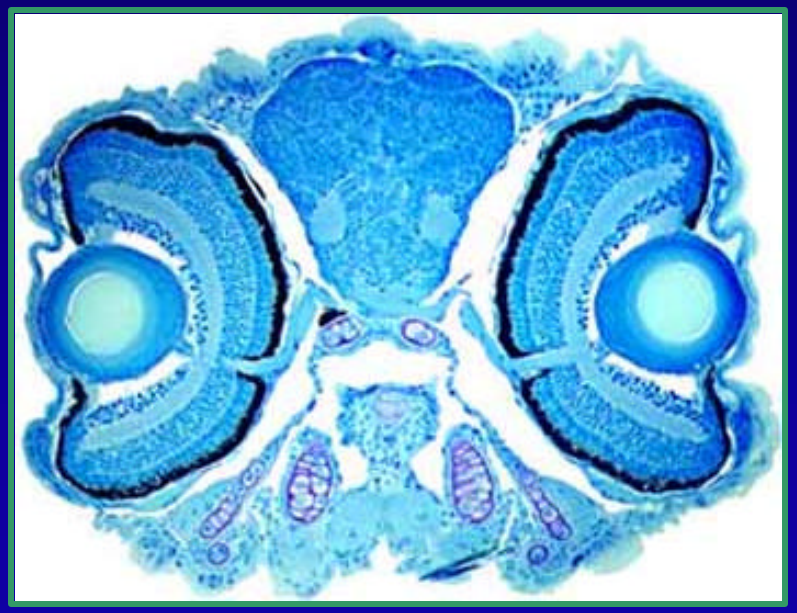
Embryology of the Eye and Visual Pathways—Anatomy and General Organization



http://www.eb.tuebingen.mpg.de/eye-screen/

Patrick O'Connor, Ph.D.
Department of Biomedical Sciences
Ohio University College of Osteopathic Medicine
Athens, Ohio
45701
oconnorp@ohiou.edu

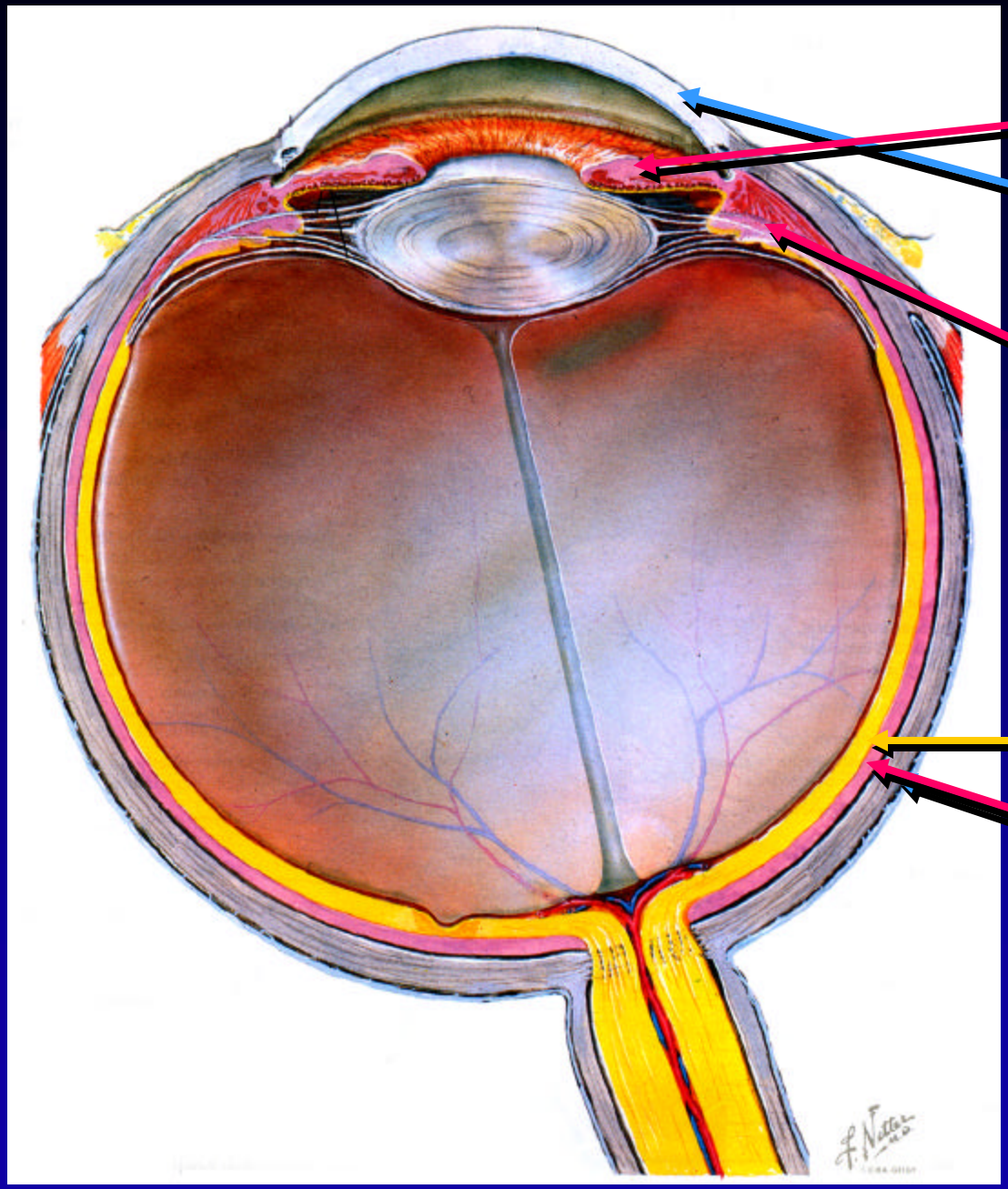
OUTLINE—Wednesday April 16, 2003

Embryology of the eye

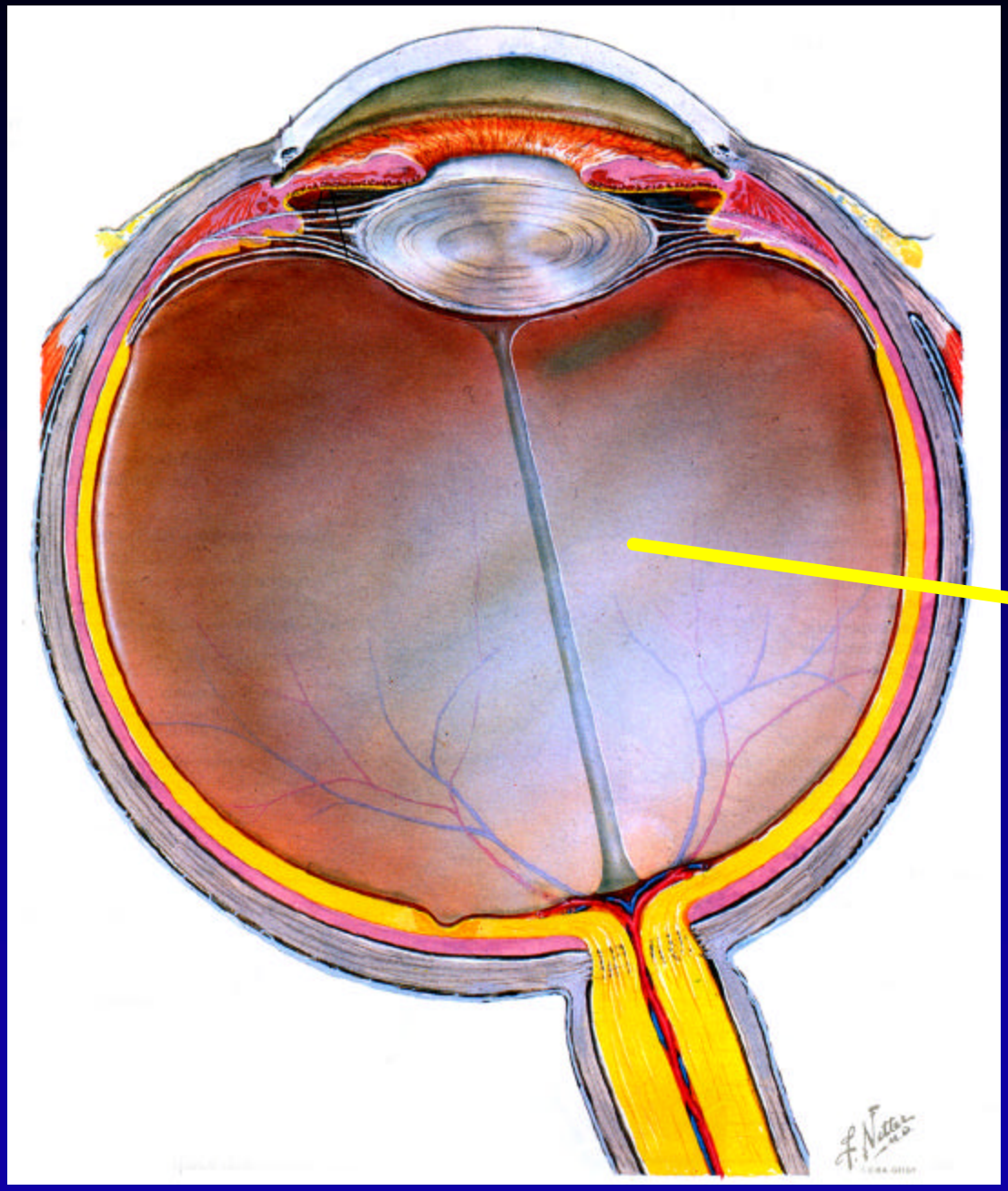
Extraocular muscles

Visual reflexes

- **Pupillary Light Reflex**
- **Near Reflex**



Modified from Netter, 1989



Vitreous Body

CHAMBERS

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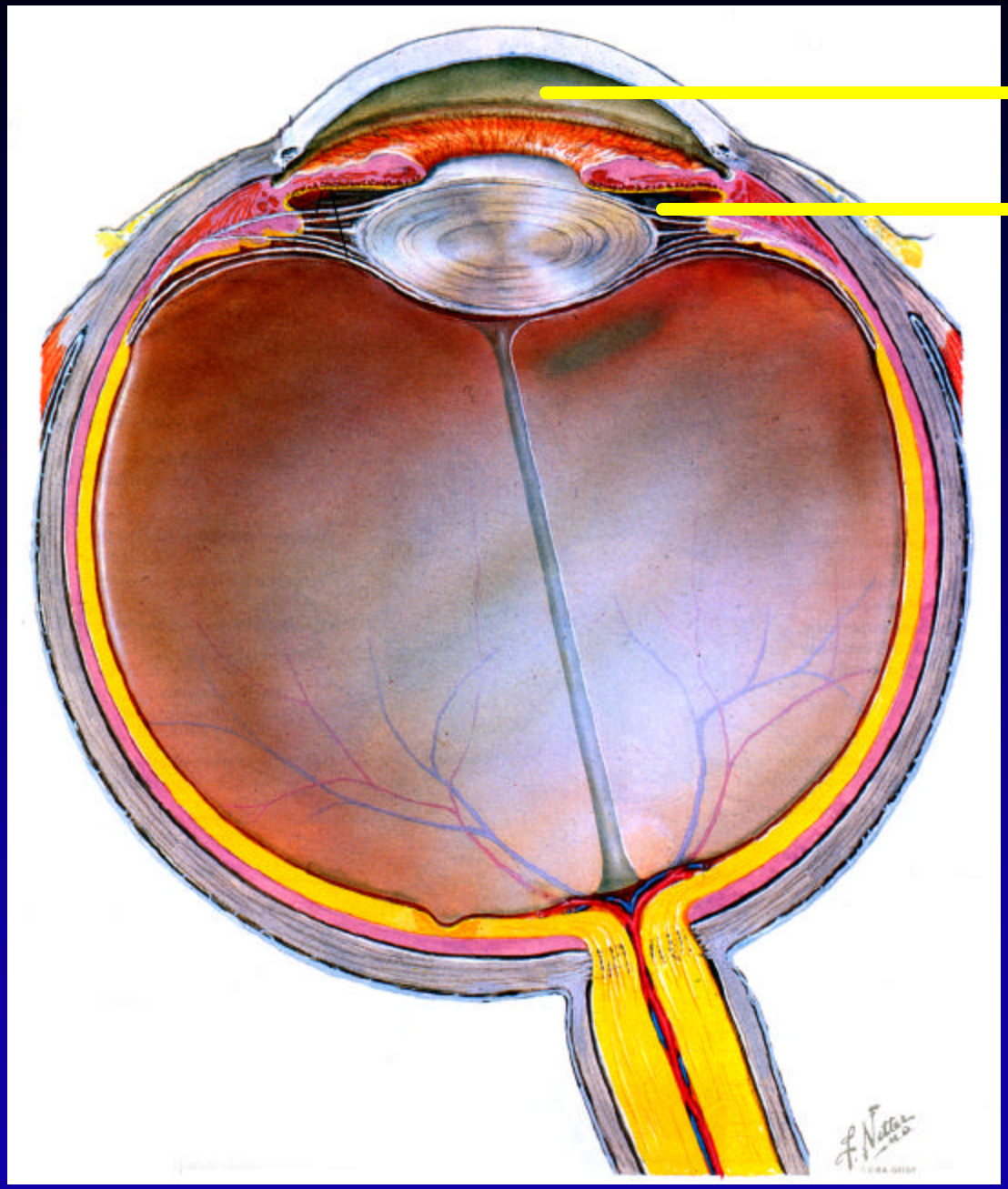

1—Anterior Chamber

2—Posterior Chamber

“Aqueous Chamber”

CHAMBERS

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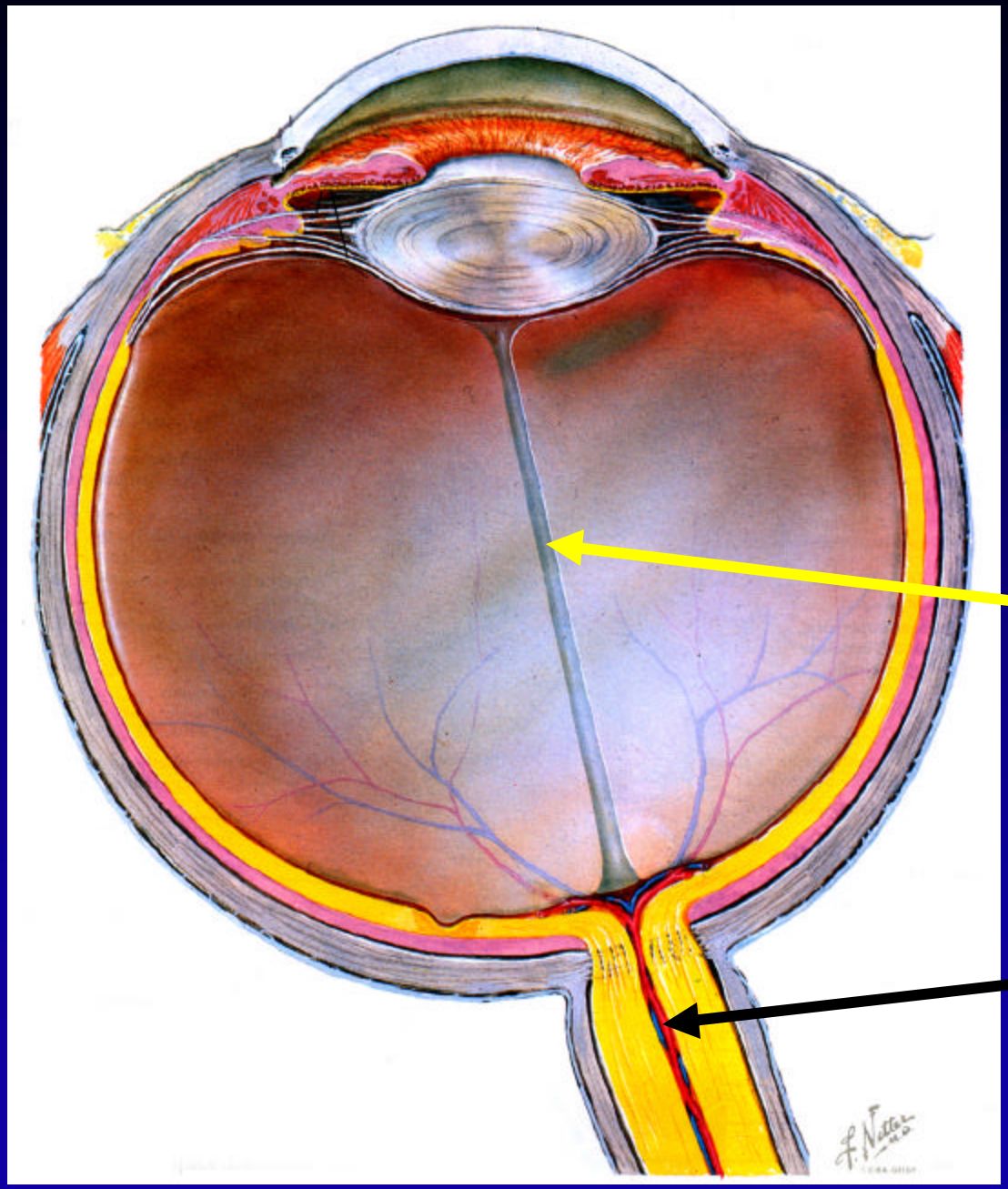


Hyaloid Canal

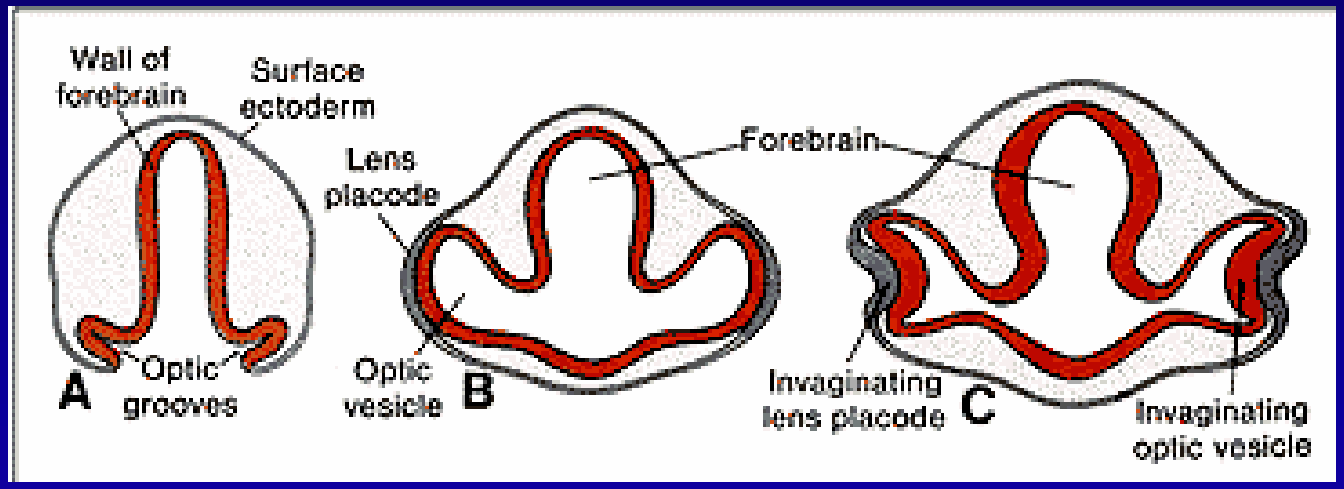
Central Vessels of Retina

Modified from Netter, 1989

Development of the Eye

I. First noticeable ~ 22days

optic grooves—developing neural tube

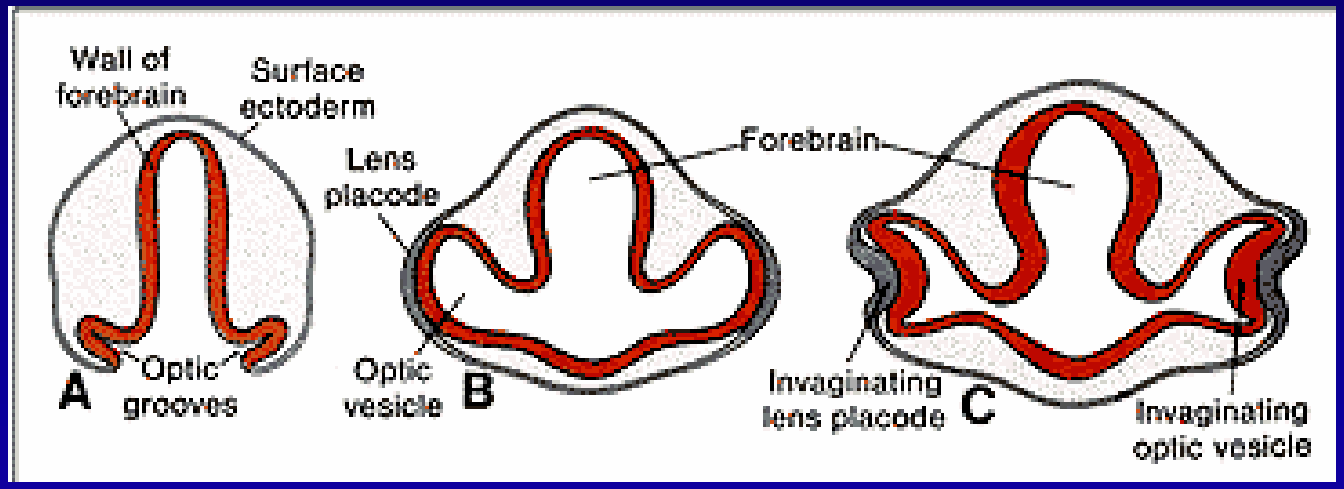


Moore and Persaud, 1998

Development of the Eye

II. As neural folds fuse (= forebrain formation)

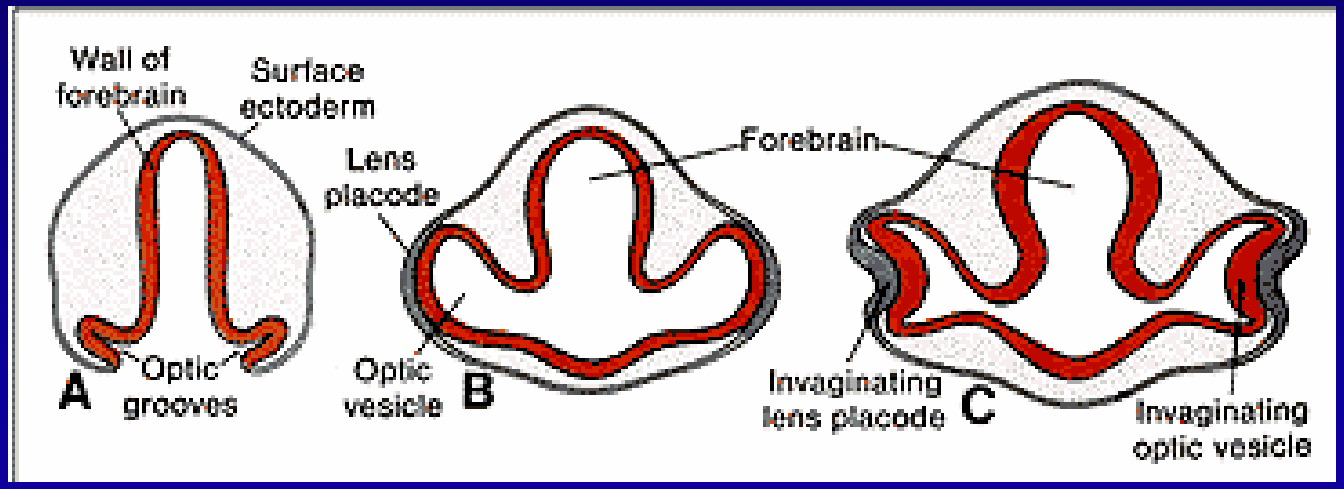
optic vesicles—evaginations of forebrain



Moore and Persaud, 1998

Development of the Eye

IIIa. Induction of lens placode (surface ectoderm)
IIIb. Formation of optic stalk and optic cup from optic vesicle



Moore and Persaud, 1998

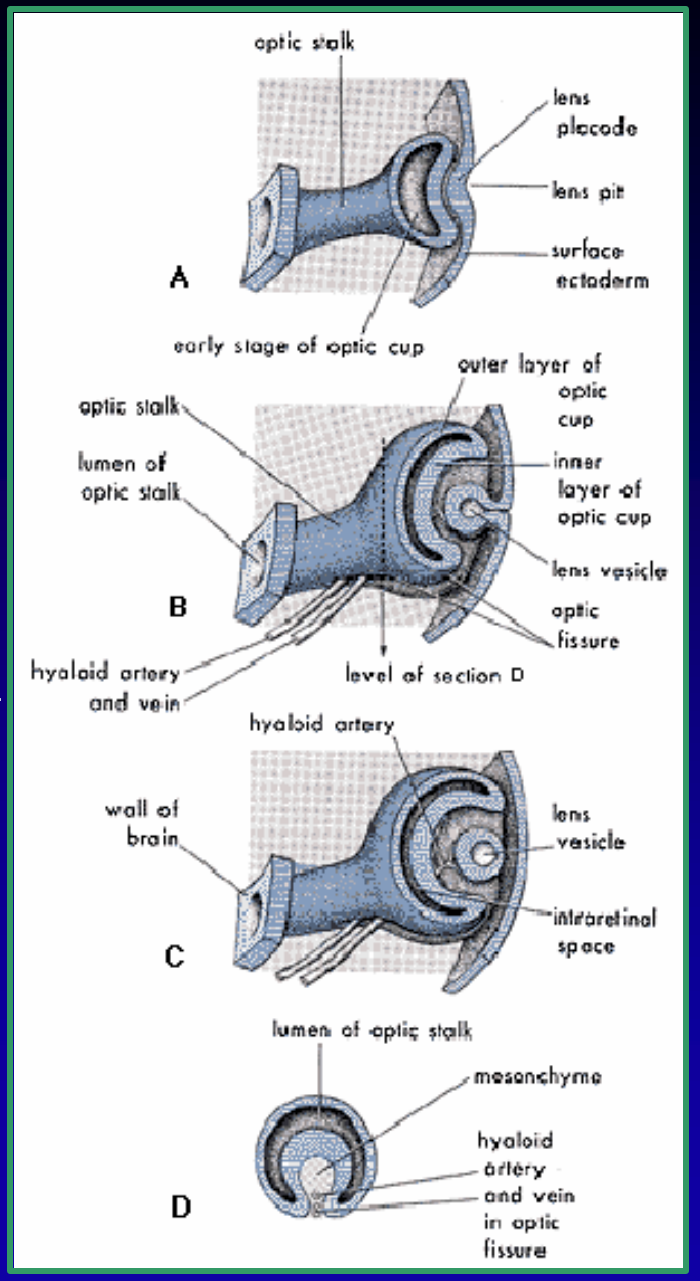
Continued development of optic cup and lens

Optic cup — invagination of distal optic vesicle to form double-walled "cup"

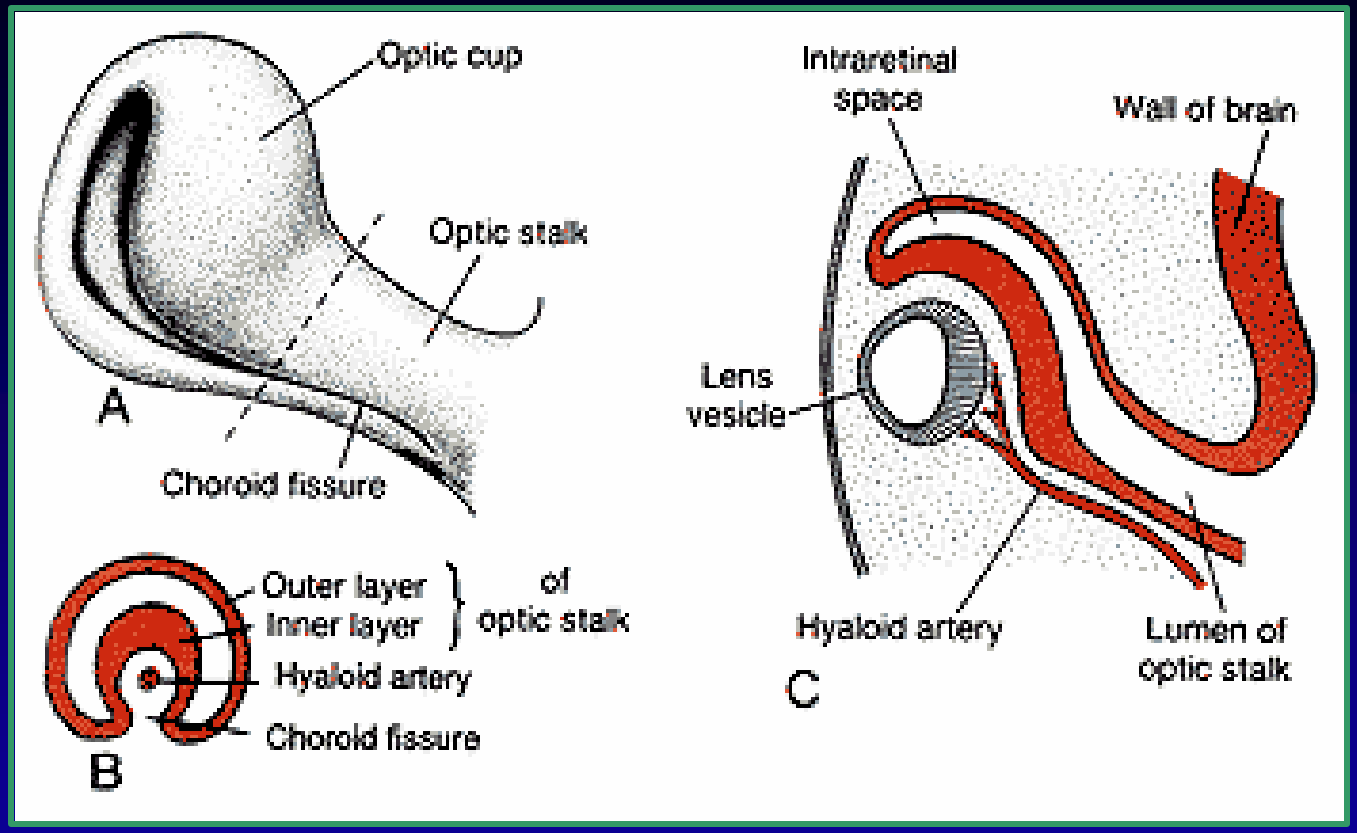
Optic (choroid) fissure —sulcus on ventral aspect optic cup/stalk (allows passage of vasculature to lens & layers of cup)

Lens placode — ectodermal thickening

Lens pit— invaginates to form lens vesicle



Moore and Persaud, 1998



Moore and Persaud, 1998

Development of the retina

outer & inner portions of the optic cup

Closure of choroid fissure ~ 6-7 weeks

Optic Cup

Inner layer — neuroepithelium
"neural retina"

Outer layer— retinal pigment epithelium

Intraretinal space

Moore and Persaud, 1998

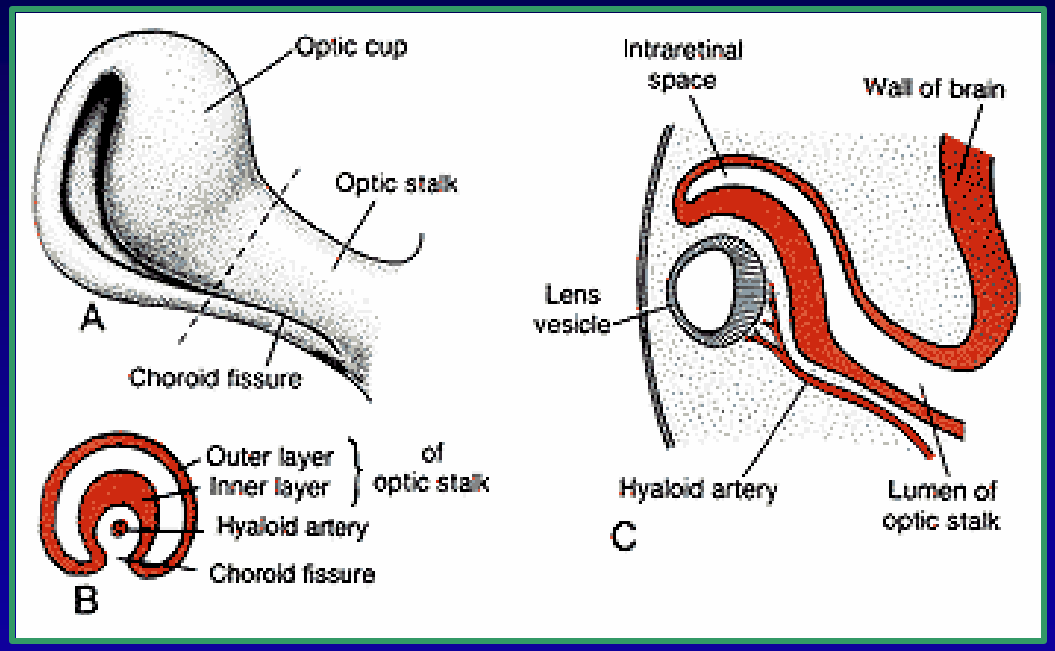
Cavity of optic stalk “filled” with axons of optic nerve

“Fusion” of inner and outer portions of the optic cup

Moore and Persaud, 1998

Lens Development

lens placode in surface ectoderm
invaginates as lens vesicle
supplied by hyaloid artery



Moore and Persaud, 1998

Aphakia —absence of the lens (extremely rare)
Congenital cataracts—(e.g., rubella virus)
Congenital galactosemia—cataract formation within 2-3 weeks of birth (galactose accumulation)

Development of Ciliary Body and Iris

—both develop from anterior portions of the optic cup and surrounding mesenchyme

Ciliary muscle —smooth muscle derived from mesenchyme near the margin of the optic cup

—"effects" accommodation reflex

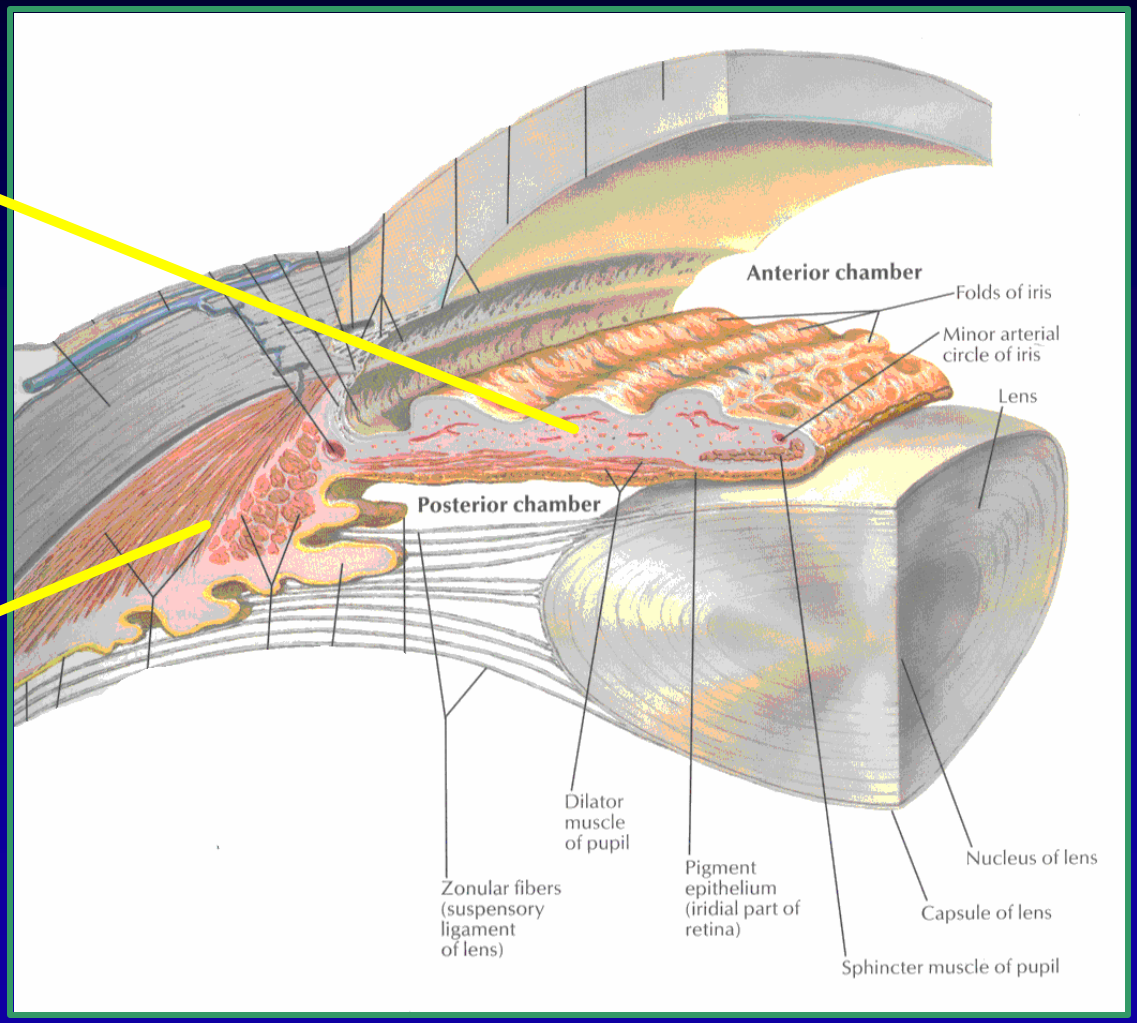
Iridial muscles —dilator and sphincter pupillae mm.

Smooth muscles derived from neuroectoderm of the optic cup

—control size of pupillary aperture

Iris

Ciliary Body



Modified from Netter, 1989

Some Ocular Anomalies

Retinal detachment—between inner and outer portions of the optic cup derivatives

- **congenital—failure of fusion**
- **acquired—trauma**

Defects in closure of optic (choroid) fissure

- **retinal coloboma**
- **iridial coloboma**

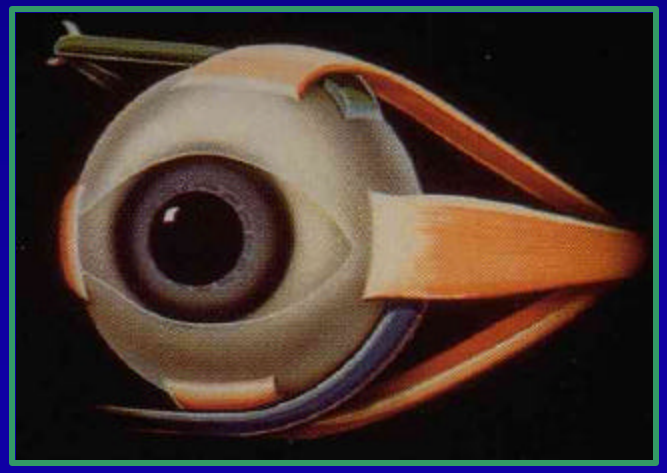
Aniridia — (rare) 1 in 75,000

Extraocular Muscles

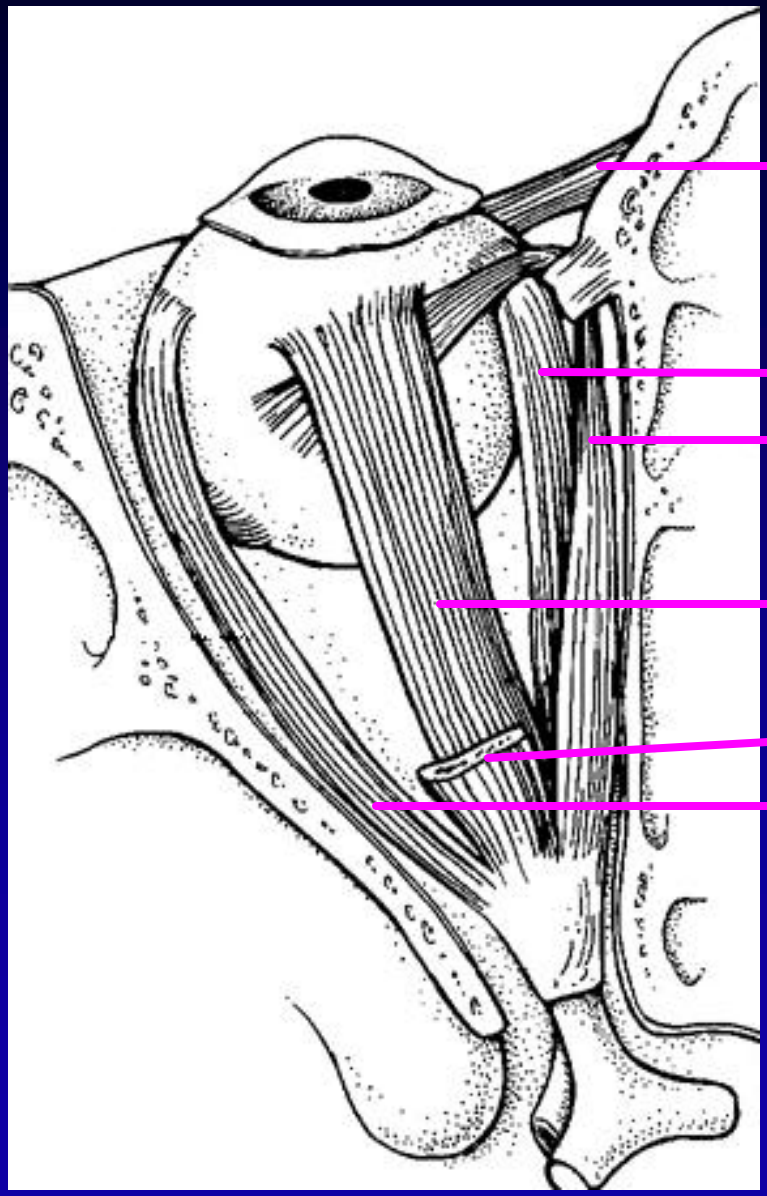
Develop from somitomeres I-IV (paraxial mesoderm cranial to the occipital somites)

Innervated via CN III, IV, & VI

Coordinate movements between the two eyes (usually conjugate, although some instances of physiological vergence exist)



Extraocular mm.



Inferior oblique

Medial rectus

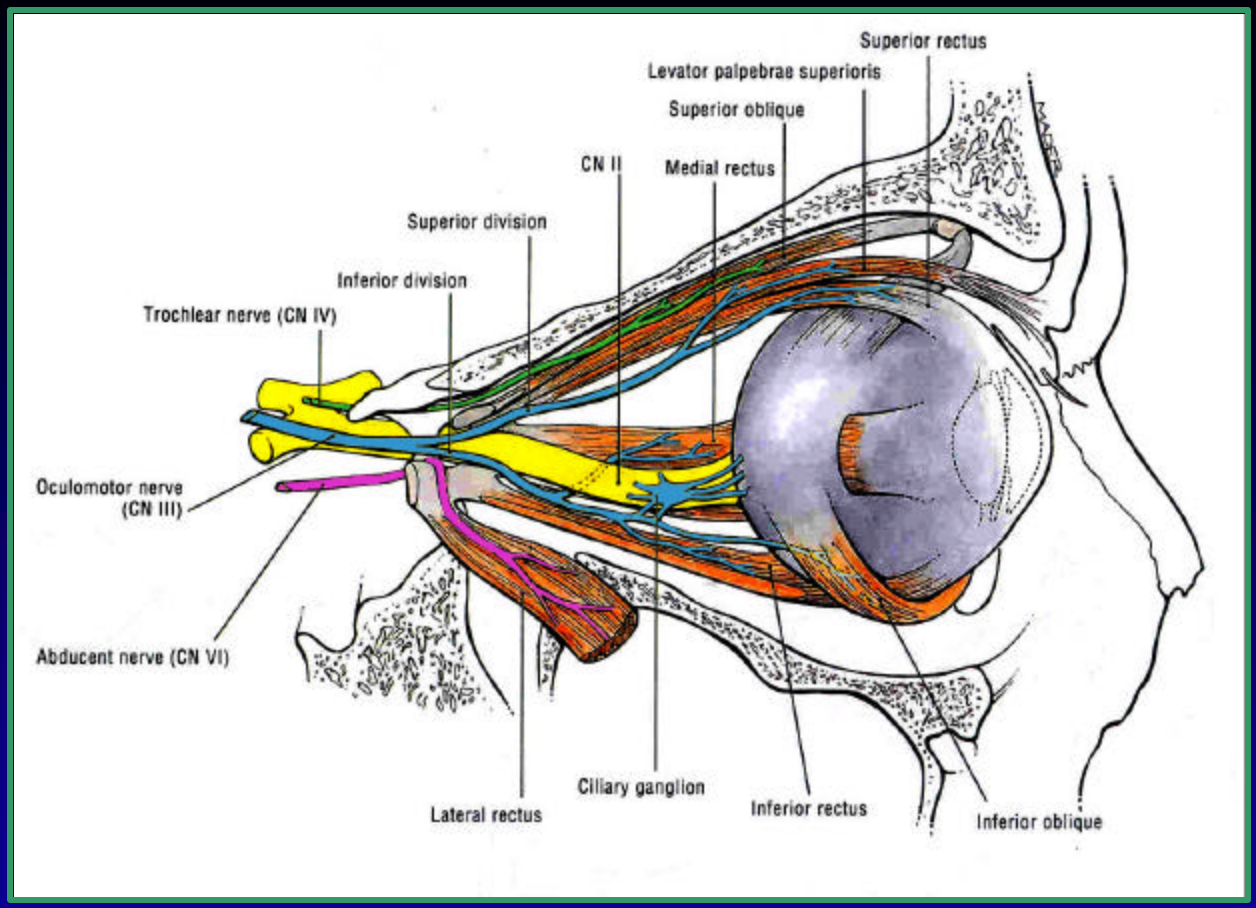
Superior oblique

Superior rectus

Levator palpebrae sup.

Lateral rectus

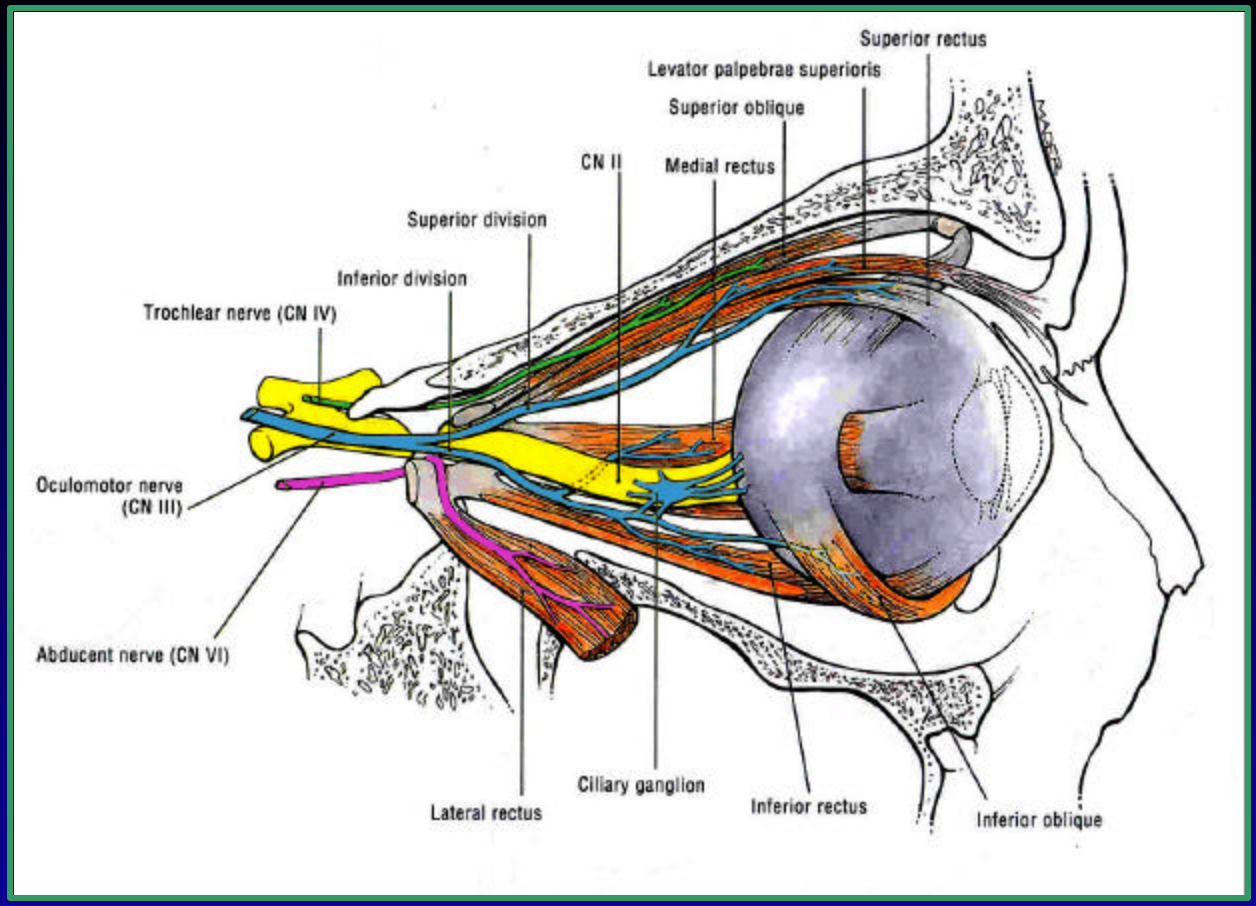
Inferior rectus
(not shown)



Oculomotor Nerve (CN III)

Somatic motor (oculomotor nucleus):
Sup. rectus, Inf. rectus, Med. rectus, Inferior oblique & Levator palpebrae superior mm.

Parasympathetic (Edinger-Westphal nucleus):
Ciliary m. & Constrictor pupillae m.



Trochlear Nerve (CN VI)

Somatic motor only (trochlear nucleus):

- **Superior oblique m.**

Abducens Nerve (CN VI)

Somatic motor only (abducens nucleus):

- **Lateral rectus m.**

Extraocular Muscle Anomalies (congenital)

Agenesis (single muscle usually)

Anomalous Attachments
- misplaced
- additional attachments

Adherence & Fibrosis Syndromes

**Failure to align visual axes (strabismus), thus potentially resulting in diplopia (double-vision)

Amblyopia—reduced/absent visual ability in one eye
- "lazy" eye

VISUAL REFLEXES

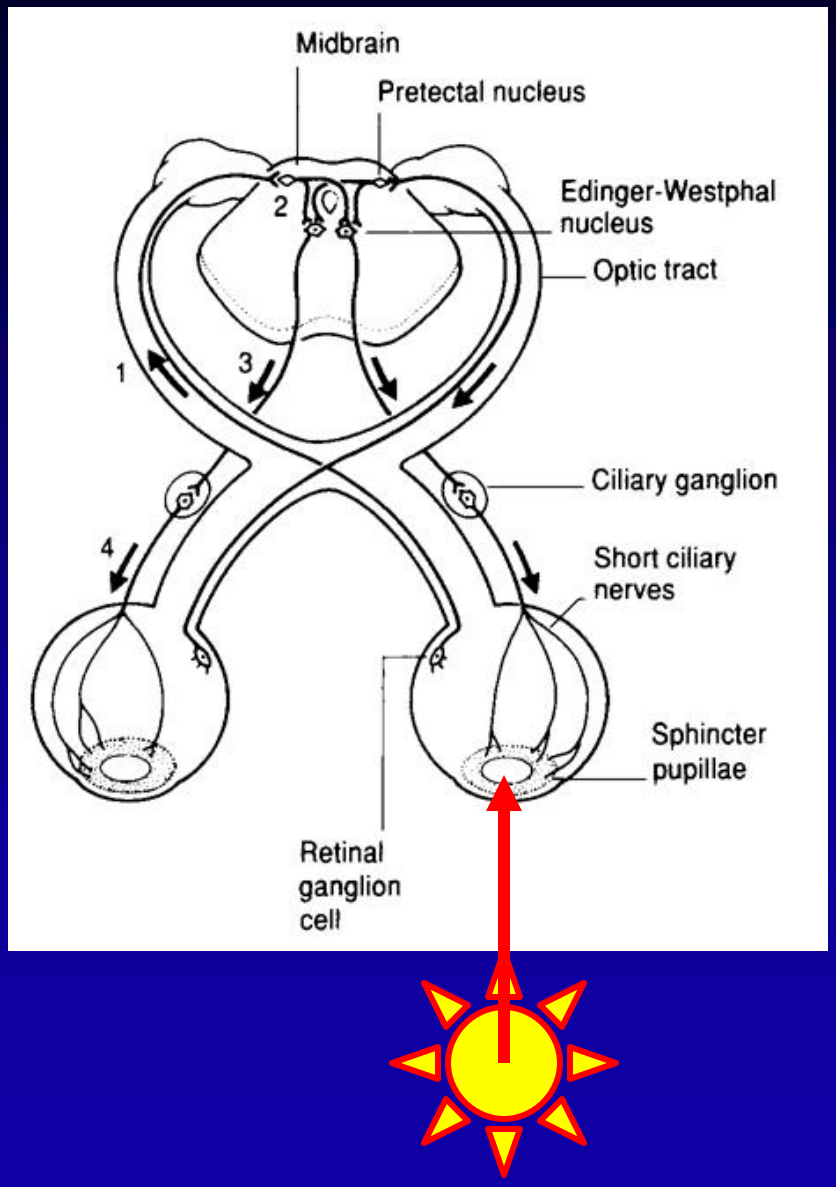
Pupillary Light Reflexes: 30wks gestation

- Constriction (parasympathetic)
- Dilation (sympathetic)

Accommodation (4 months = well developed)

(The Near Reflex)

PUPILLARY CONSTRICTION (PARASYMPATHETIC)

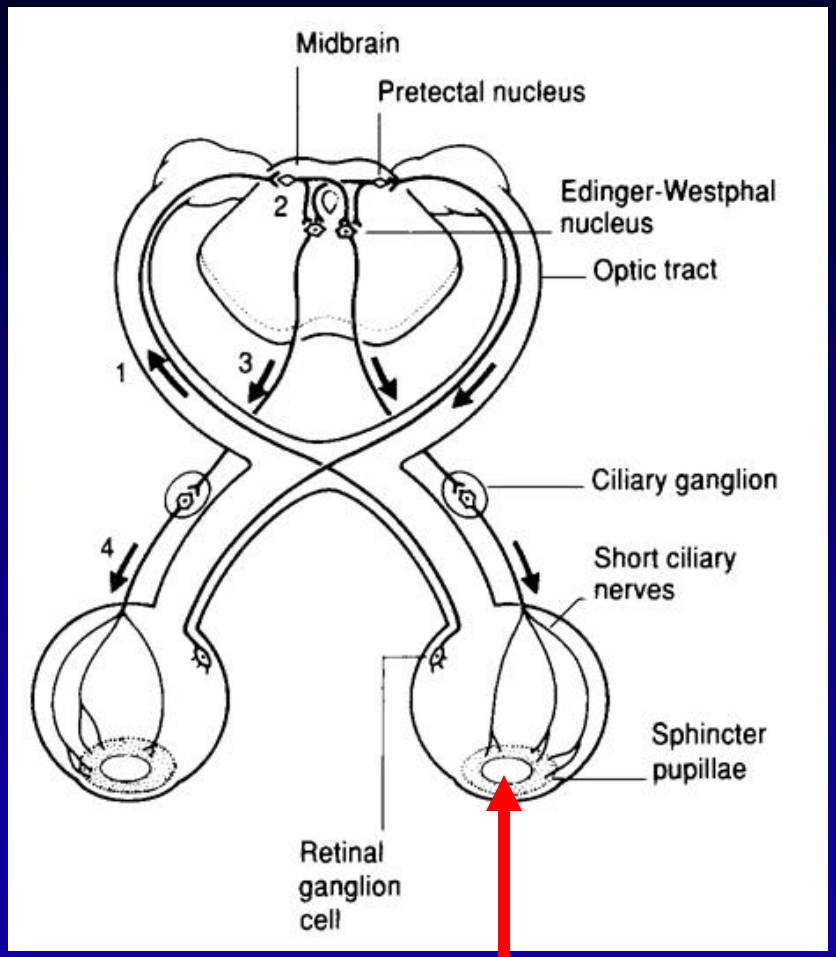


Pretectal nuclei project <u>bilaterally</u> to E-W nuclei

<u>Responses</u>:

- Direct (ipsilateral to stimulus)
- Consensual (contralateral) due to bilateral projection from pretectal nuclei to Edinger-Westphal nuclei

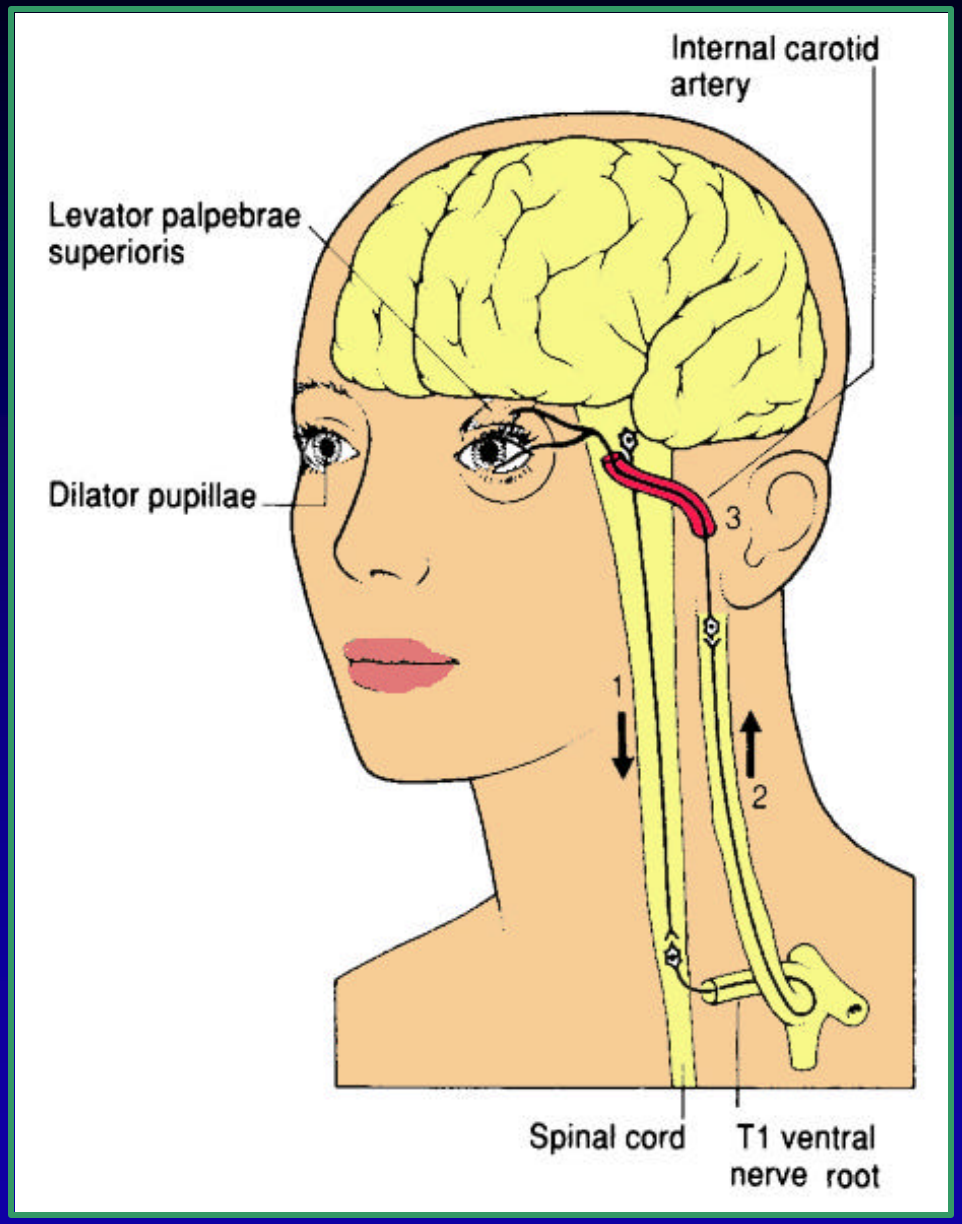
Where is the lesion?



Consensual response in left eye

No direct response in right eye

PUPILLARY DILATION (SYMPATHETIC)



3-neuron chain:

- Hypothalamus to spinal cord (T1-2)
- Spinal cord to superior cervical ganglion (preganglionic)
- Superior cervical ganglion to dilator pupillae m. (postganglionic)

Focusing on a Near Object

1. Accommodation (parasympathetic)

- Oculomotor efferent axons from Edinger-Westphal nucleus signal ciliary m. to contract
- Reduce tension of suspensory ligaments of lens
- Curvature of lens increases

(well-developed @ 4 months)

Focusing on a Near Object

2. Convergence of optic axes (somatic motor)

- Oculomotor nucleus signals both medial rectus mm. to contract (disjunct eye movements)

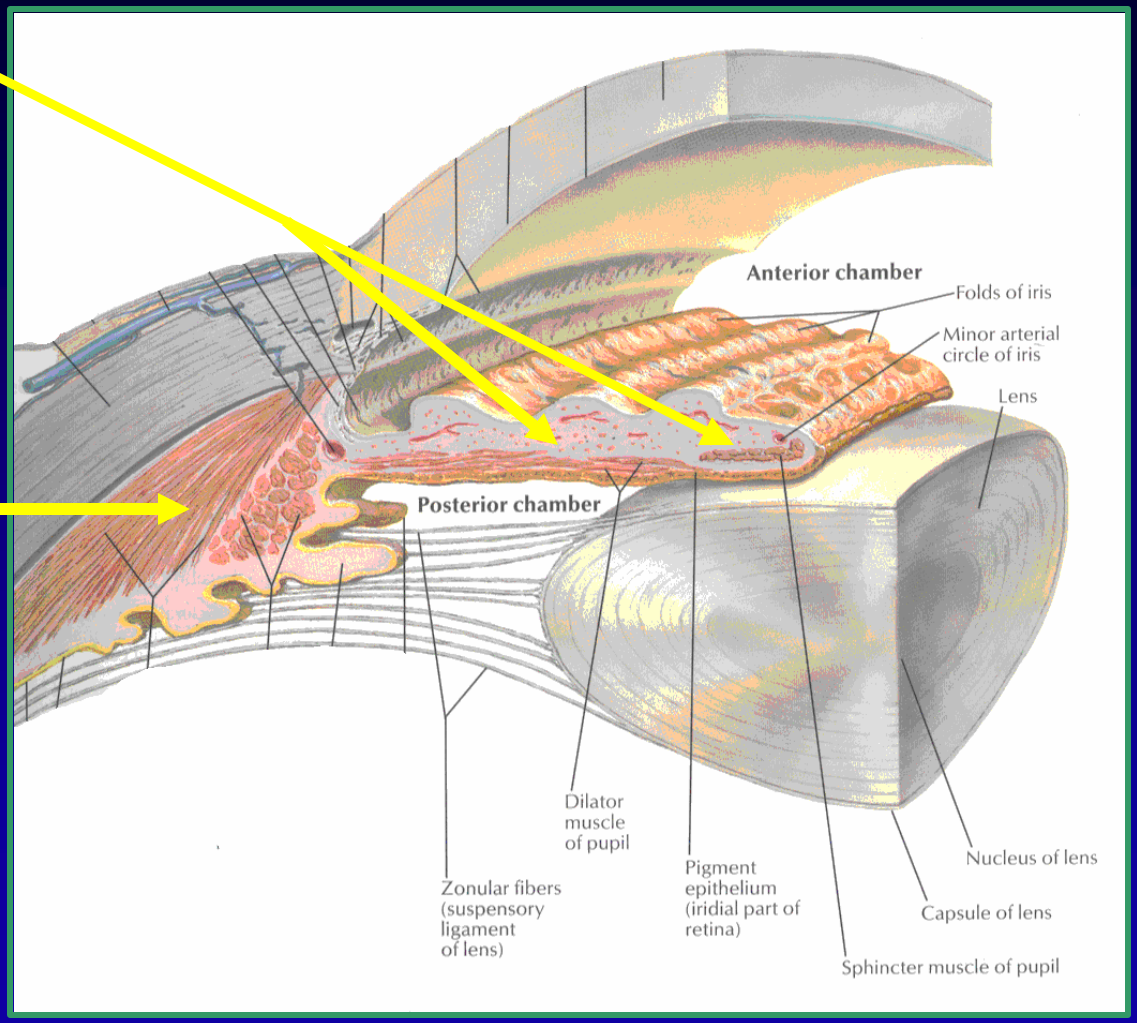
3. Pupillary constriction (parasympathetic)

- Oculomotor efferent axons from Edinger-Westphal nucleus signal sphincter pupillae m. to contract
- Small pupil sharpens image on retina and reduces light intensity

(well-developed at 4 months)

Iridial Muscles

Ciliary Muscle



Modified from Netter, 1989

Visual Developmental “Milestones”

Pupillary Light Reaction—30 wks gestation
(CN II/symp/parasymp integration)

Lid closure in response to bright light—30 wks gest.
(CN II—CN VII reflex)

Blink response to visual threat—2-5months
(CN II—CN VII reflex)

Visual Fixation—birth (well dev=6-9wks)

Visual Following—3 months

Accommodation—4 months

Resources

The Developing Human—6th Edition
K. L. Moore & T. V. N. Persaud – 1998

The Essentials—Walsh & Hoyt's Clinical Neuro-Ophthalmology—5th Edition
Editors—N.R. Miller and N.J. Newman—1999

Neuro-ophthalmology—3rd Edition
Editor—J.S. Glaser—1999