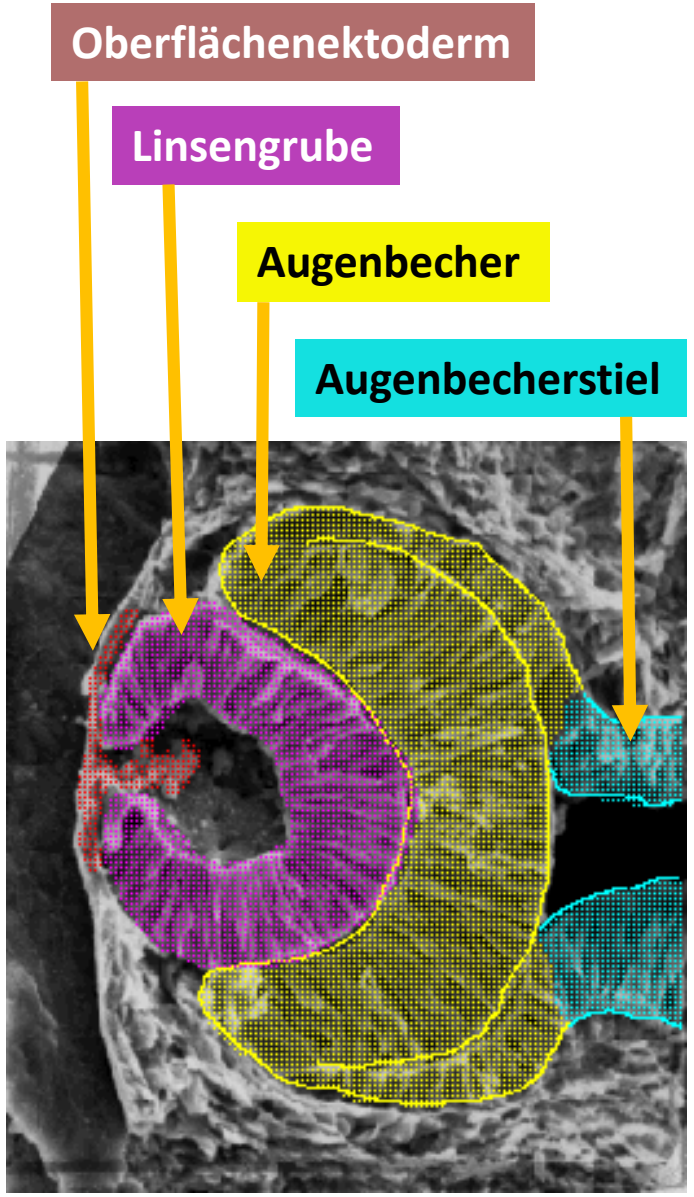
Anfang der 4. Woche erweitert sich der Sulcus opticus nach lateral. Der Sulcus opticus wird zum Augenbläschen (Vesicula optica), dessen Hohlraum in den Hohlraum der späteren III. Ventrikel übergeht.

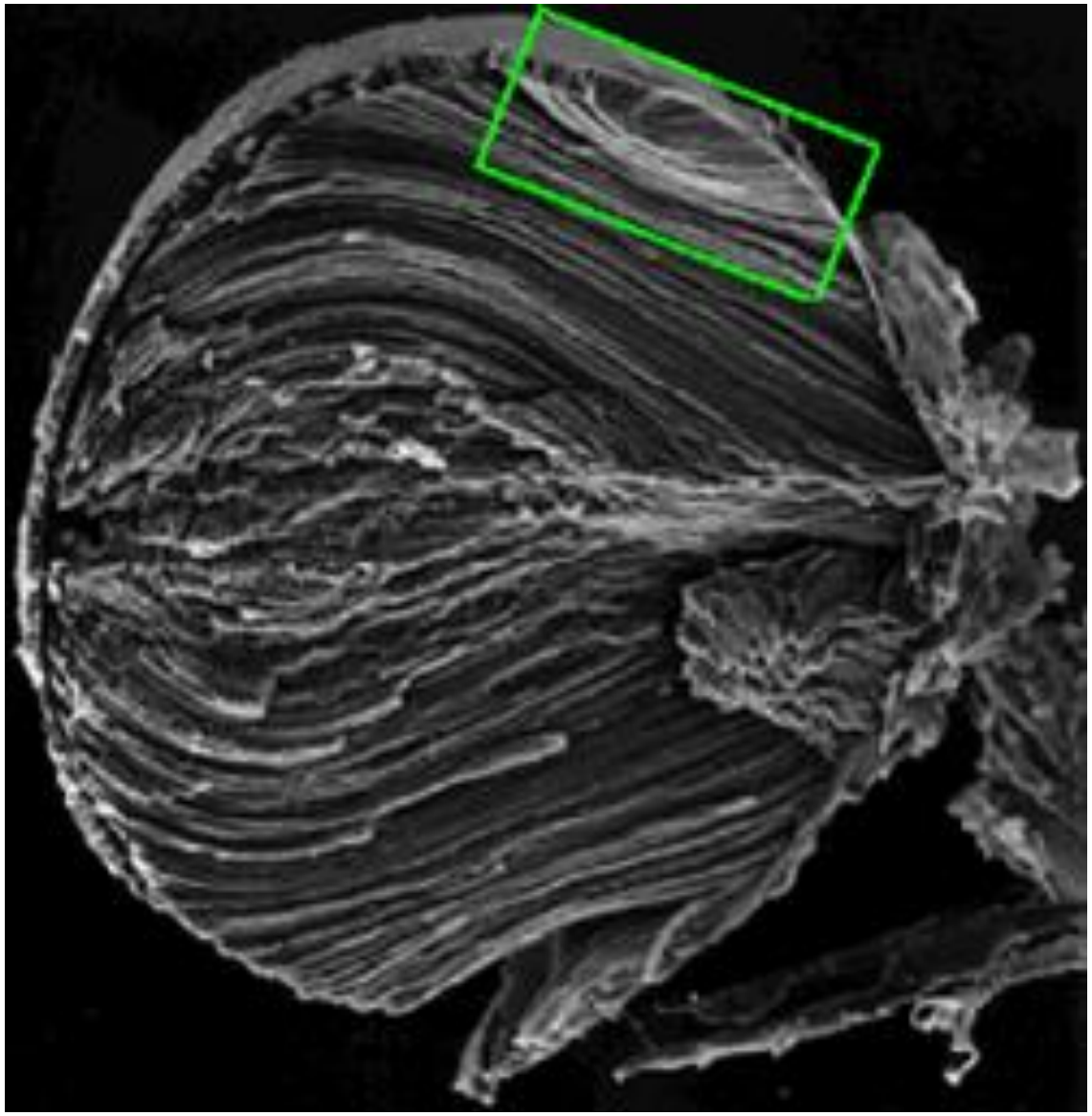


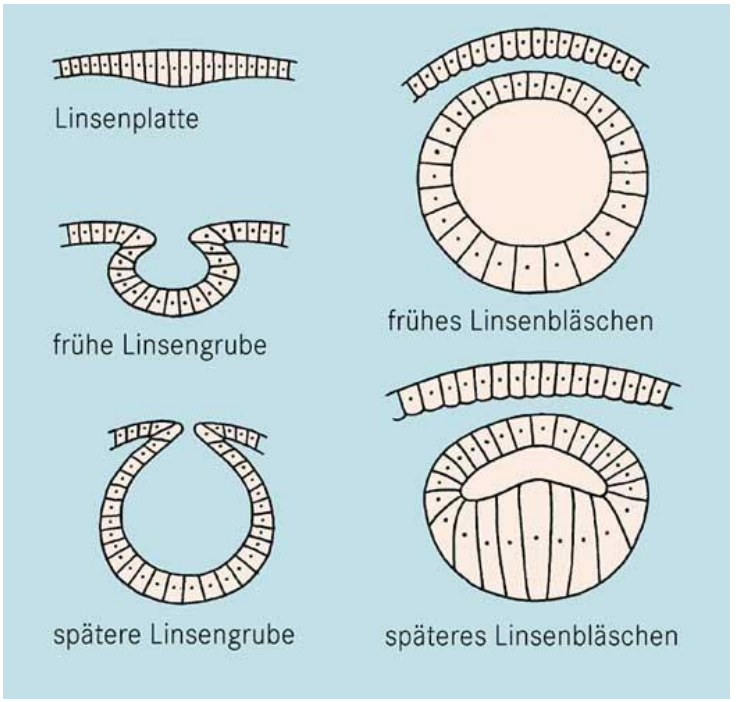
Das Augenbläschen bleibt im direkten Kontakt mit dem Oberflächenektoderm.

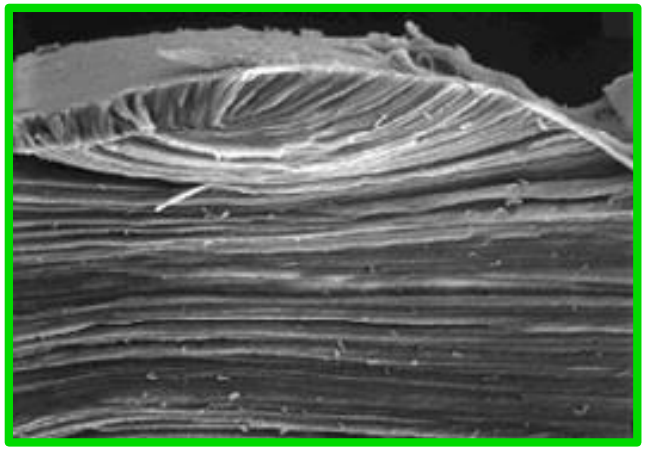


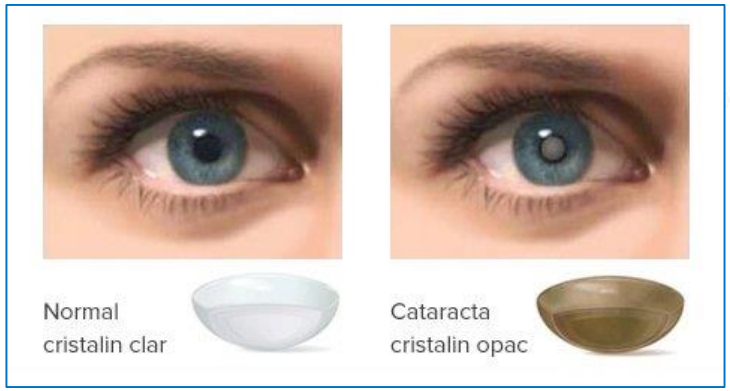
Die Linsenplakode sinkt zur Linsengrube ein. Der laterlar Abschnitt des Augenbläschens stülpt sich ein, wodurch ein zweiblättriger Augenbecher ensteht.

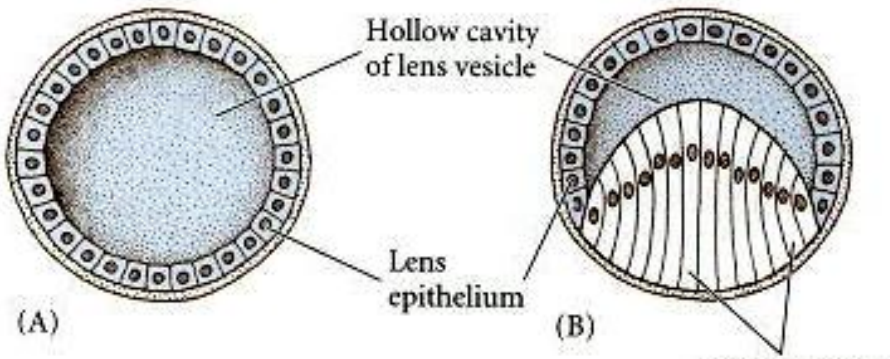

Oberflächenektoderm
Linsengrube
Augenbecher
Augenbecherstiel

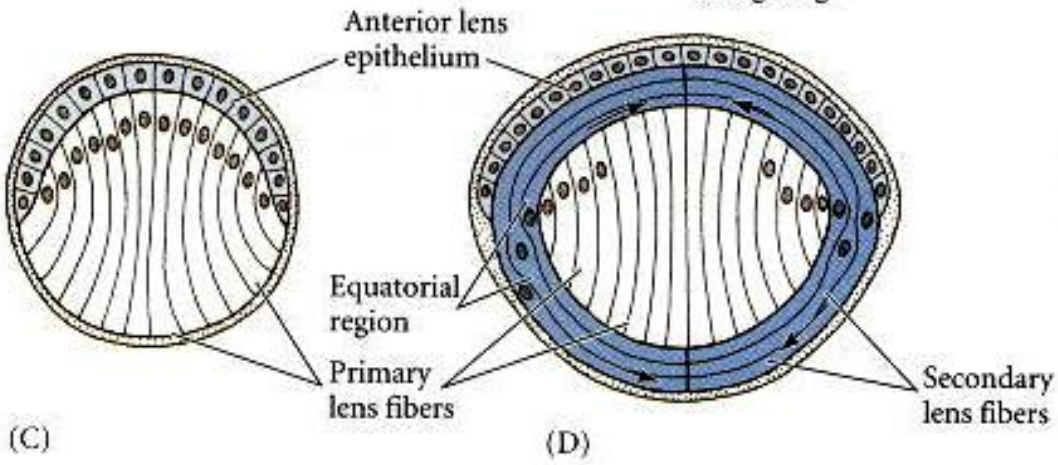


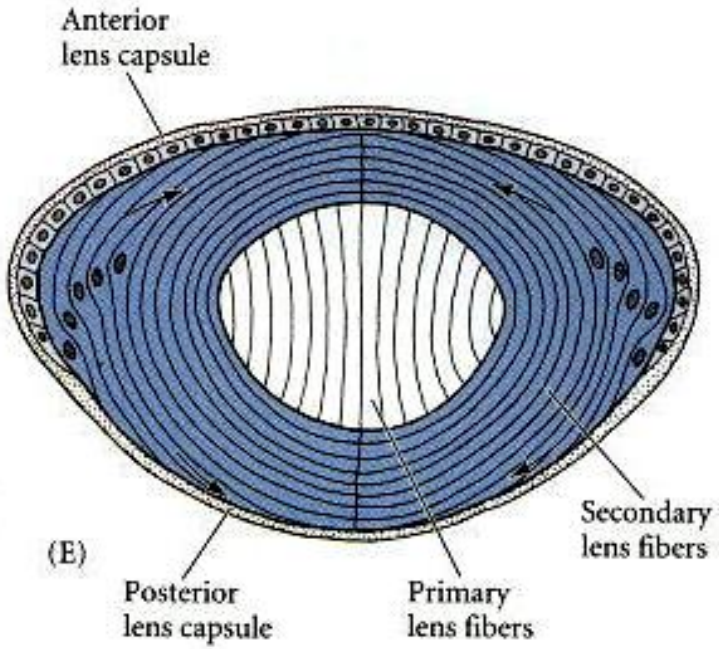

Linsenplatte
frühe Linsengrube
frühes Linsenbläschen
spätere Linsengrube
späteres Linsenbläschen









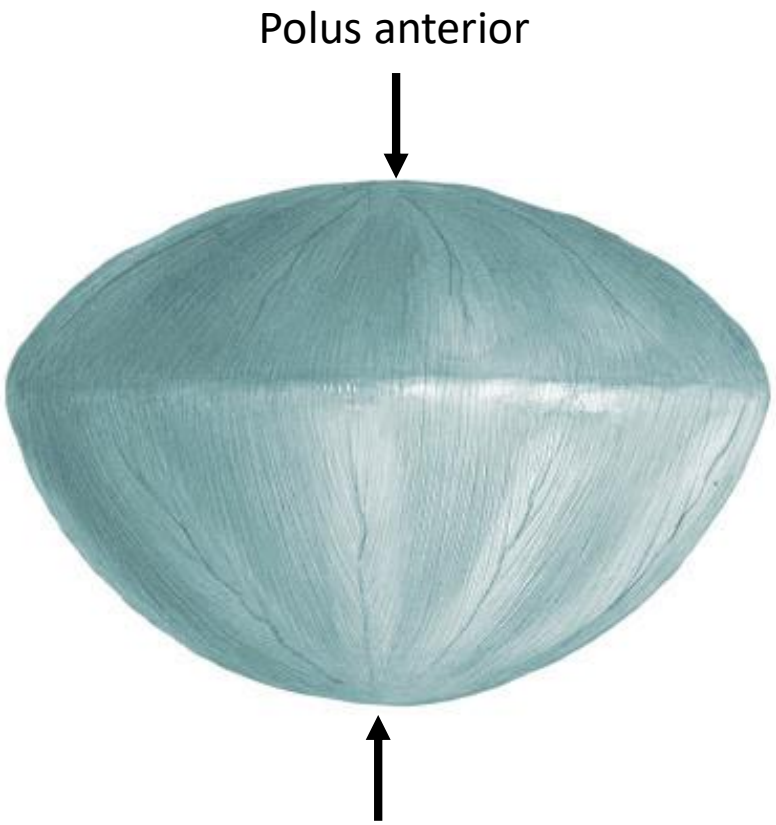


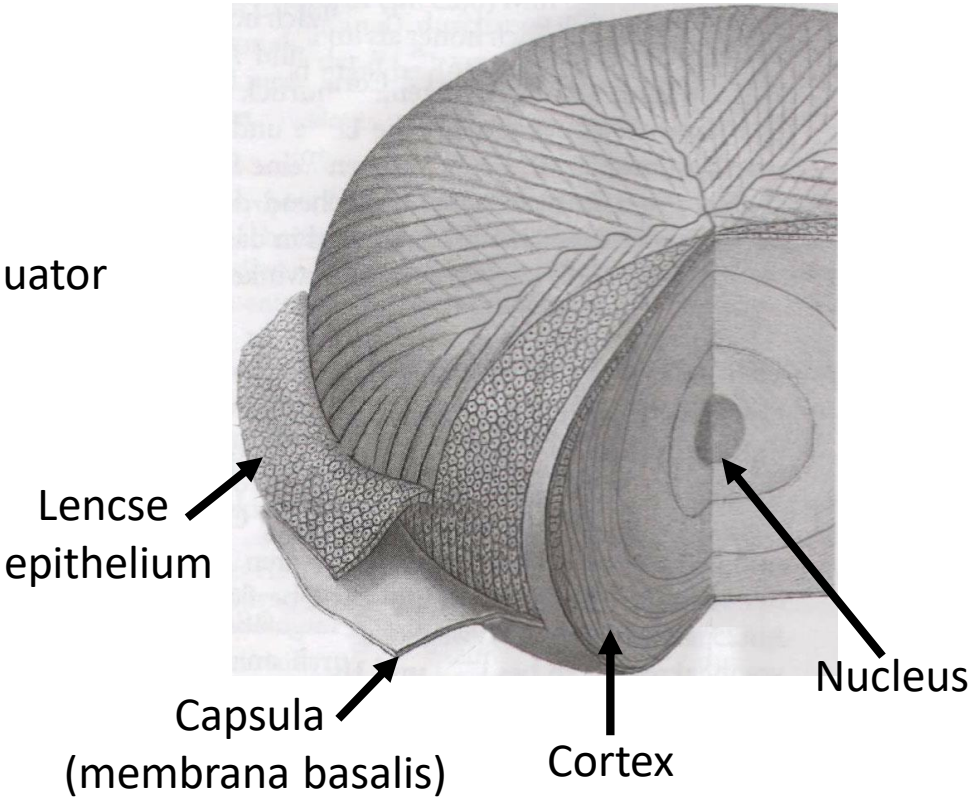
Das Linsenbläschen trennt sich von dem Oberflächenektoderm schon an der 5. Woche ab. Seine Basalmembran wird zur Capsula lentis.

Die Linsenepithelzellen der dorsalen Linsenbläschenwand verlengern sich und wandeln sich in primären Linsenfasern um. Die sekundäre Linsenfasern bilden sich ab dem 3. Embryonalmonat.

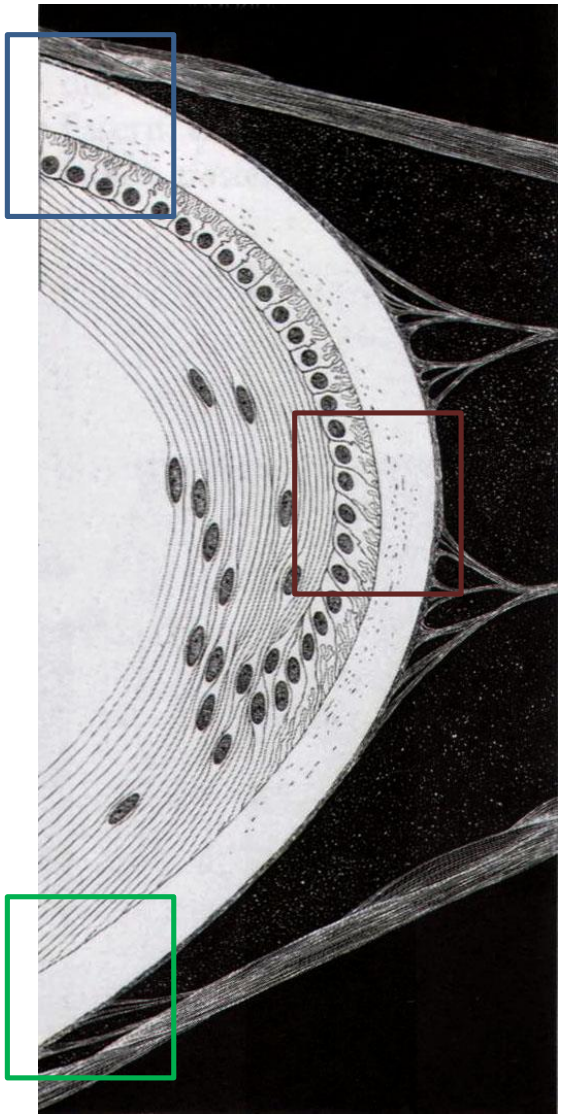
Cataracta congenita: angeborene Katarakt (zB. Rubeola Infektion an der 4-7. Woche!!!)

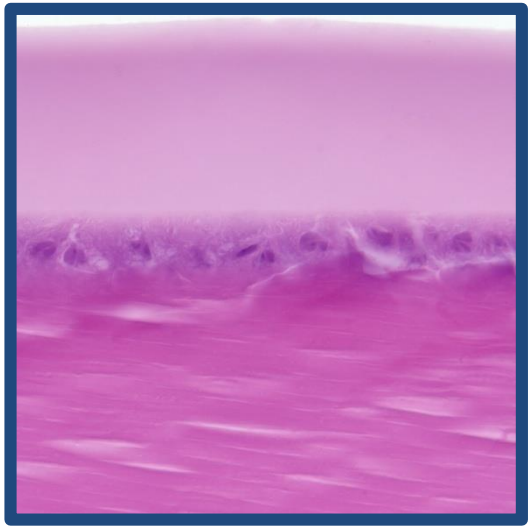
Aufbau der Linse

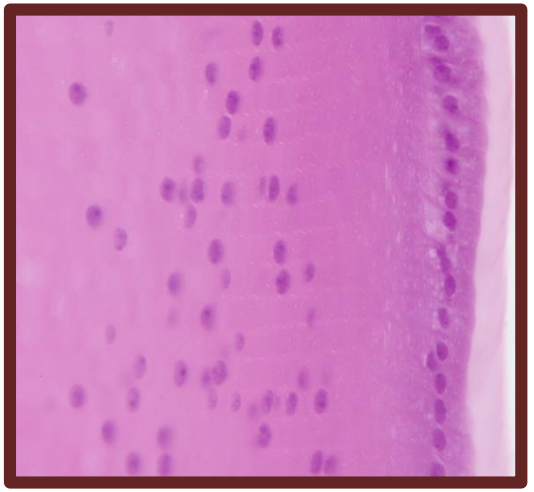


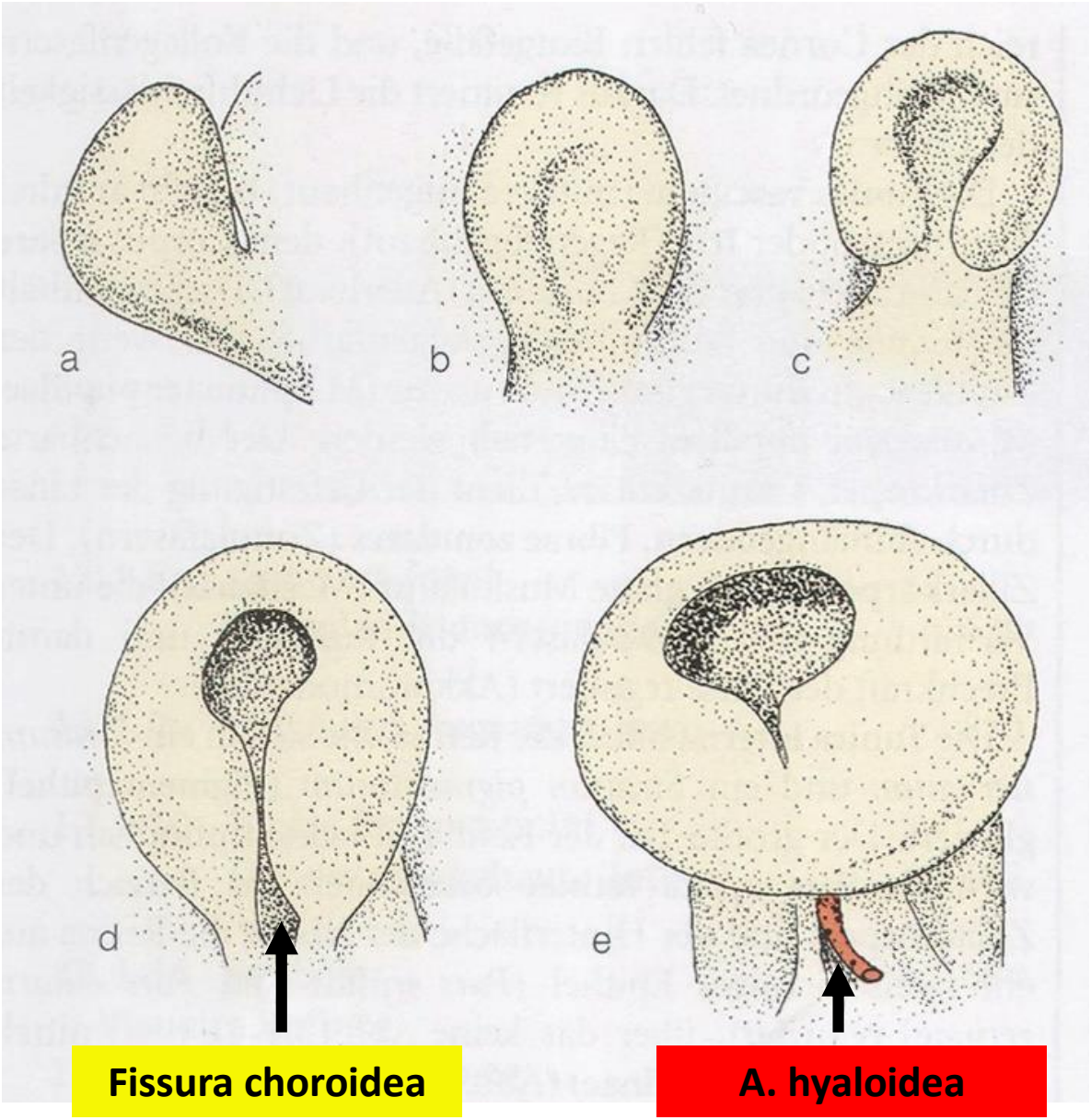


Histologie der Linse



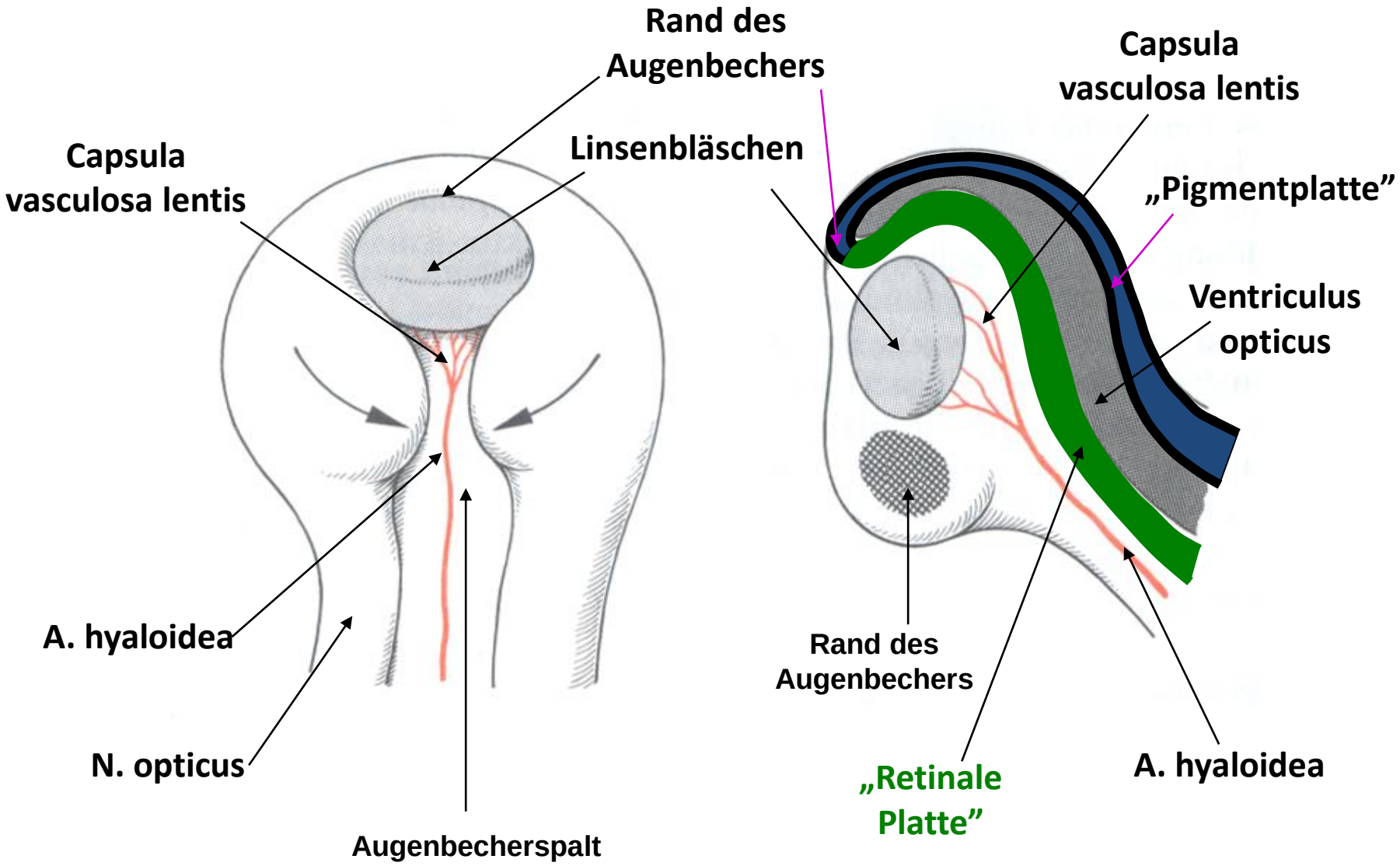




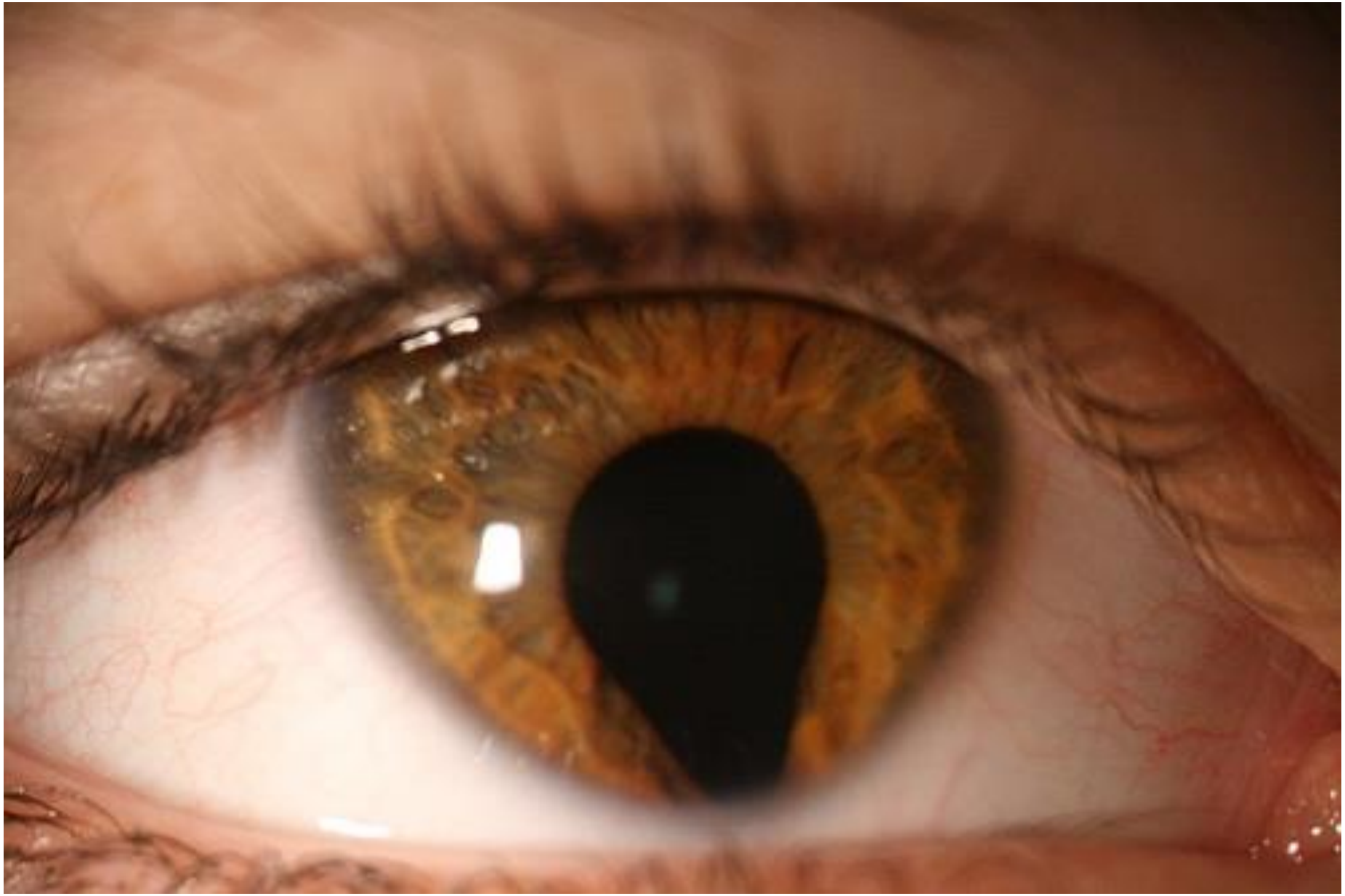


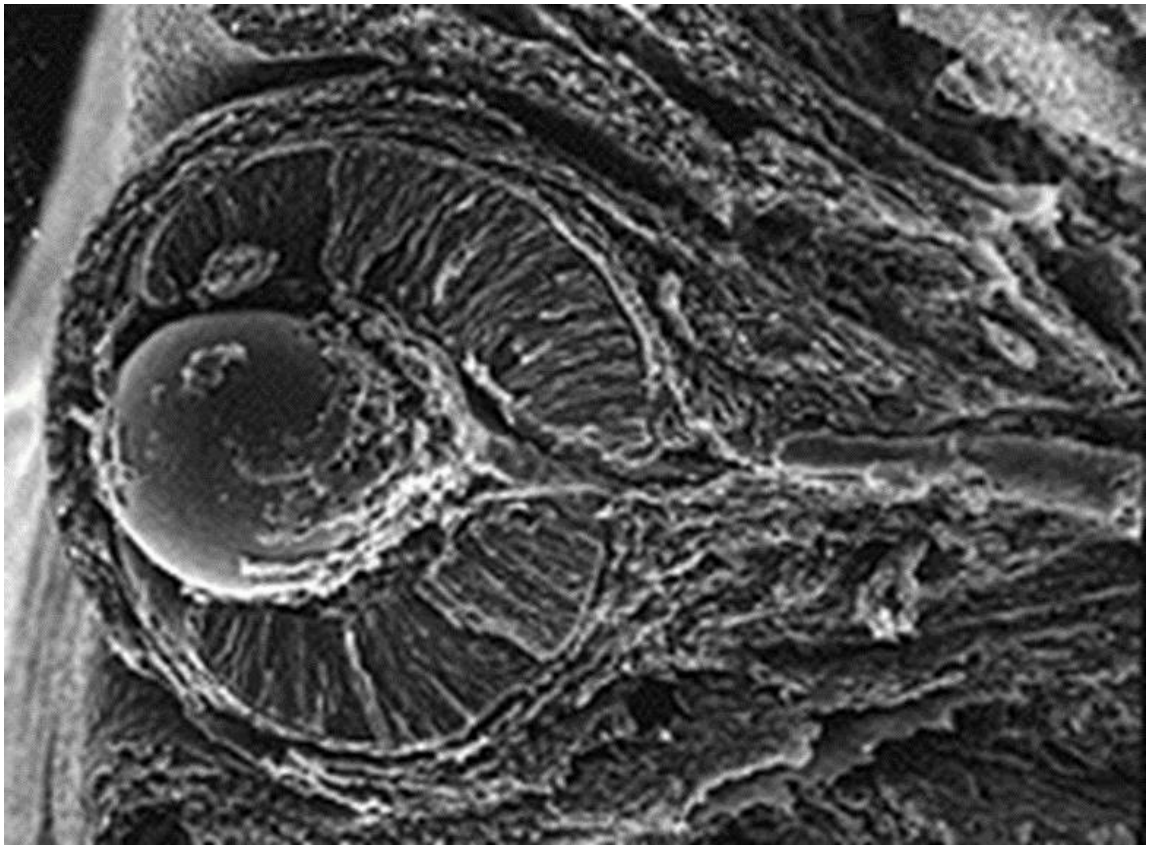
Die Eindellung des Augenbechers ist asymmetrisch. Auf der ventralen Seite des Augenbecherstiels entsteht der Augenbecherspalt (Fissura choroidea), der als Leitstruktur für die Axonen des Nervus opticus dient. Durch die Fissura choroidea tritt die Arteria hyaloidea in den Augenbecher ein.

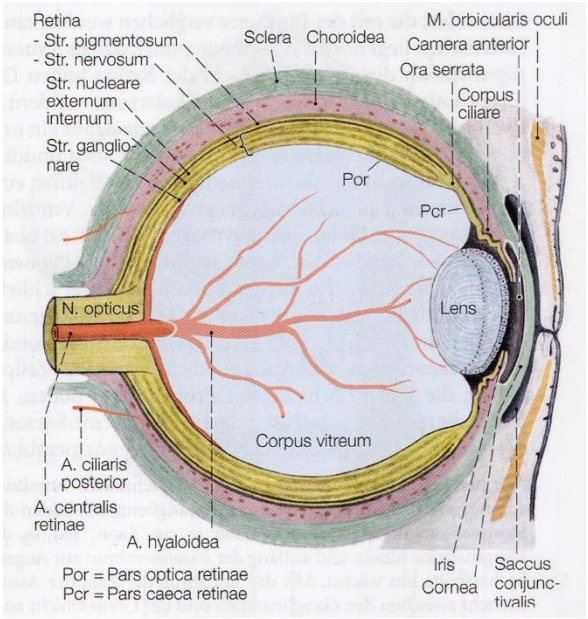
Entwicklung des Augenbecherstiels



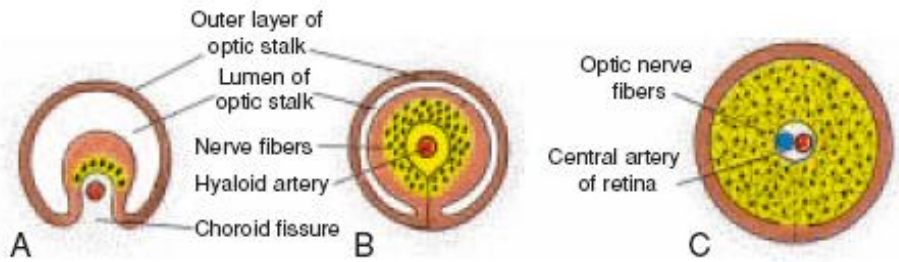
Kolobom





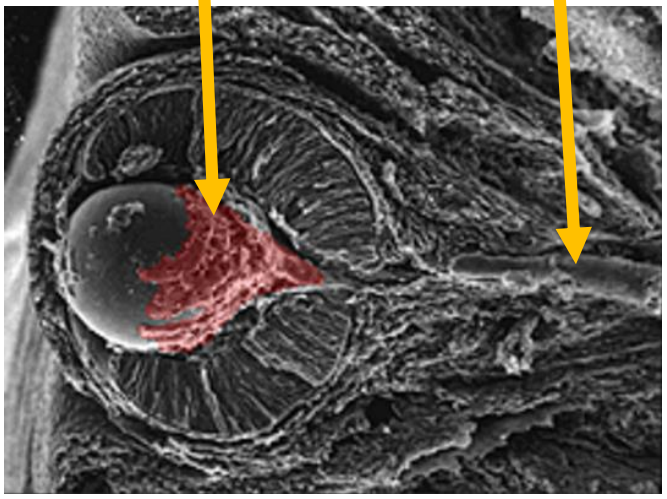


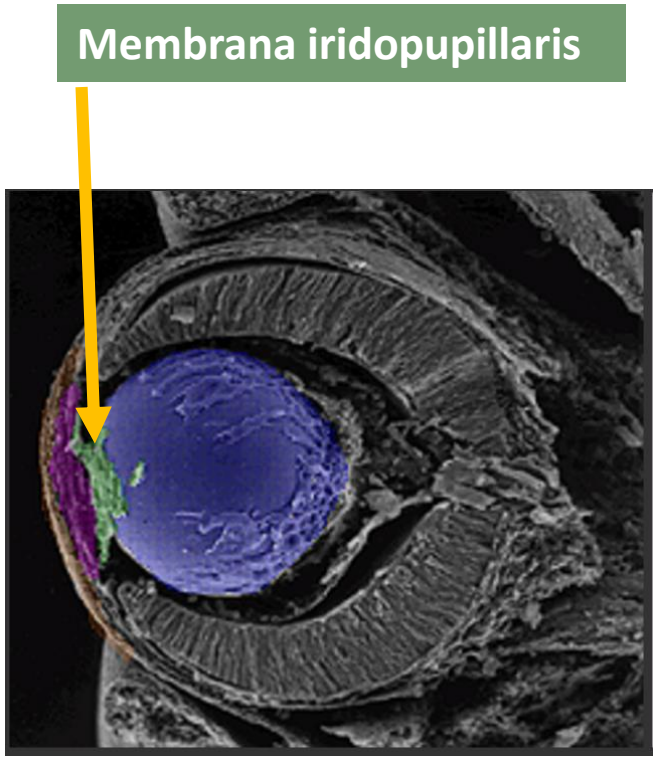
Der distaler Teil der Arteria hyaloidea bildet sich im achten Embryonalonat zurück. Ihr proximaler Teil verbleibt und wird zur Arteria centralis retinae.



A. hyaloidea

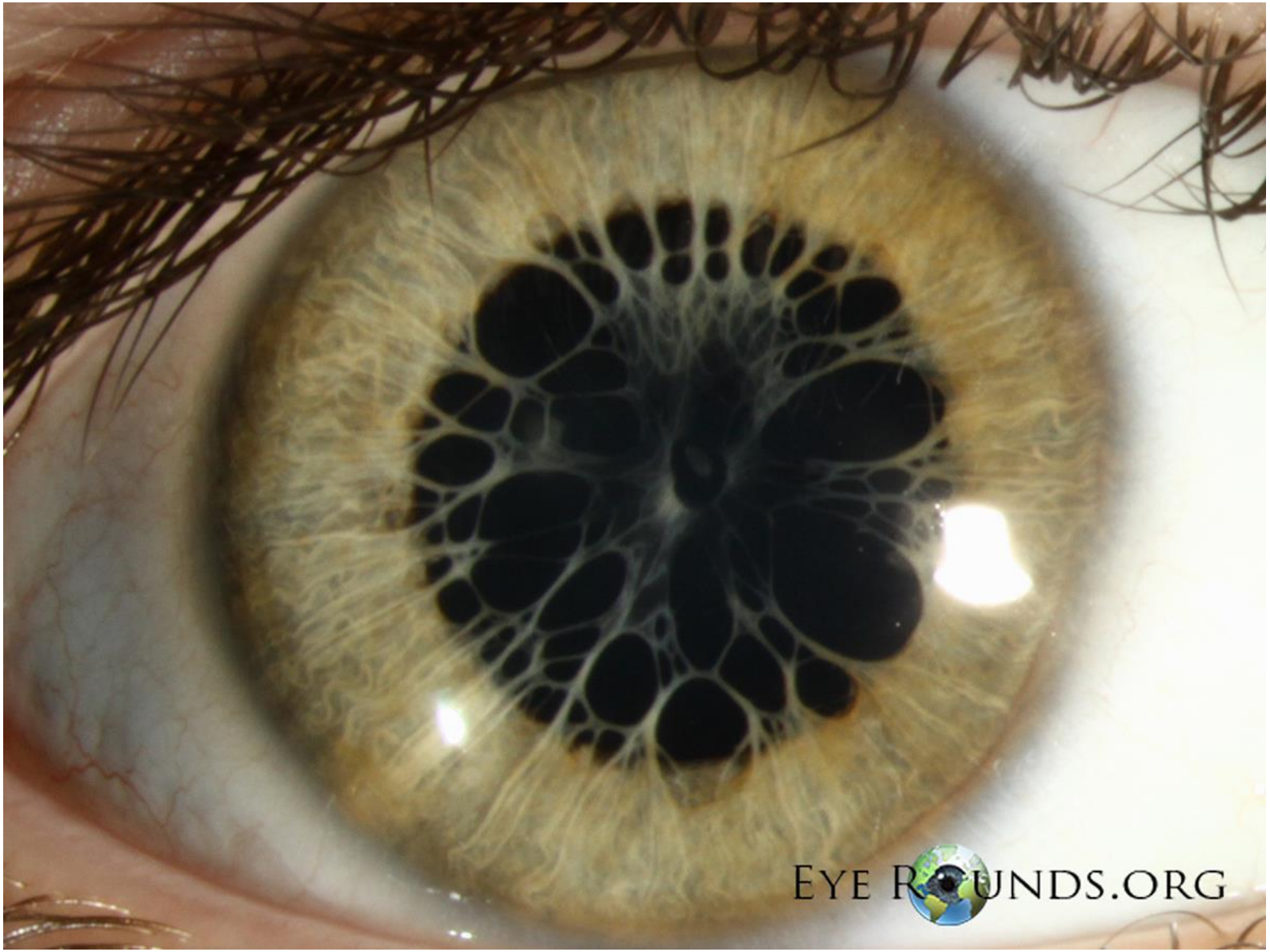
A. centralis retinae

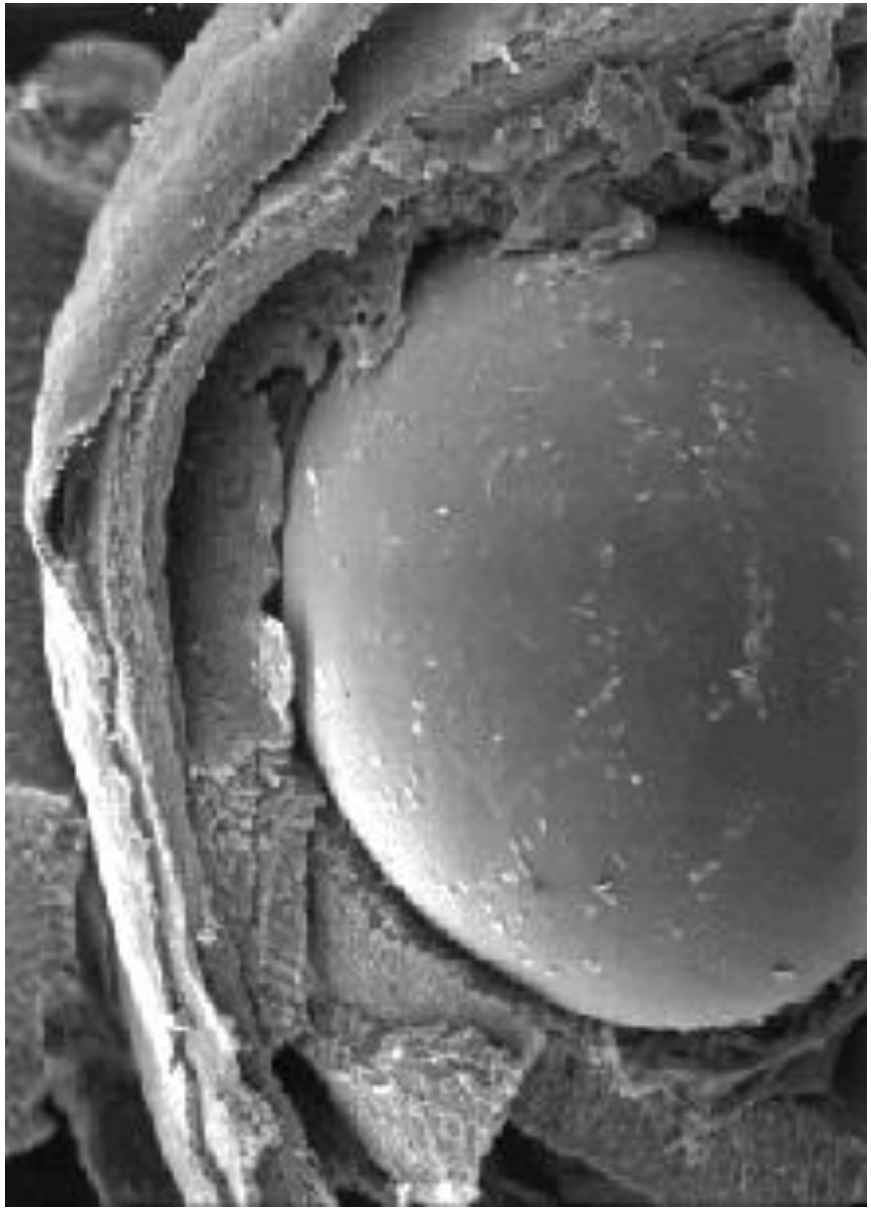


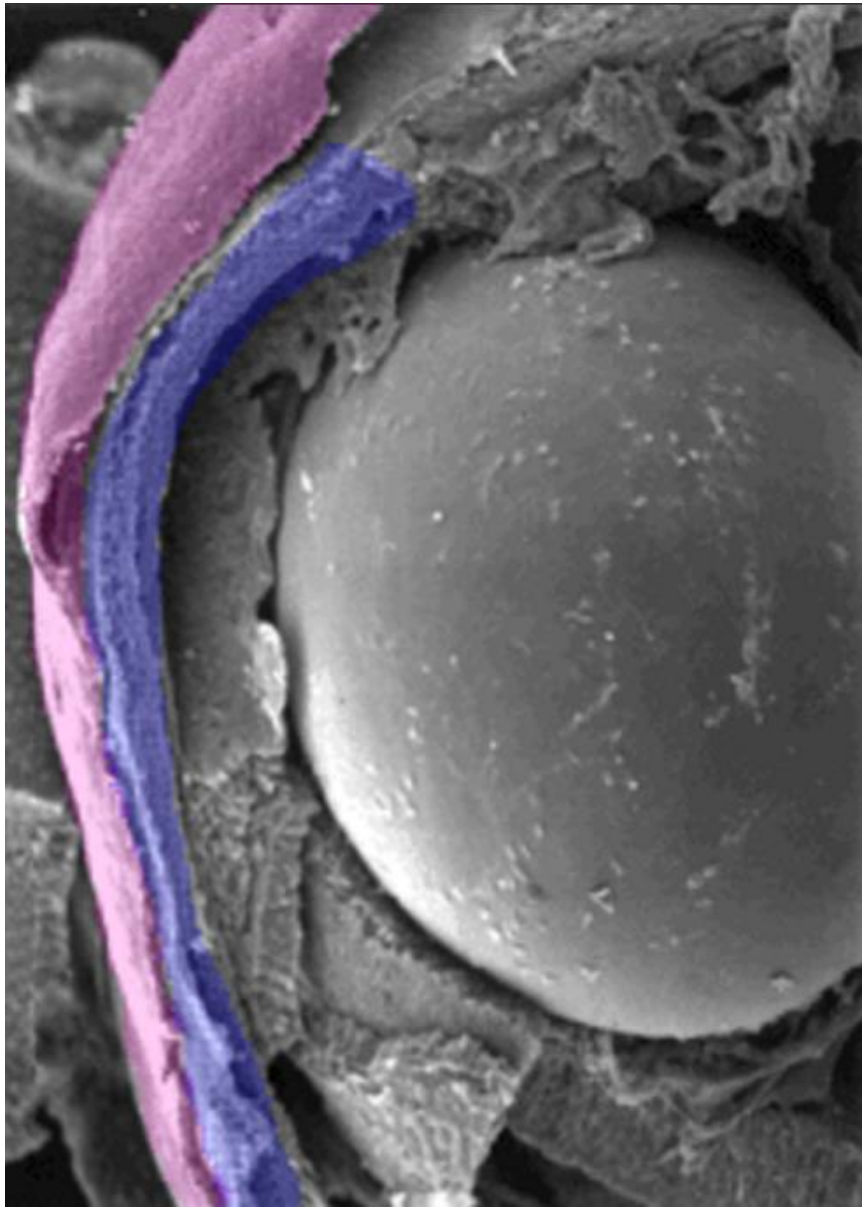


In dem zweiten Monat entsteht ein stark vaskularisiertes Mesenchym um die Linse.
Der Vorderer Teil dieser Zellmasse wird zur Pupillenmembran (Membrana iridopupillaris).
Mit der Rückbildung der Gefäßen bildet sich auch die Pupillenmembran zurück.

Pupillenatresie

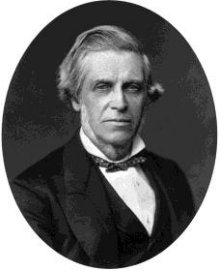






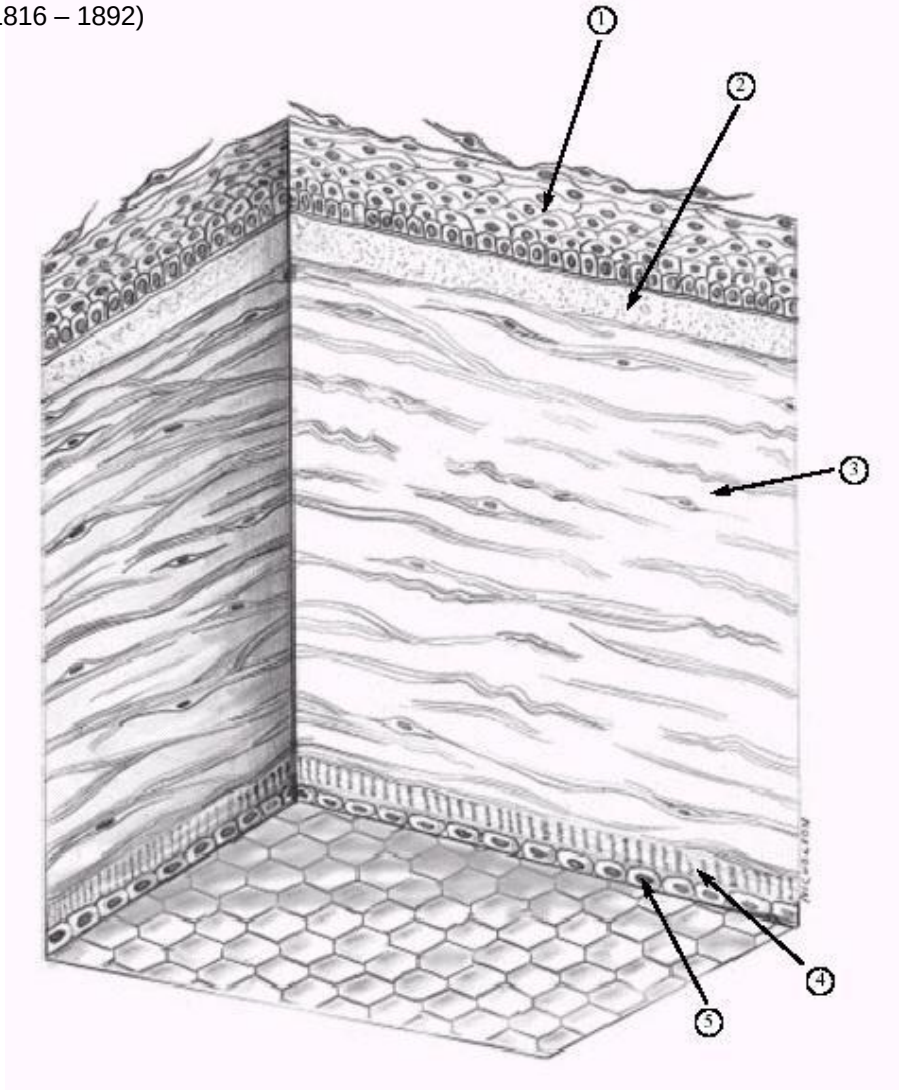
Die Cornea entsteht aus zwei Anlagen. Das Epithelium corneae ist ein Derivat des Oberflächenektoderms, während die Stroma und das innere Endothelium entsteht aus Zellen der Neuralleiste.

Cornea



Sir William Bowman
(1816 – 1892)

Jean Descemet
(1732-1810)



1. Epithelium anterius corneae

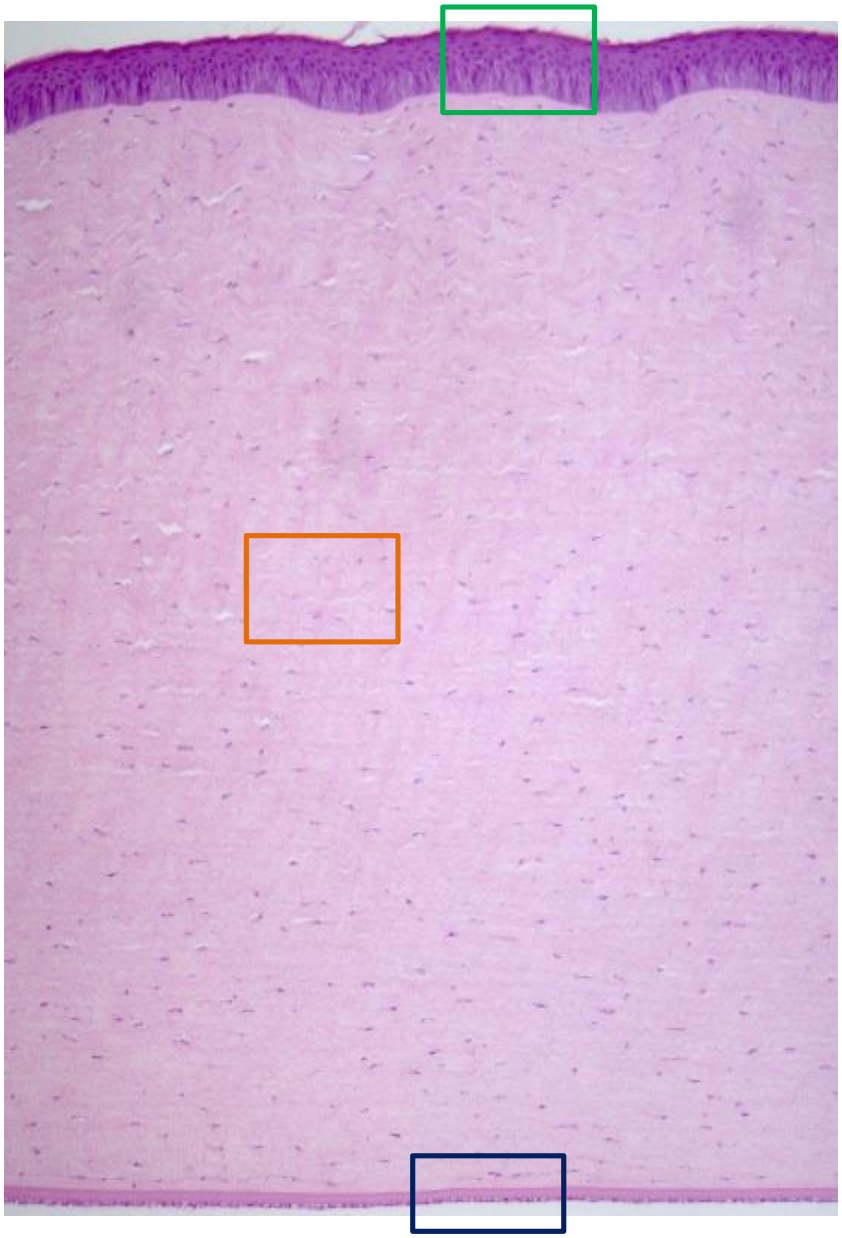
2. Membrana limitans anterior (Bowman-féle membrán/réteg)

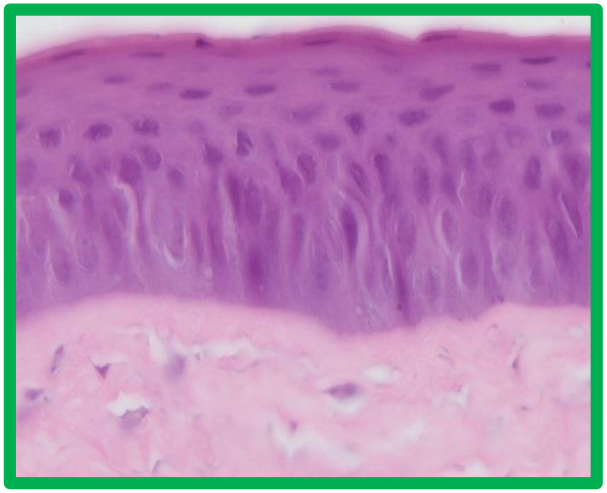
3. Substantia propria (Stroma)

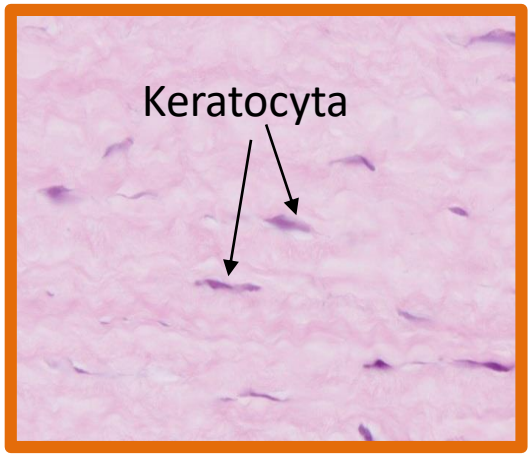
4. Membrana limitans posterior (Descemet-féle membrán)

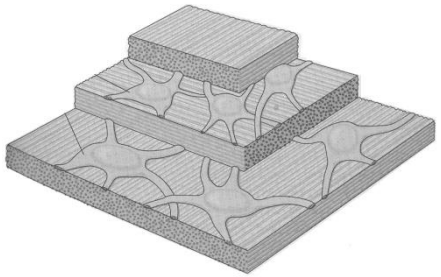
5. Endothelium corneae (endothelium camerae anterioris)

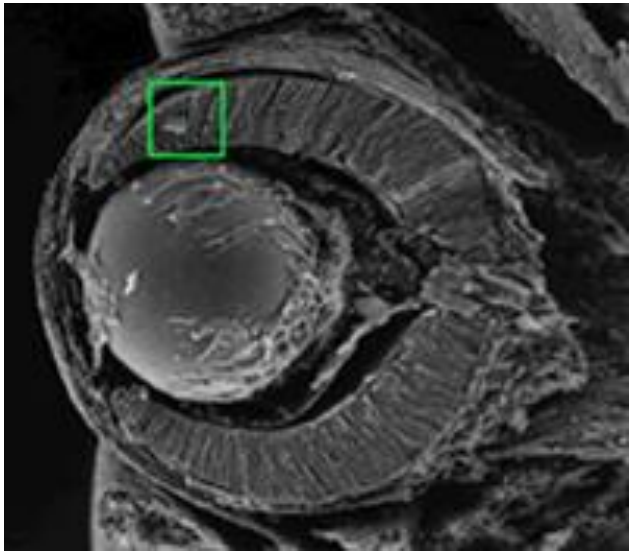
Cornea

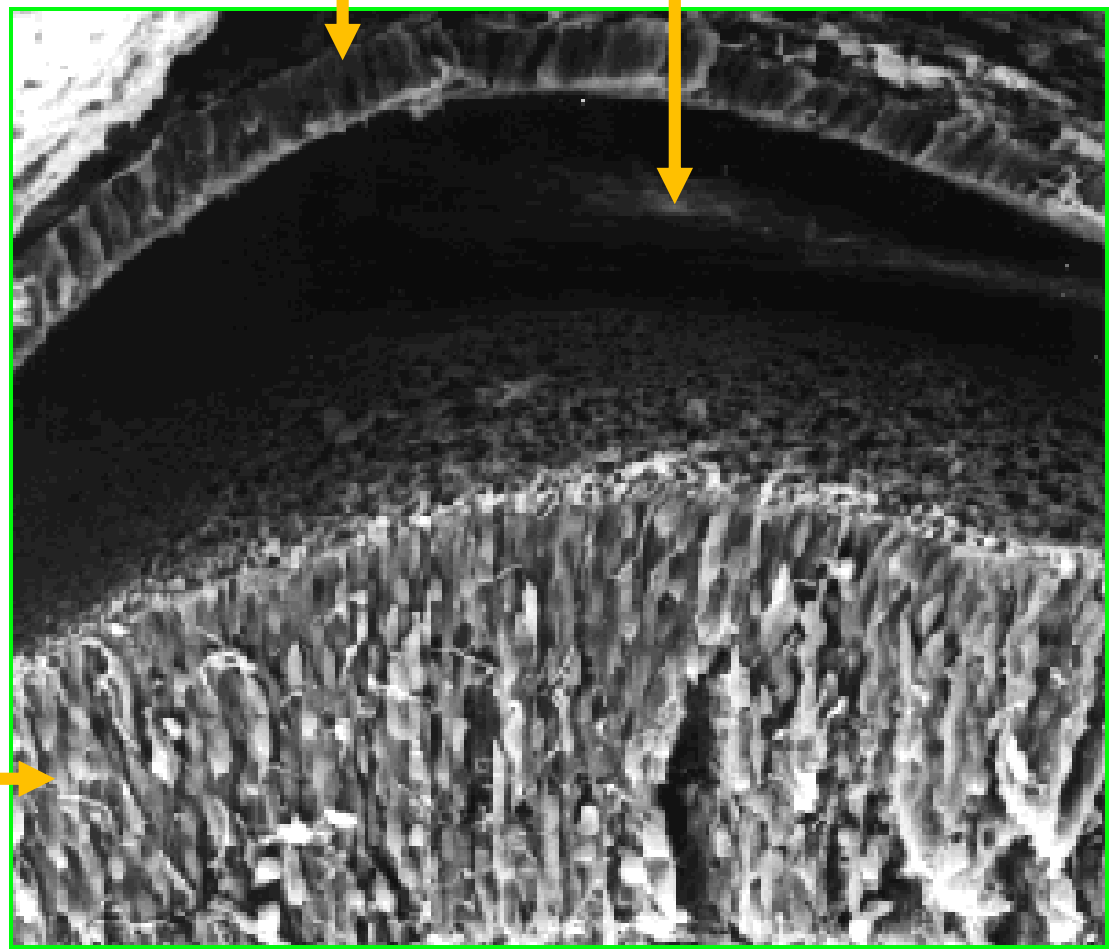




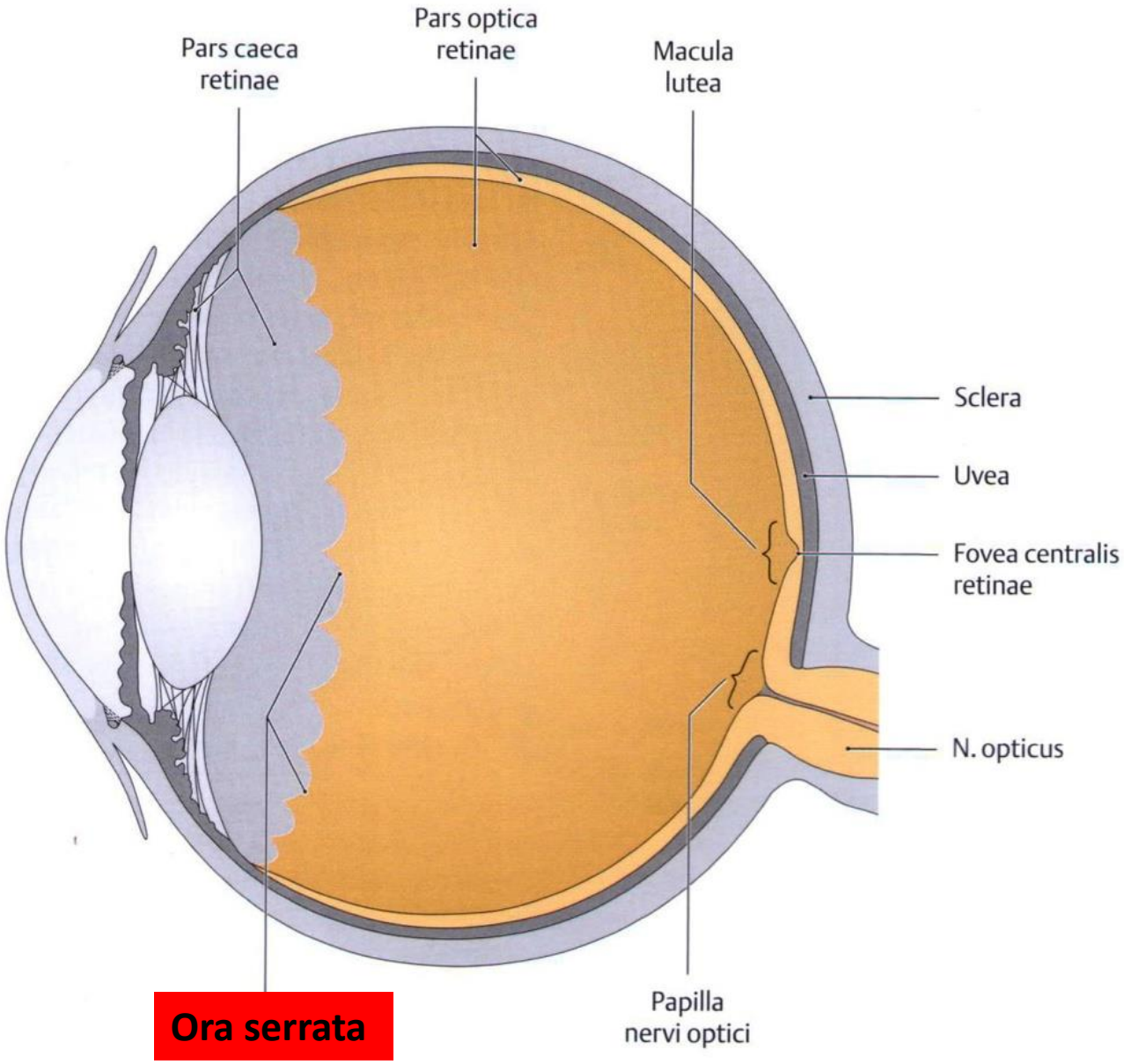




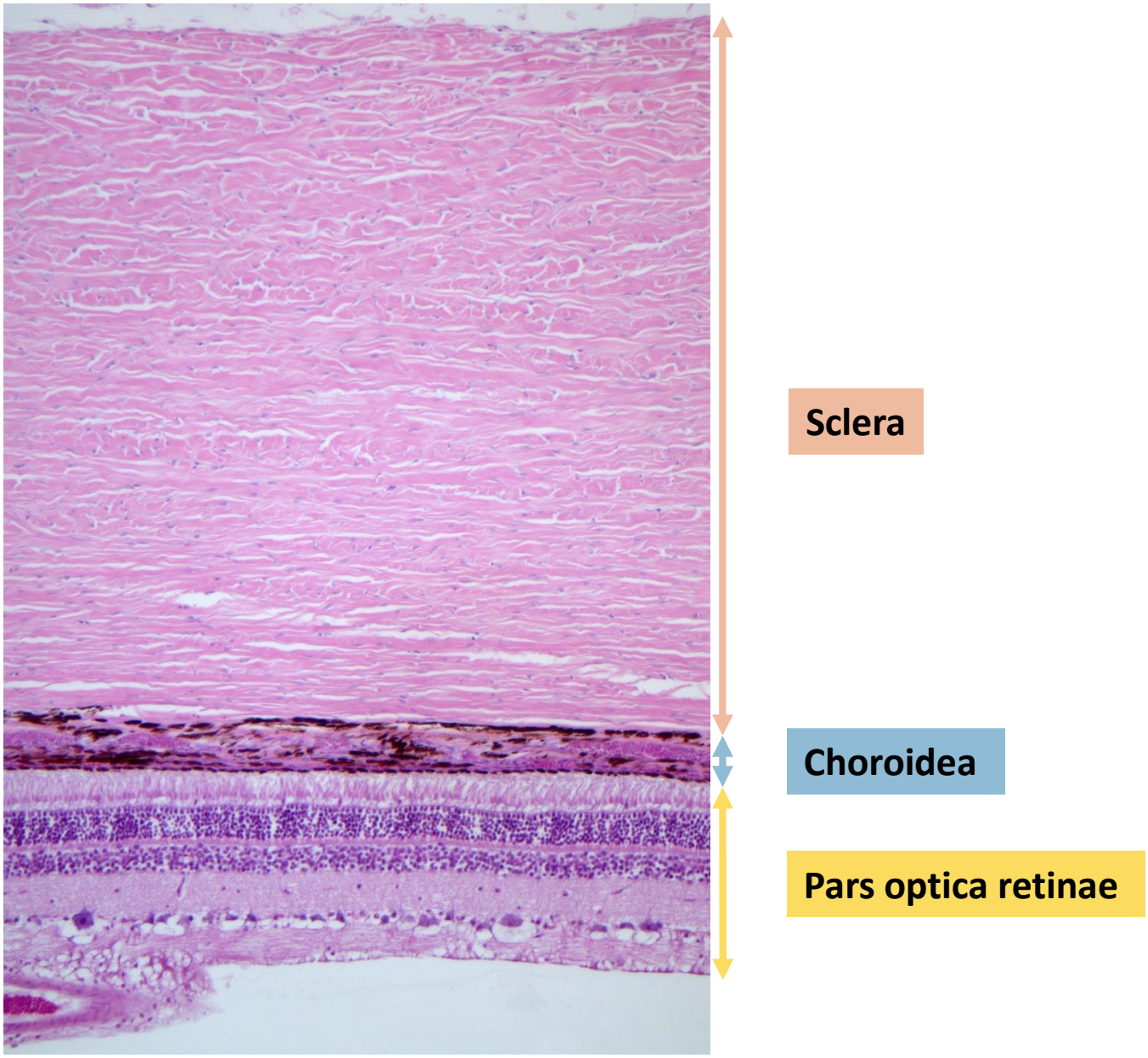


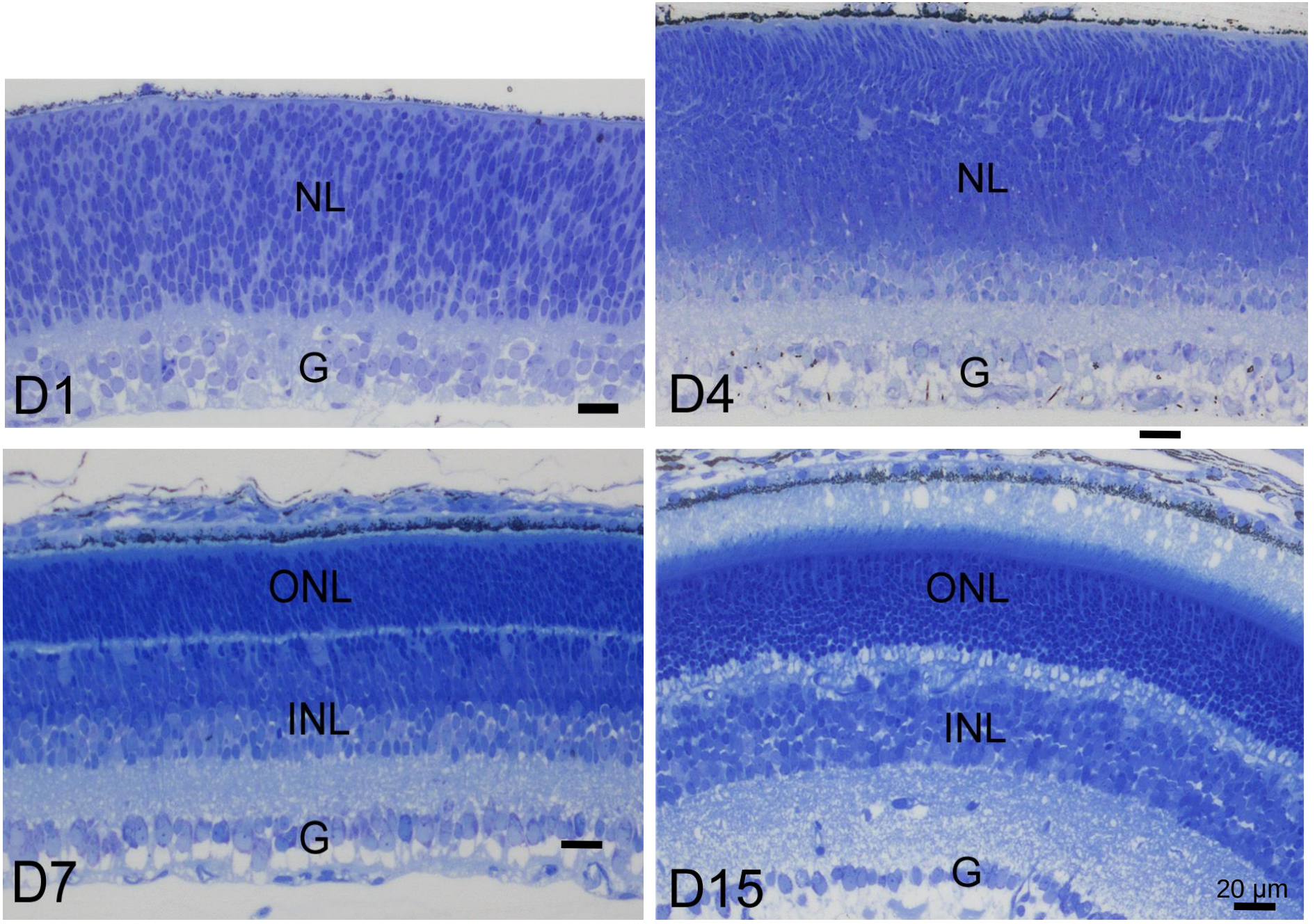

Pigmentepithel
Ventriculus opticus
Stratum nervosum retinae

Pars optica retinae

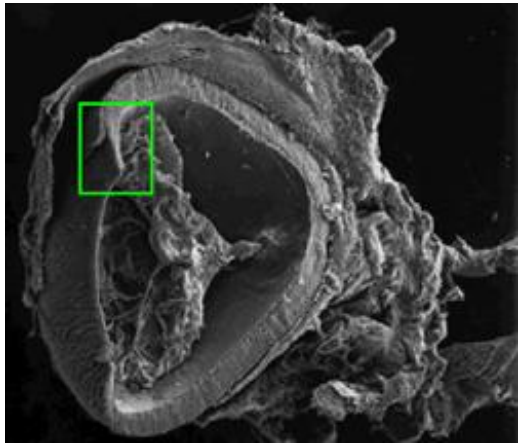


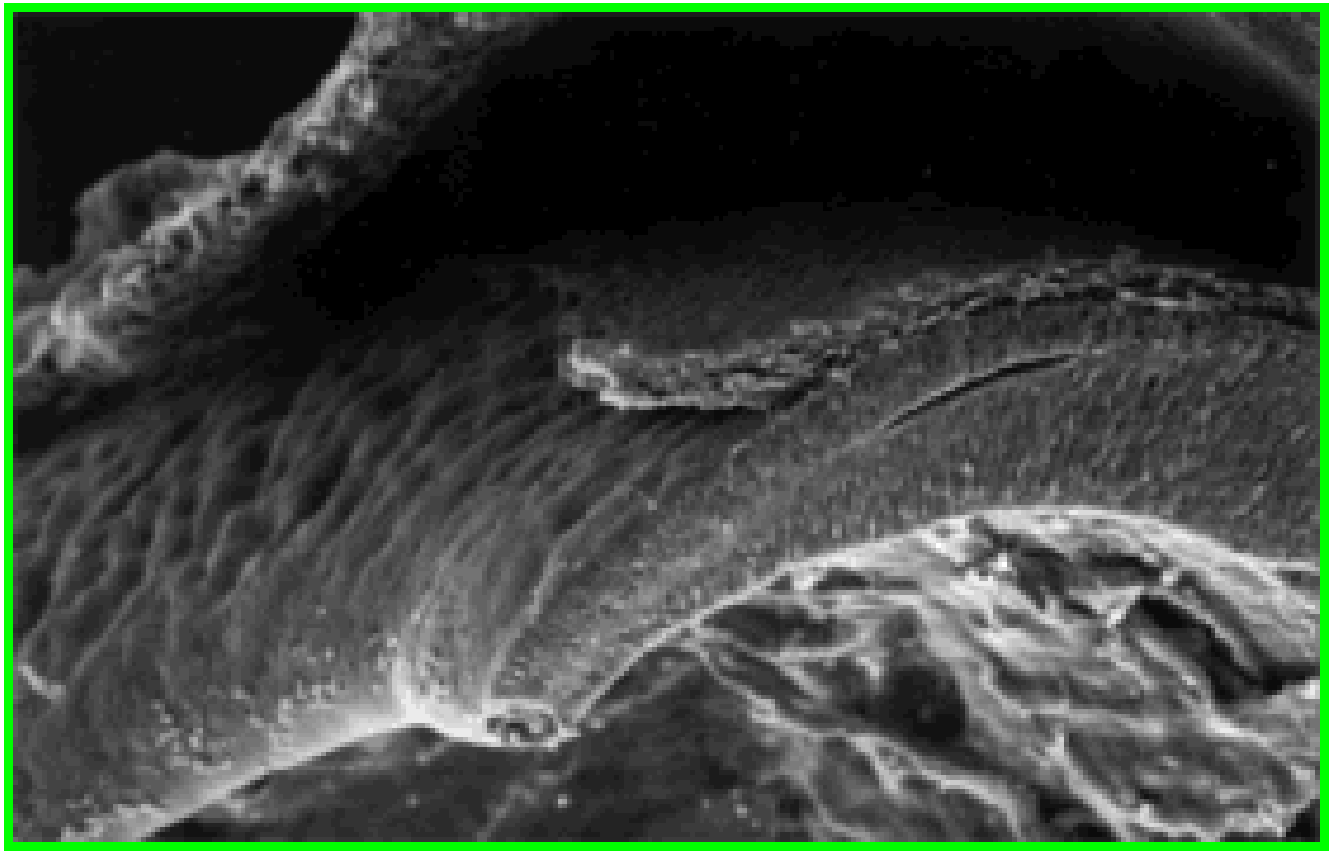
Pars optica retinae

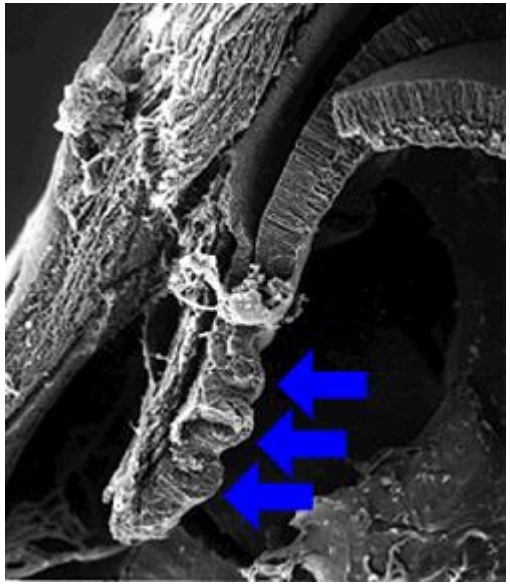




Präparaten von Dr. Ákos Lukáts. Hamster Retina

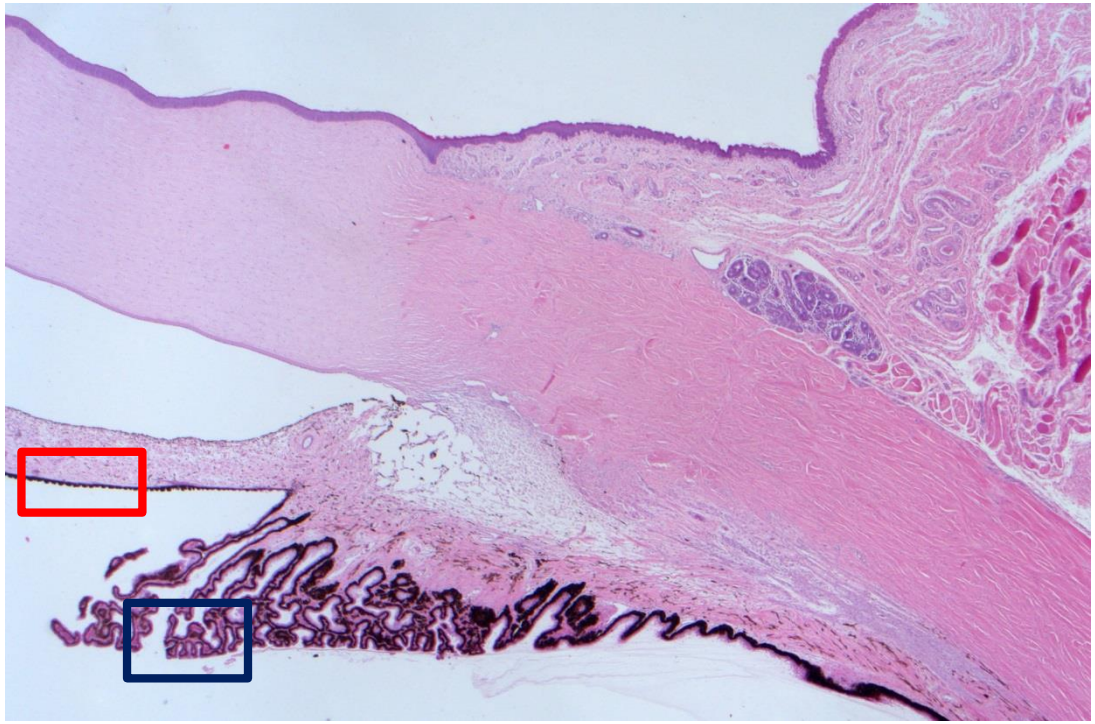




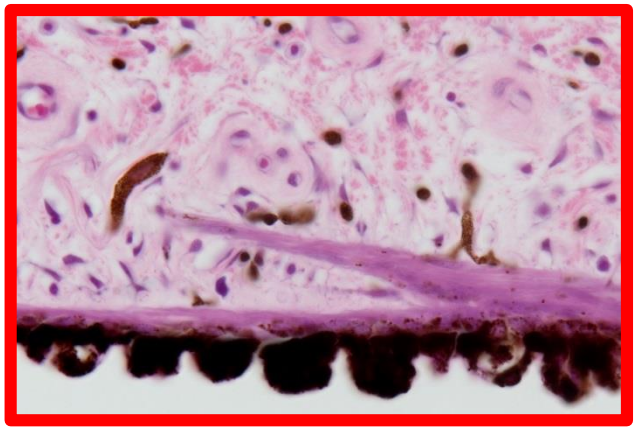


Der Ziliarkörper und die Iris entstehen am Rand des Augenbechers.

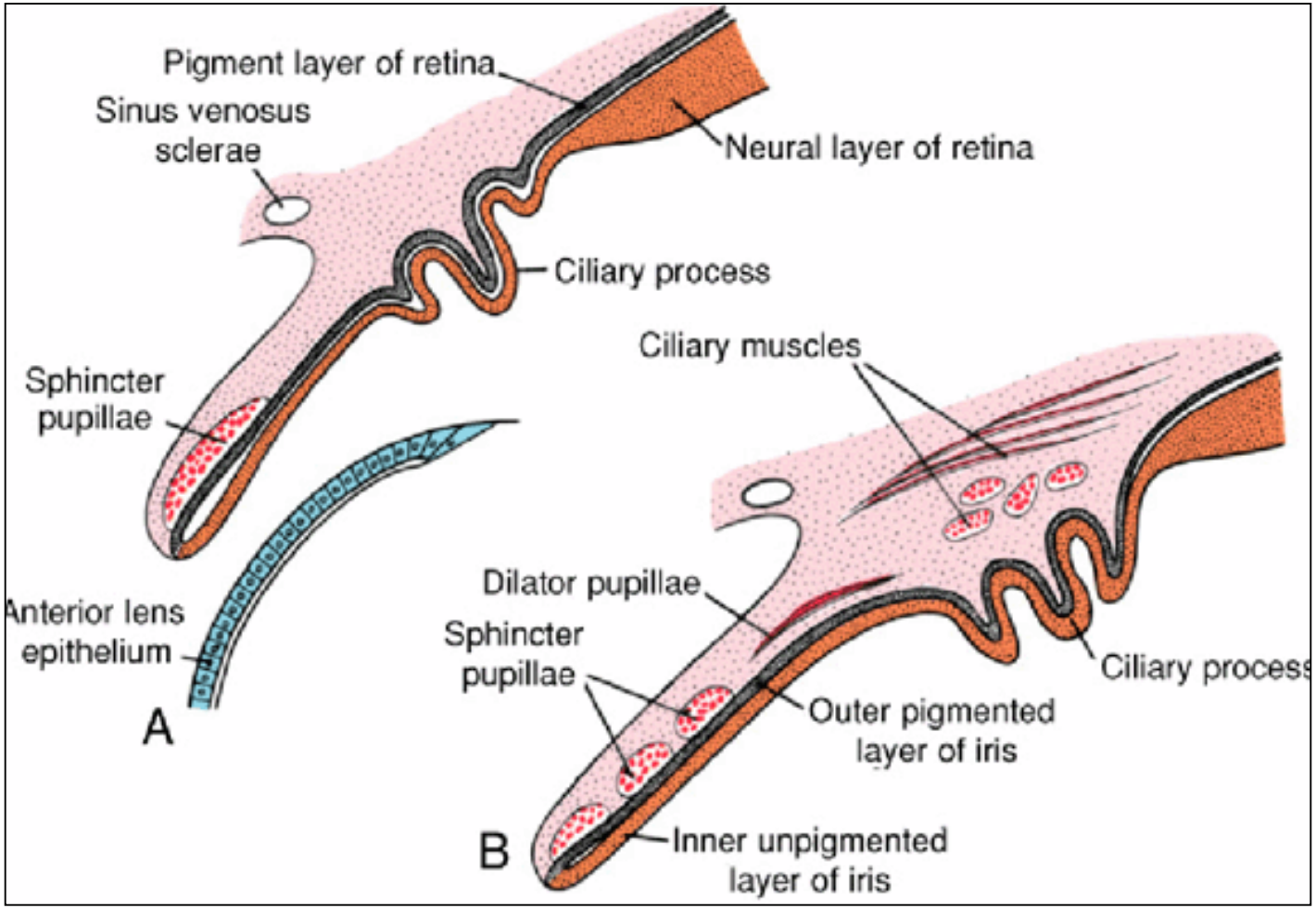
Pars coeca retinae



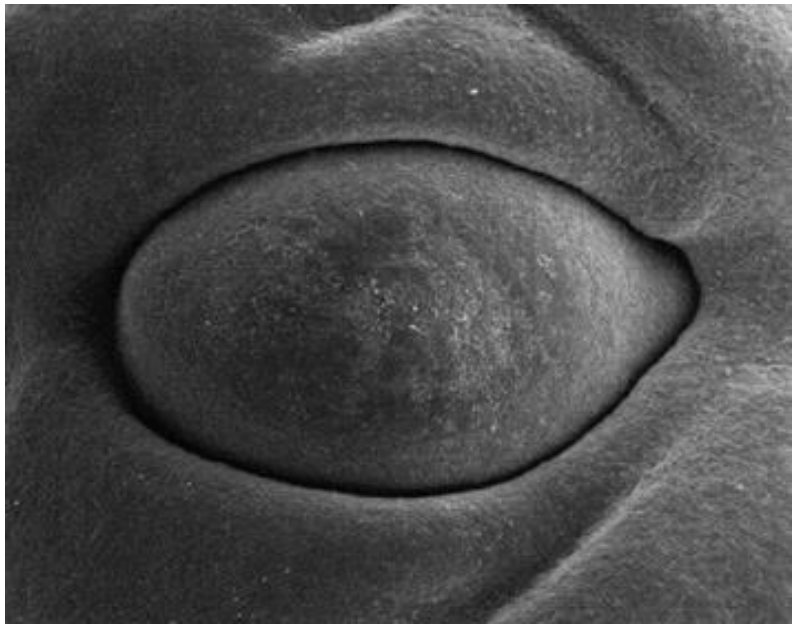
Pars ciliaris retinae

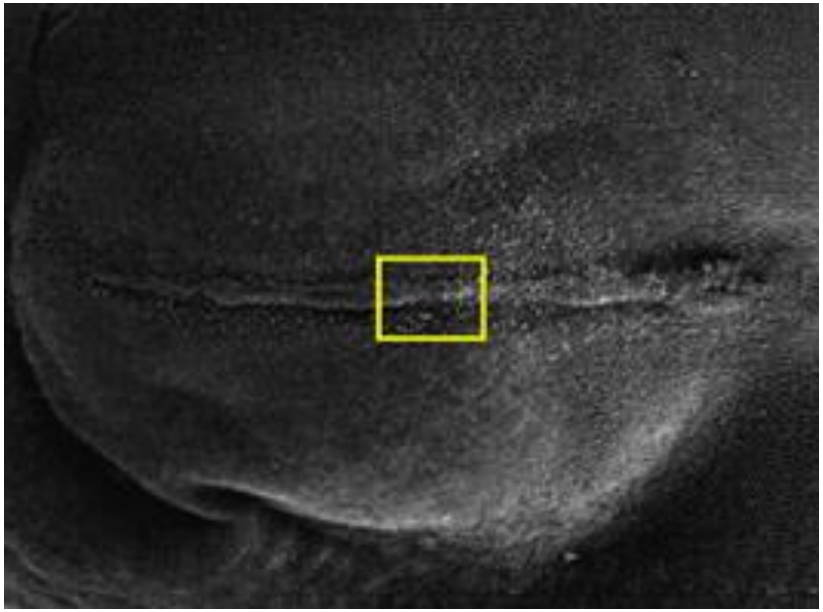


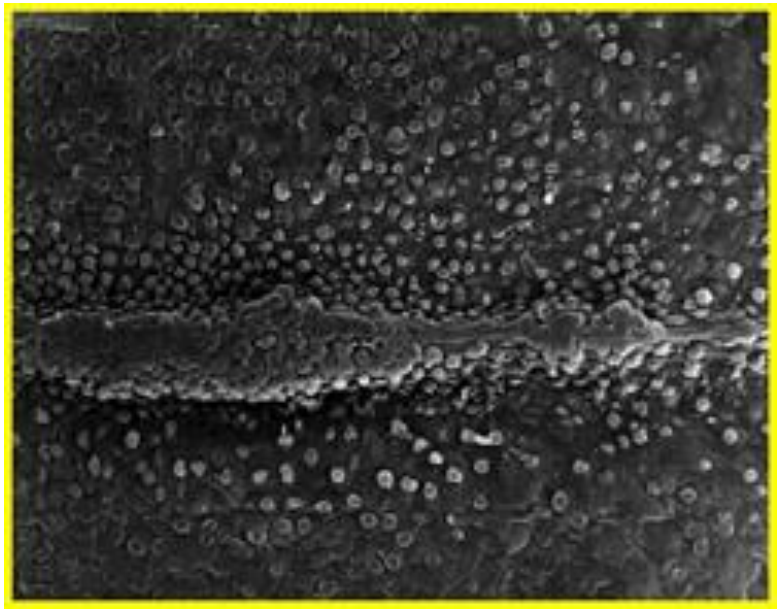
Pars iridica retinae



Der M. sphincter pupillae und der M. ciliaris entstehen aus dem Ectoderm (Plakode und/oder Neuralleiste). Der M. dilatator pupillae entsteht aus dem außeren Blatt des Augenbechers.







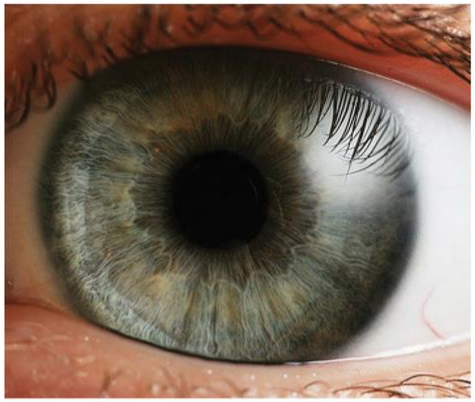
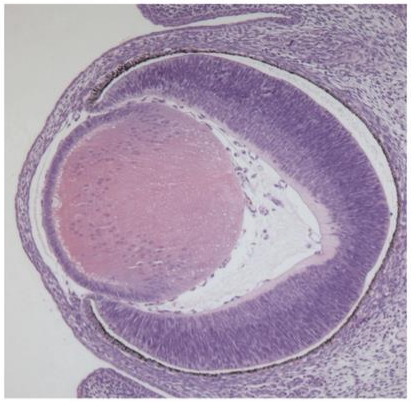
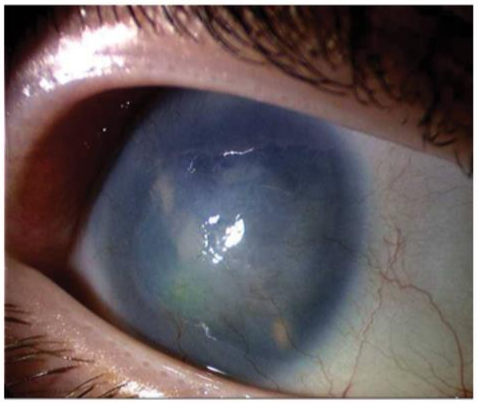
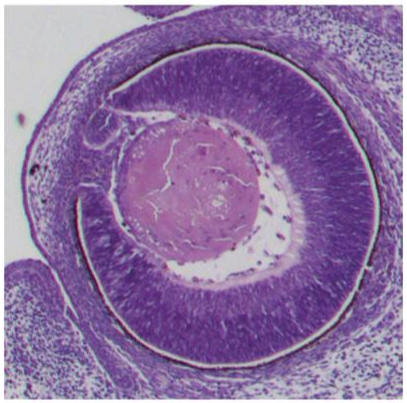
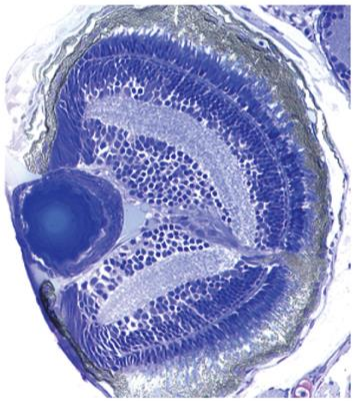
Die Augenlieder und die akzessorischen Sehorgane entstehen in einem späteren Zeitpunkt. Die Augenlieder wachsen am Anfang des zweiten Trimesters zusammen, und lösen sich nur im dritten Trimester voneinander.

Genetische Kontrolle der Augenentwicklung

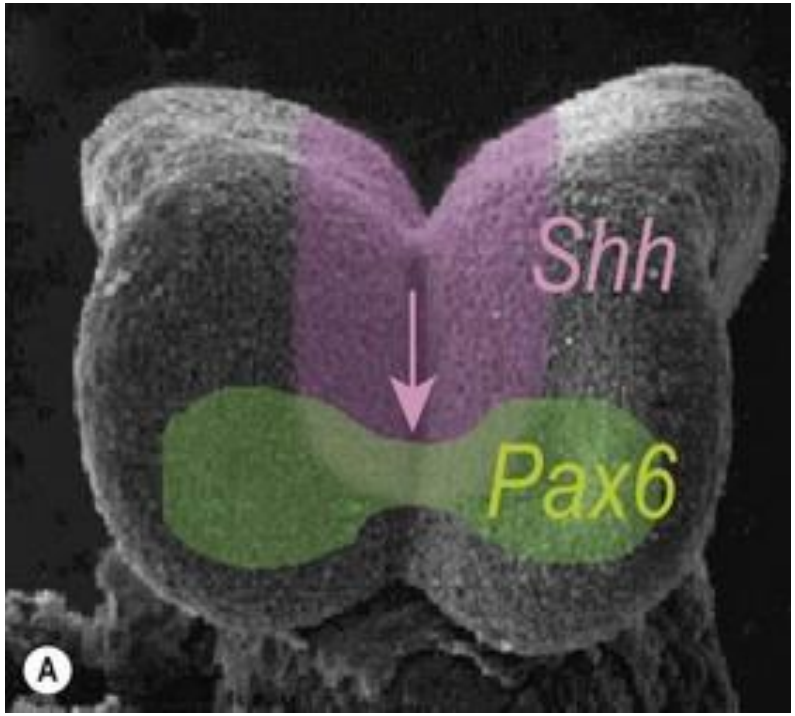
Gene	Role
Eye field, Optic vesicle	
Rx	Transcription factor, mutations result in anophthalmia in humans and mice
Pax6	Transcription factor, loss of function results in microphthalmia and anophthalmia in rodents
Otx2	Transcription factor, loss of function results in missing forebrain, microphthalmia, and cyclopia in mouse
Six6	Transcription factor, regulates proliferation of eye field in frog; haploinsufficiency causes anophthalmia in humans
Six3	Transcription factor, mutations are associated with holoprosencephaly in humans; loss of forebrain when mutated in mouse; overexpression results in ectopic eye formation in zebrafish
Retinoic acid signaling	Vitamin and morphogen, deficiency results in microphthalmia in mouse; vitamin A deficiency might cause developmental eye defects such as coloboma in humans
Shh	Secreted protein, mutations can result in holoprosencephaly and cyclopia in humans and other vertebrates
Neural retina	
Pax6	Transcription factor, required for survival and multipotency of retinal progenitor cells in mouse and chick
Chx10	Transcription factor, regulates progenitor cell differentiation; loss of function causes microphthalmia and congenital cataract in humans and ocular retardation in mouse
Sox2	Transcription factor, mutation causes microphthalmia in humans and mouse; functions to maintain neuronal progenitor identity
Notch	Transmembrane protein, regulates multipotency and proliferation of retinal progenitors
Pigmented epithelium	
Otx2	Transcription factor, required for pigmented epithelium specification and differentiation in vertebrates
Mitf	Transcription factor, required for pigmented epithelium specification and differentiation in vertebrates
Rx3	Transcription factor, required for earliest pigmented epithelium specification in zebrafish

Lens	
Six3	Transcription factor, sufficient and required for lens formation in mouse
Pax6	Transcription factor, expression in lens ectoderm is required for lens induction in mouse
FoxE3	Transcription factor, mutations cause anterior segment dysgenesis in humans and lens defects in "Dysgenetic lens" mice
Fgf pathway	Secreted protein, required for lens induction and differentiation
Pitx3	Transcription factor, recessive mutation in mouse ("Aphakia") results in absence of lens and microphthalmia
Prox1	Transcription factor, required for lens fiber differentiation in mouse

Pax6

	Human	Mouse	Zebrafish	*Drosophila*
WT				
mut				
	***PAX6*$^{+/-}$**	***Pax6*$^{-/-}$**	***pax6b*$^{-/-}$**	***ey*$^{-/-}$**
EQs	cornea opaque iris absent retina degenerate lens opaque aqueous humor of eyeball increased pressure	eye decreased size lens fused_to cornea iris morphology anterior chamber absent	eye decreased size lens decreased size retina malformed	eye absent

Cyclopia – Mutation von Shh



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