بسم الله الرحمن الرحيم

BASIC ANATOMY AND PHYSIOLOGY

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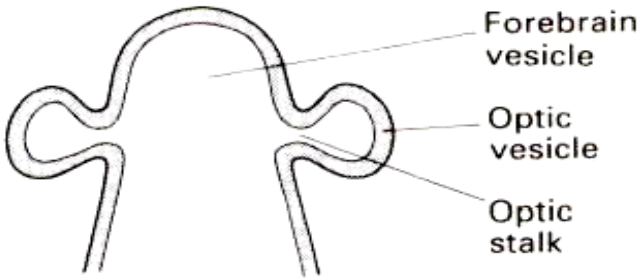
ANATOMY

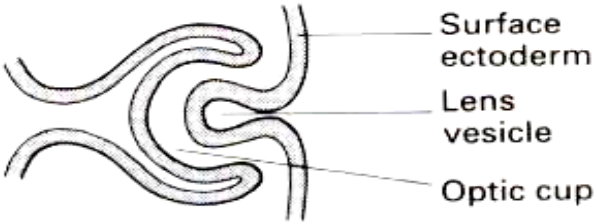
EMBRYOLOGY OF THE EYE

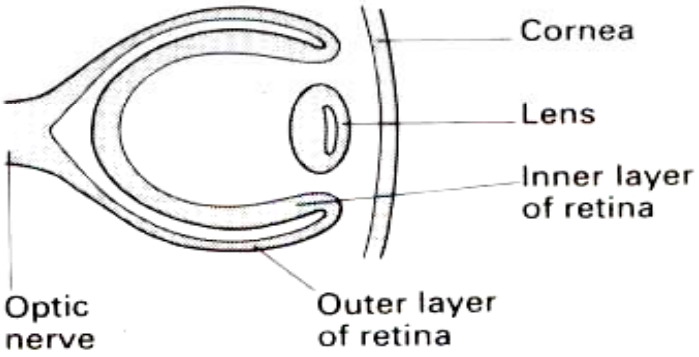
- This highly specialized sensory organ is derived from neural ectoderm, mesoderm and surface ectoderm.
- The eye is essentially an outgrowth from the brain (neural ectoderm).
- Started as ***Optic vesicle*** connected to the forebrain by ***Optic stalk***.

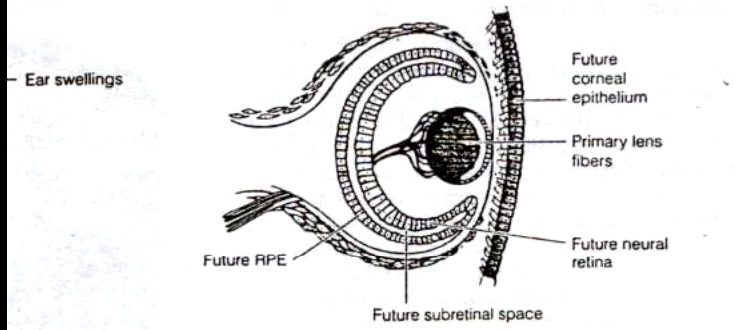
EMBRYOLOGY (cont.)

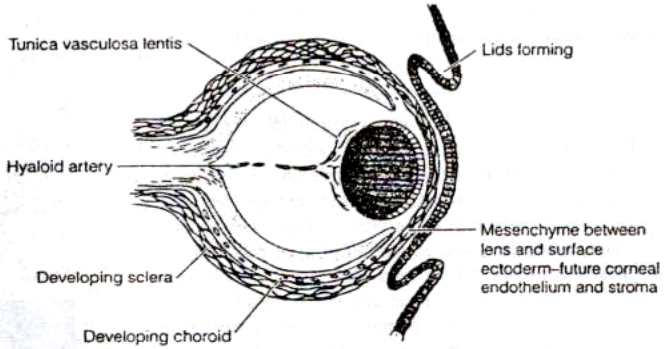
- Invagination of both the optic vesicle to form ***Optic cup*** and the optic stalk to form ***Choroidal fissure*** inferiorly.
- Surface ectoderm invaginate to form the lens vesicle.
- Mesodermal tissues invade the developing eye to share in vascular, muscular and supportive tissues of the eye.

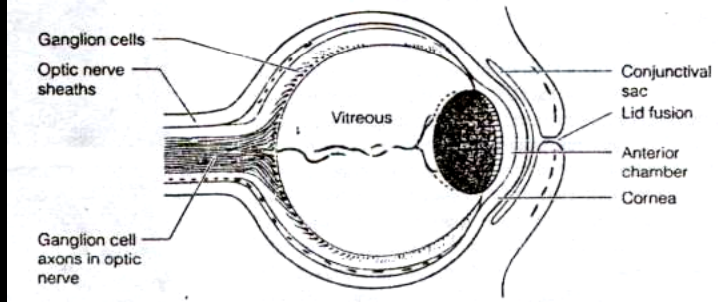

Forebrain vesicle
Optic vesicle
Optic stalk


Surface ectoderm
Lens vesicle
Optic cup


Cornea
Lens
Inner layer of retina
Optic nerve
Outer layer of retina

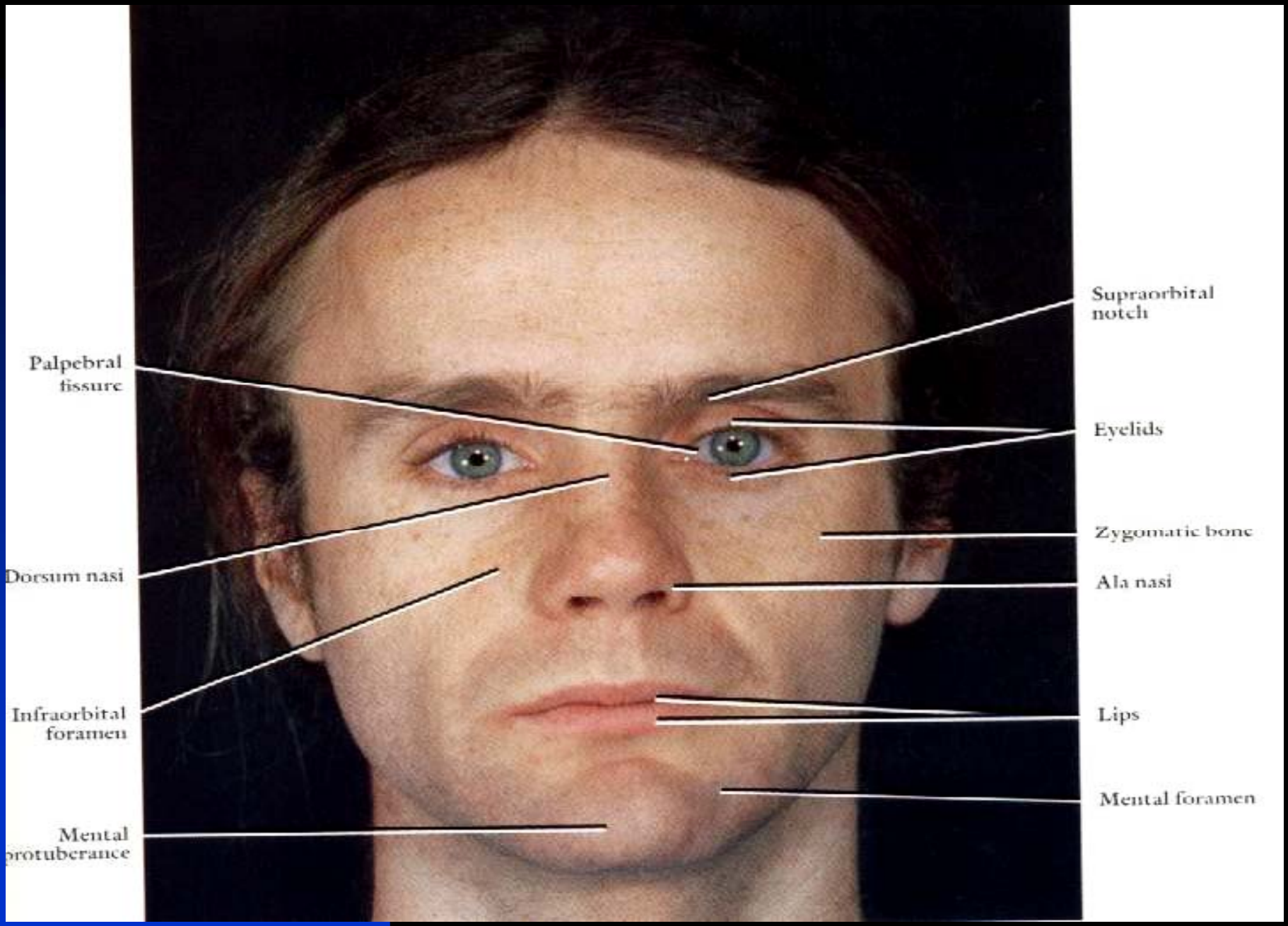

Ear swellings
Future corneal epithelium
Primary lens fibers
Future neural retina
Future RPE
Future subretinal space


Tunica vasculosa lentis
Lids forming
Hyaloid artery
Mesenchyme between lens and surface ectoderm–future corneal endothelium and stroma
Developing sclera
Developing choroid


Ganglion cells
Optic nerve sheaths
Vitreous
Conjunctival sac
Lid fusion
Anterior chamber
Cornea
Ganglion cell axons in optic nerve

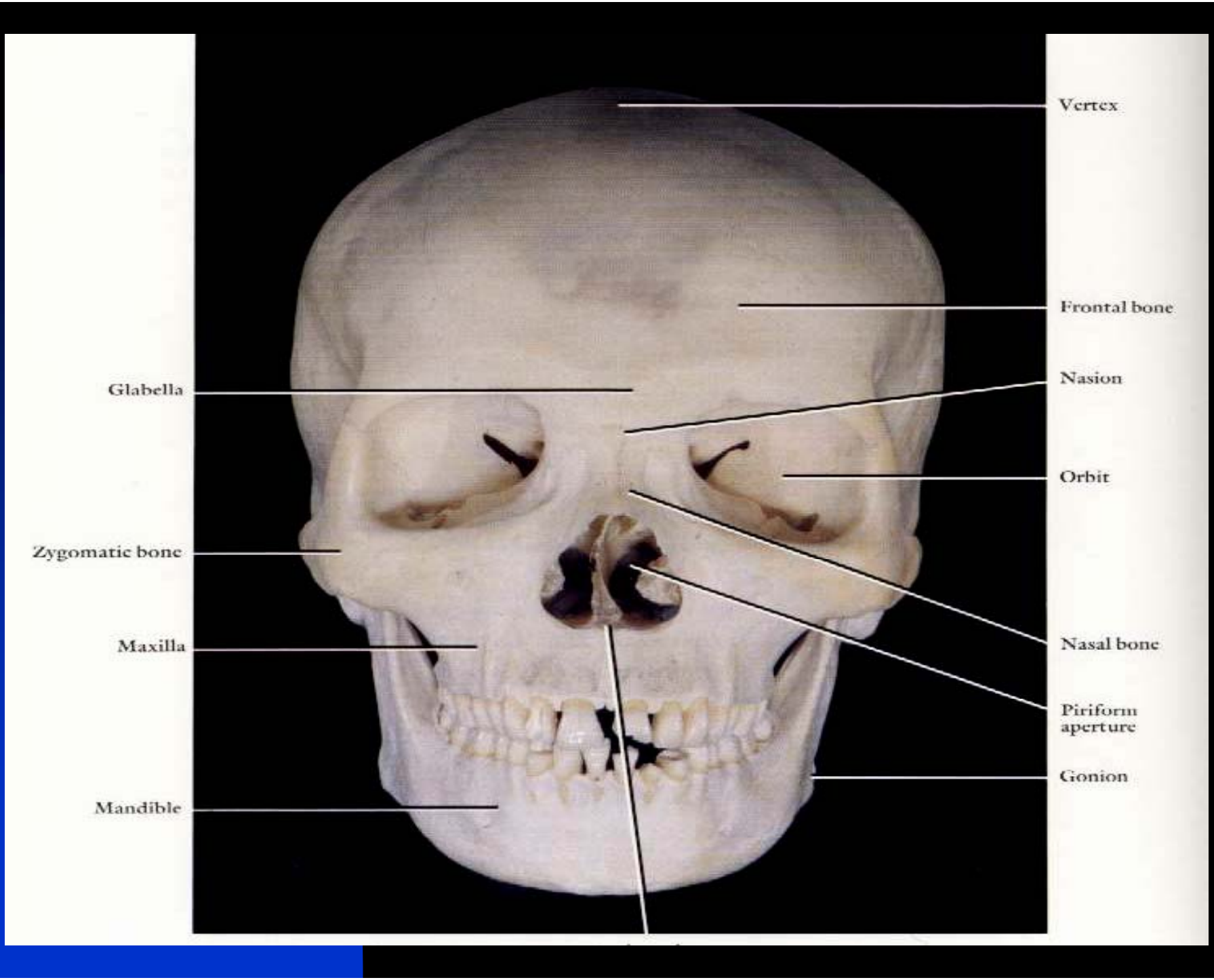
DEVELOPMENT OF THE EYE AFTER BIRTH

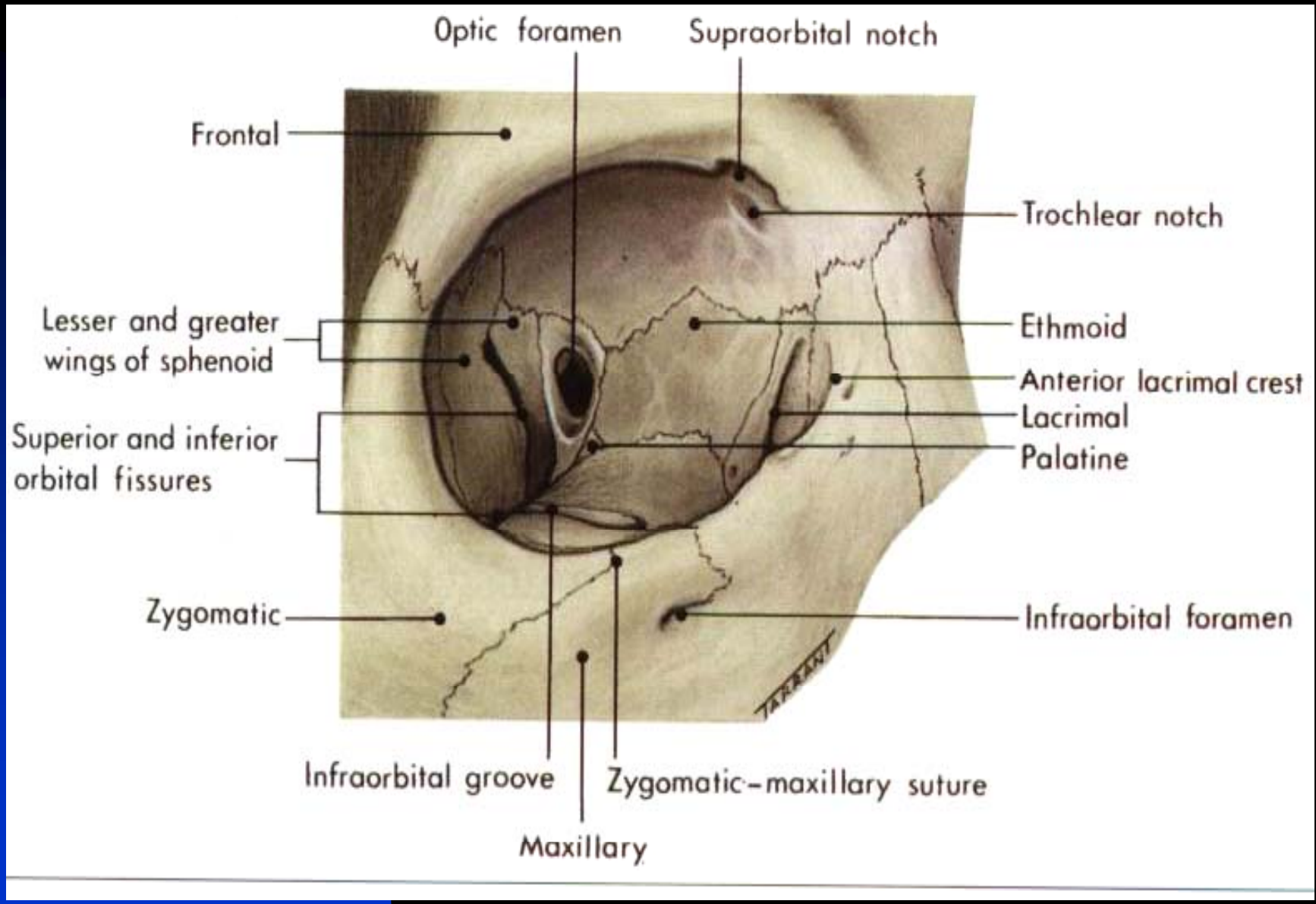
- At birth, the eye is relatively large in relation to the rest of the body.
- The eye reaches full size by the age of 8 years.
- The lens continues to enlarge throughout the life.
- The iris has a bluish color due to little or no pigment on the anterior surface.
- During early infant life, the cornea & sclera can be stretched by raised IOP → enlargement of the eye.

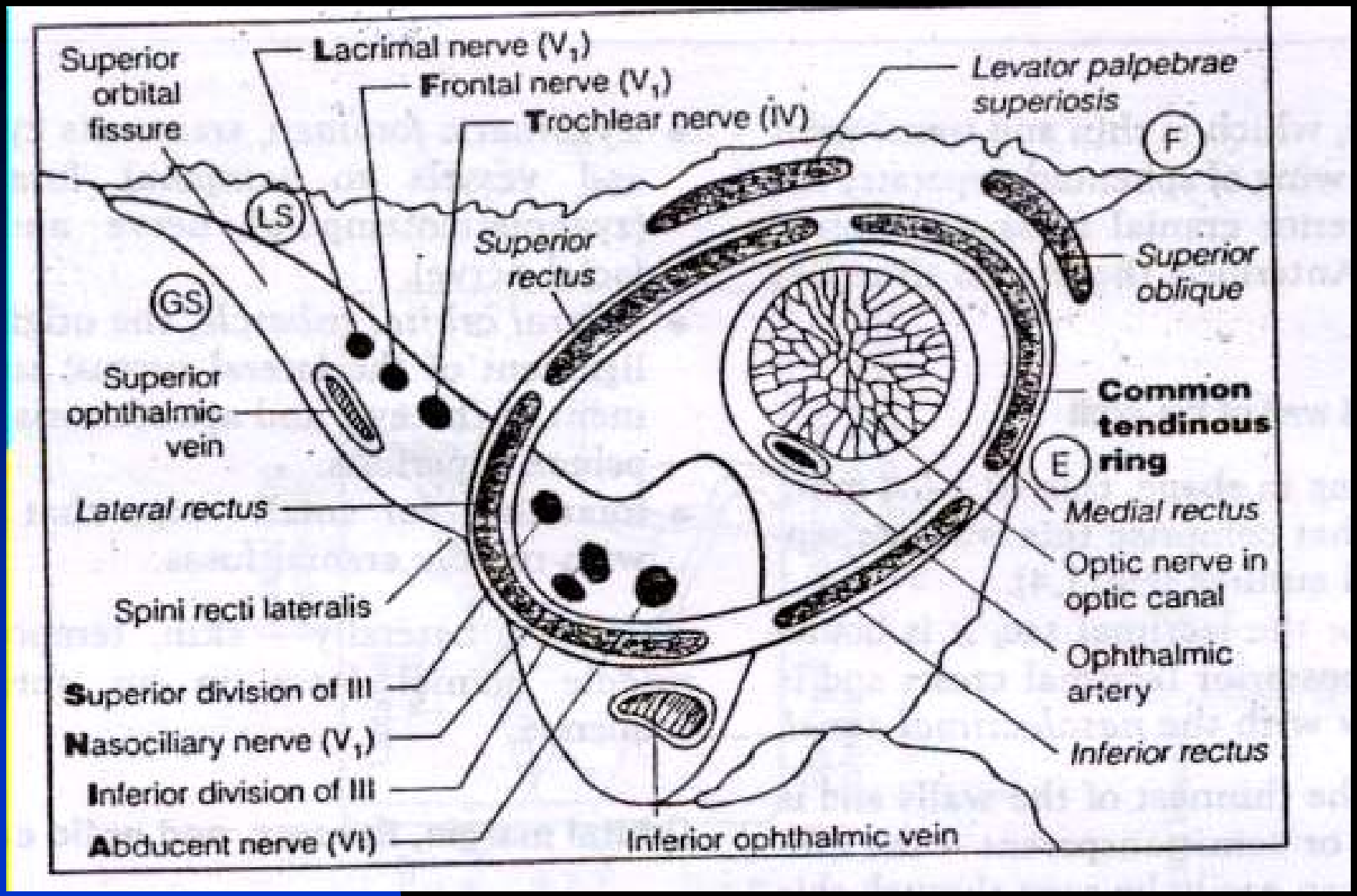

Palpebral fissure
Dorsum nasi
Infraorbital foramen
Mental protuberance
Supraorbital notch
Eyelids
Zygomatic bone
Ala nasi
Lips
Mental foramen

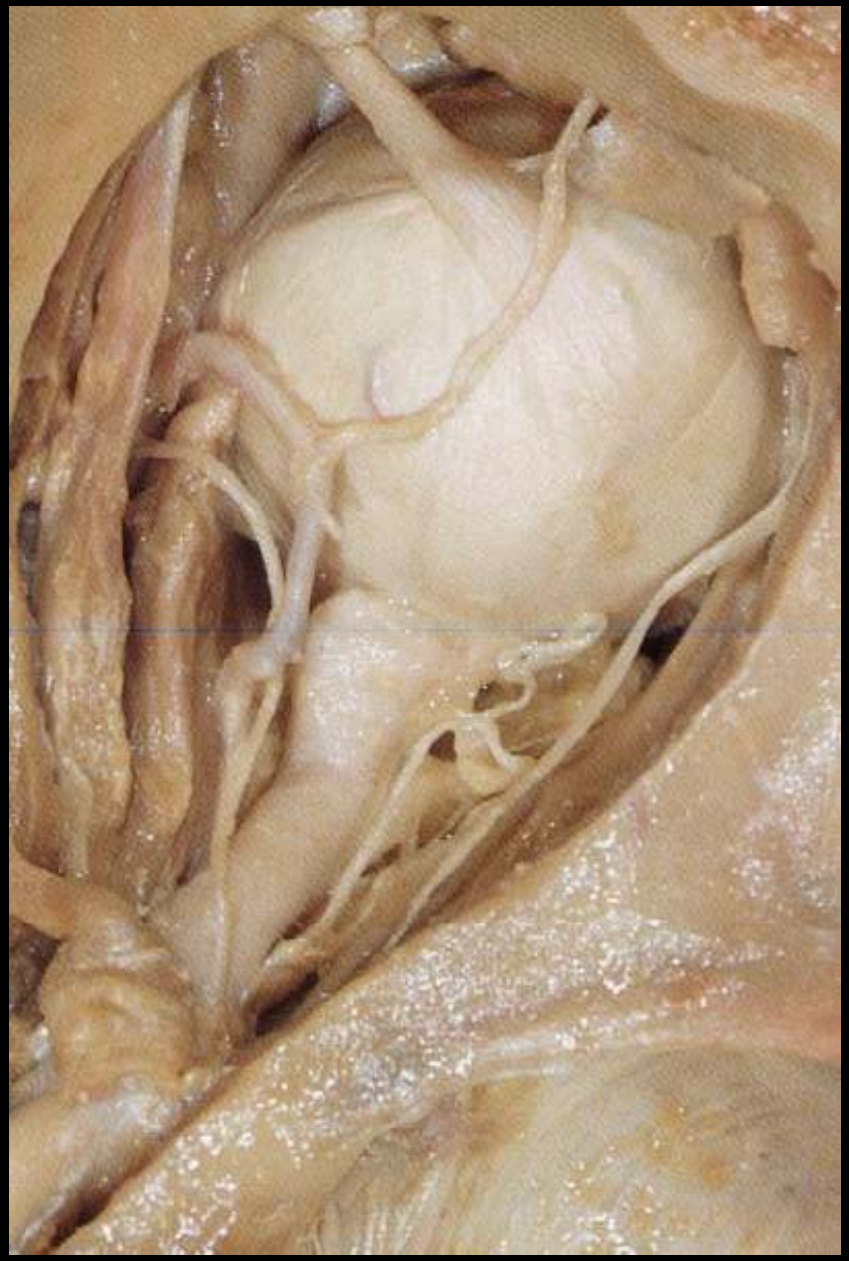
THE ORBIT

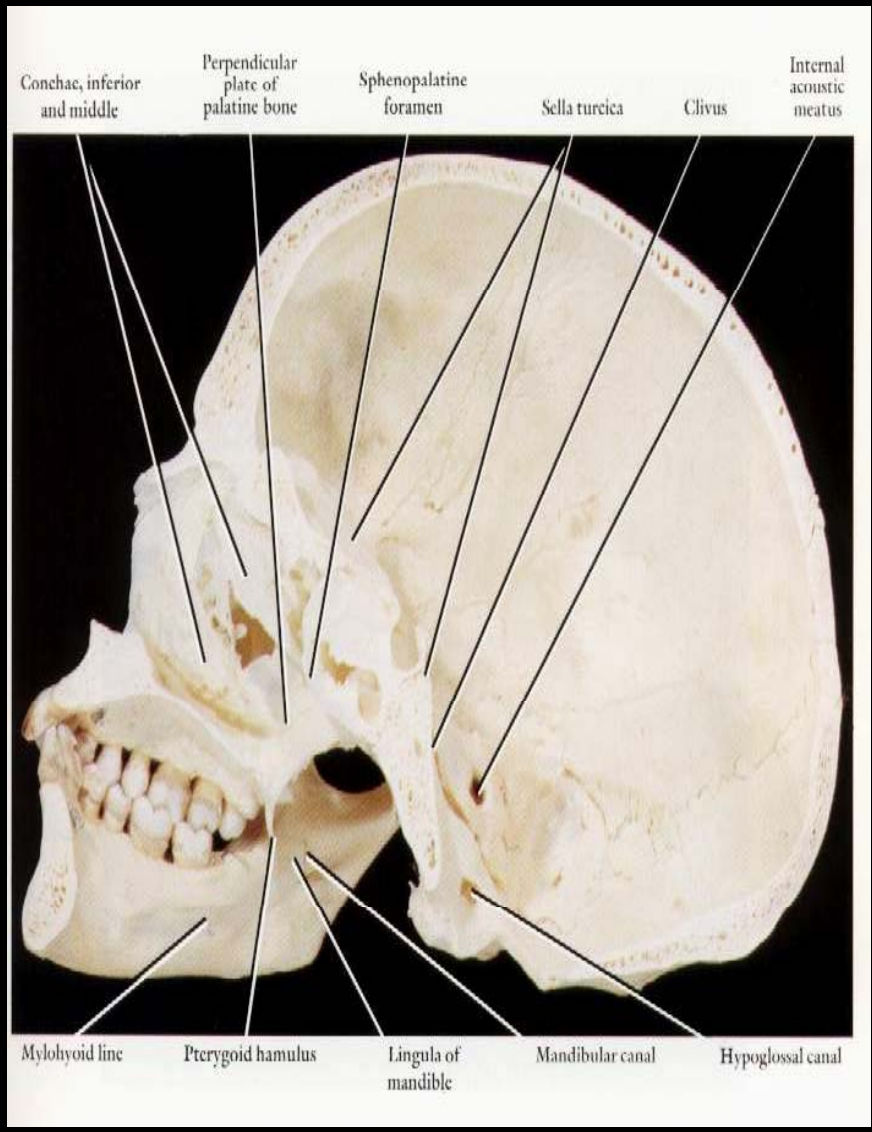
- As a socket, contains & protect the eye.
- The weakest parts are the floor & the medial wall.
- Seven bones contribute the bony orbit.
- Surrounded by nasal sinuses.
- Important openings are:
  - Optic foramen.
  - Superior orbital fissure.
  - Inferior orbital fissure.

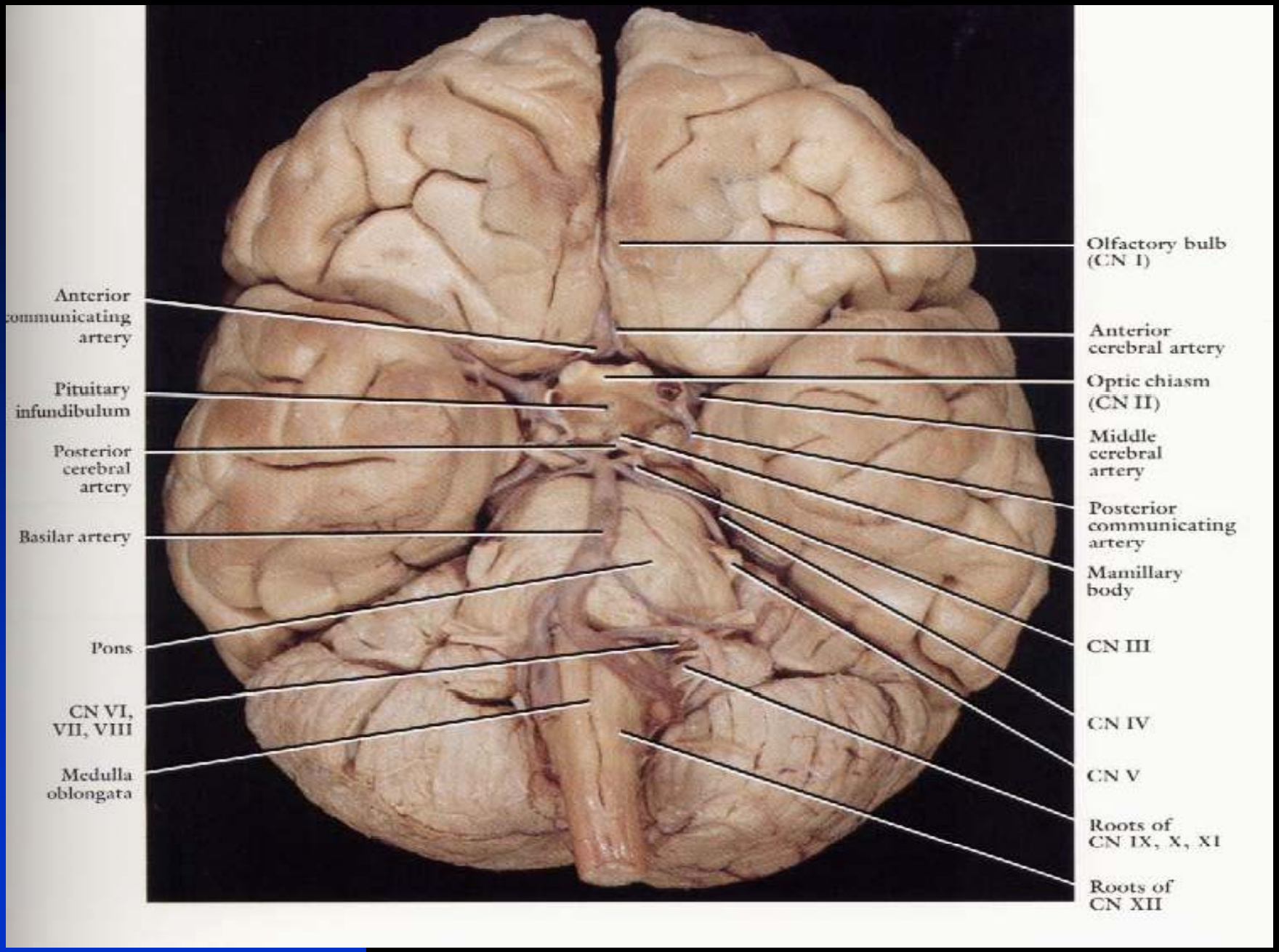

Vertex
Frontal bone
Glabella
Nasion
Orbit
Zygomatic bone
Maxilla
Nasal bone
Piriform aperture
Gonion
Mandible


Optic foramen
Supraorbital notch
Frontal
Trochlear notch
Lesser and greater wings of sphenoid
Ethmoid
Anterior lacrimal crest
Lacrimal
Superior and inferior orbital fissures
Palatine
Zygomatic
Infraorbital foramen
Infraorbital groove
Zygomatic-maxillary suture
Maxillary
TARRANT


Superior orbital fissure
Lacrimal nerve (V_1)
Frontal nerve (V_1)
Trochlear nerve (IV)
Levator palpebrae superiosis
F
LS
Superior rectus
Superior oblique
GS
Superior ophthalmic vein
Common tendinous ring
E
Lateral rectus
Medial rectus
Optic nerve in optic canal
Spini recti lateralis
Ophthalmic artery
Superior division of III
Nasociliary nerve (V_1)
Inferior rectus
Inferior division of III
Abducent nerve (VI)
Inferior ophthalmic vein

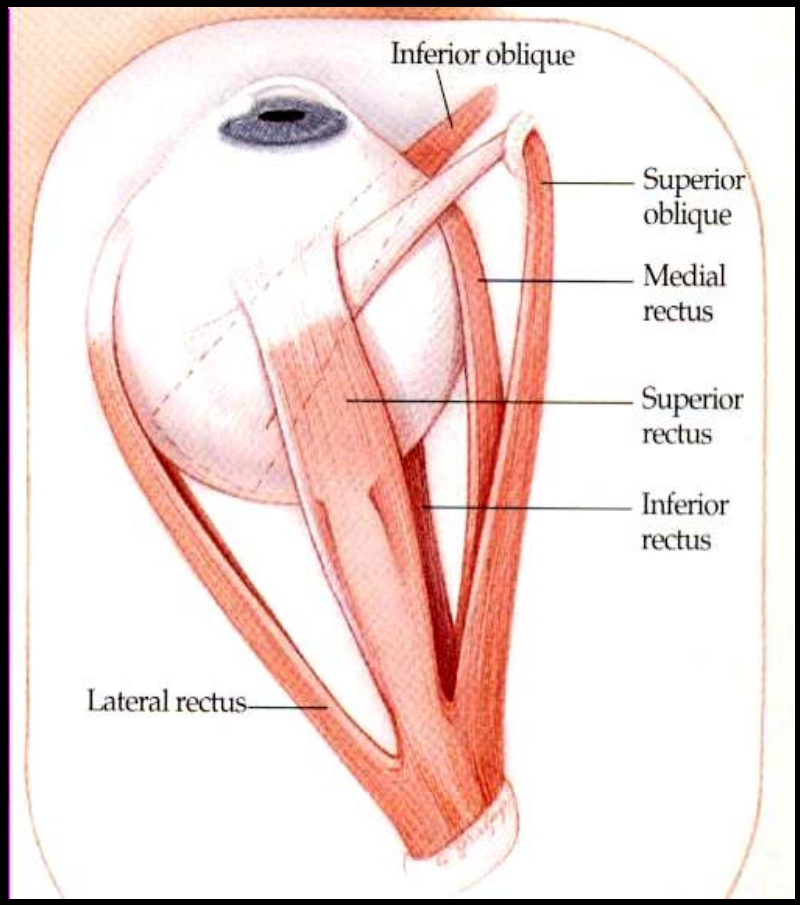


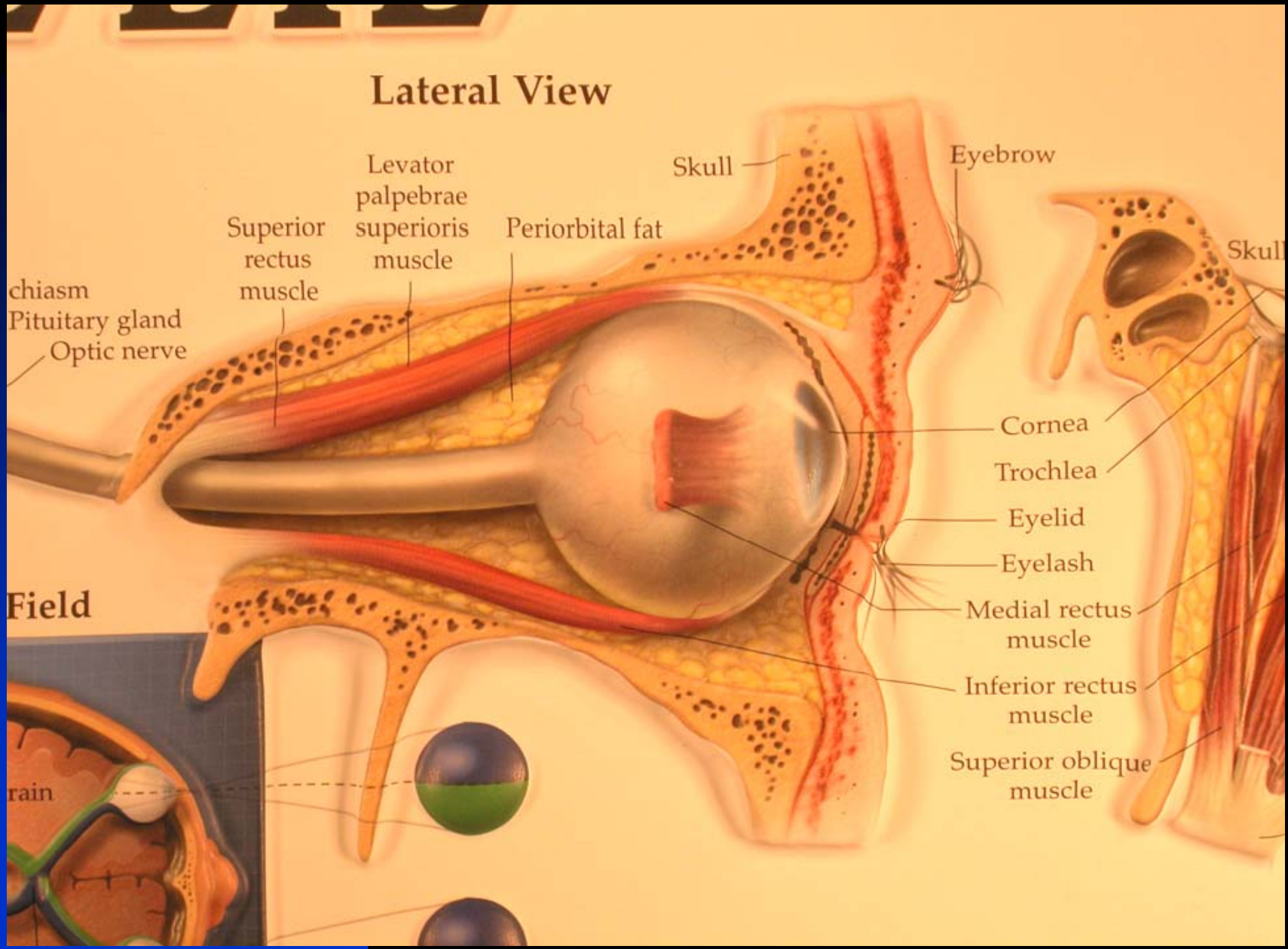

Conchae, inferior and middle
Perpendicular plate of palatine bone
Sphenopalatine foramen
Sella turcica
Clivus
Internal acoustic meatus
Mylohyoid line
Pterygoid hamulus
Lingula of mandible
Mandibular canal
Hypoglossal canal

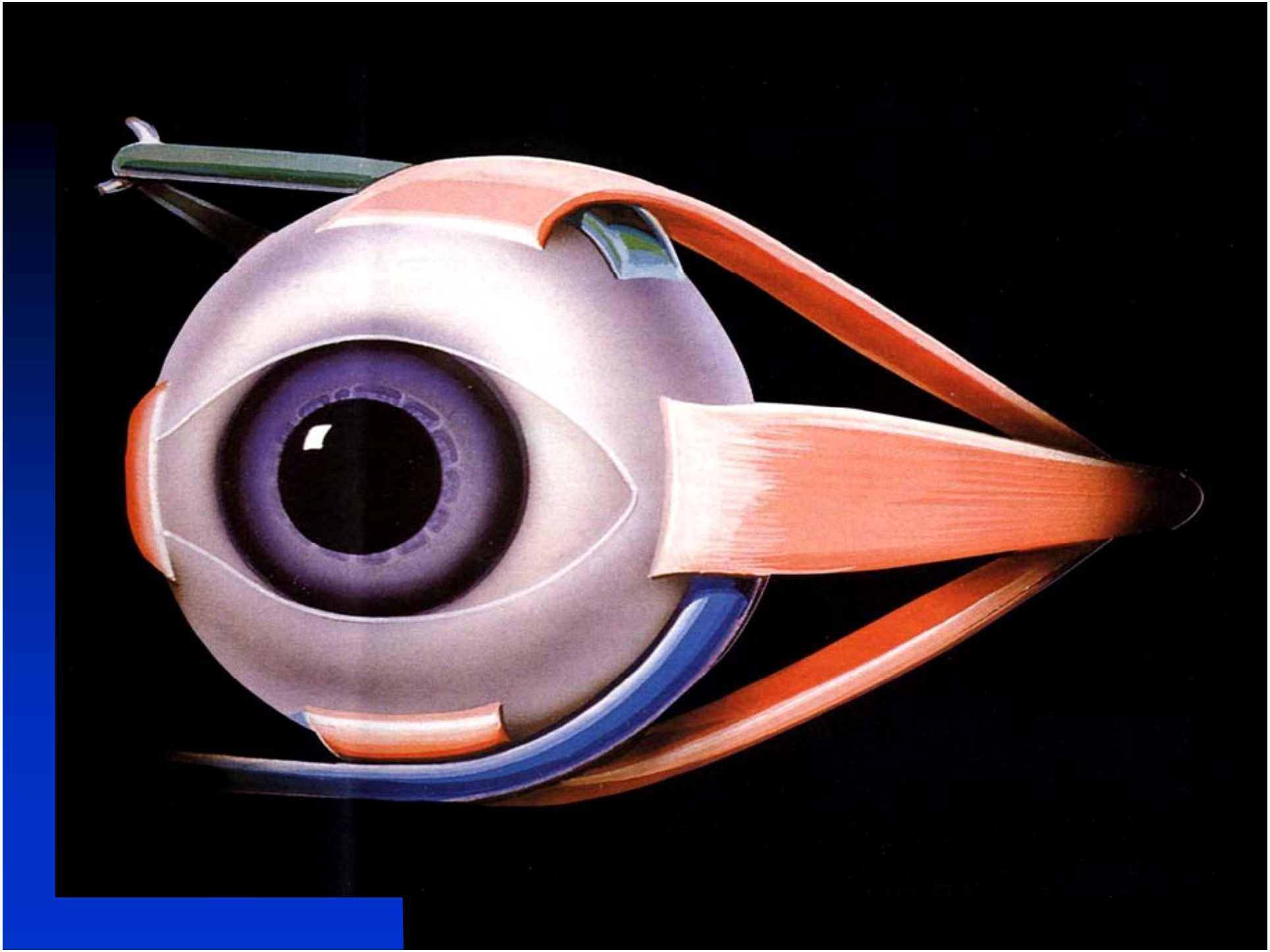

Anterior communicating artery
Pituitary infundibulum
Posterior cerebral artery
Basilar artery
Pons
CN VI, VII, VIII
Medulla oblongata
Olfactory bulb (CN I)
Anterior cerebral artery
Optic chiasm (CN II)
Middle cerebral artery
Posterior communicating artery
Mamillary body
CN III
CN IV
CN V
Roots of CN IX, X, XI
Roots of CN XII

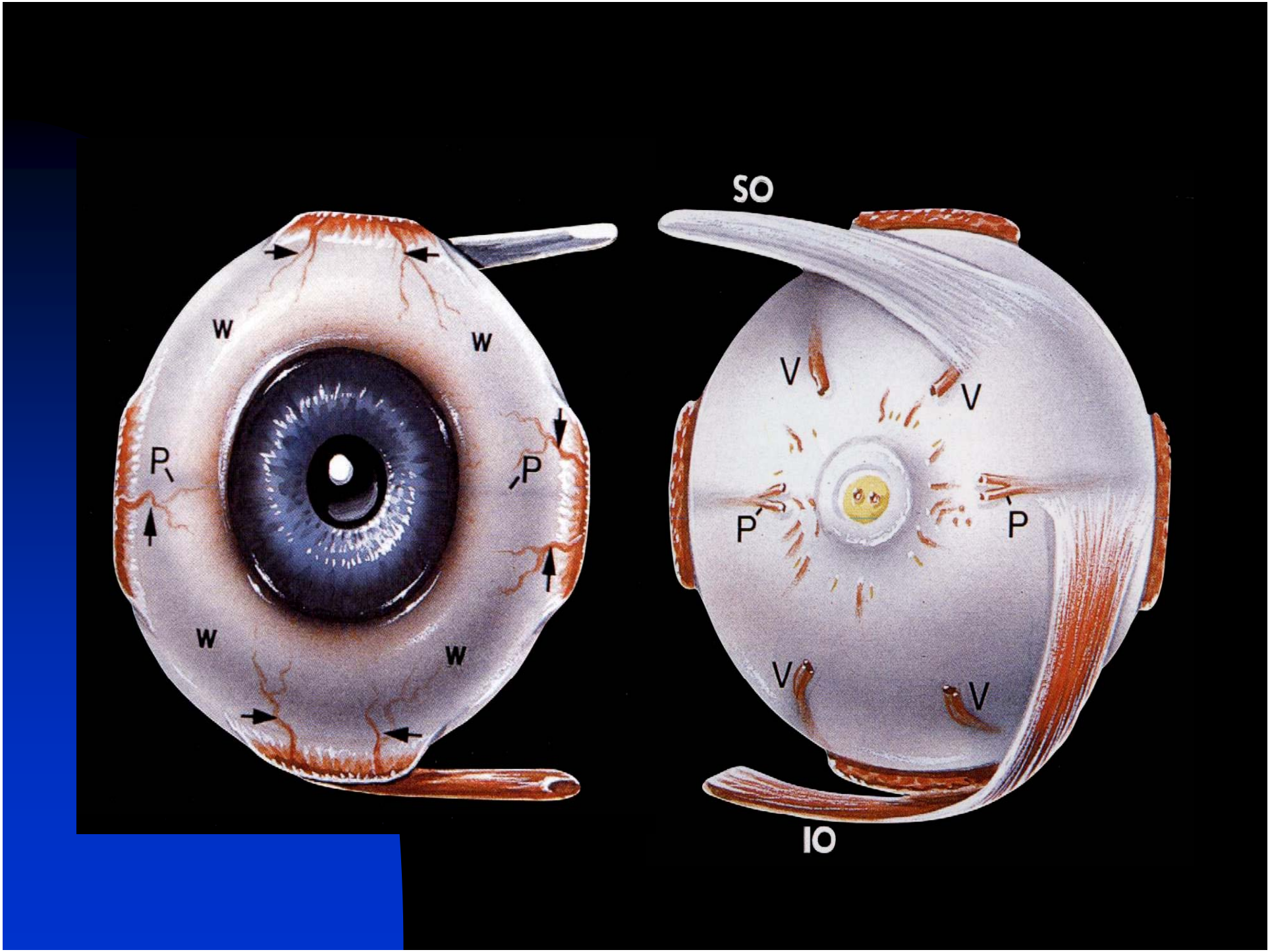
THE EXTRAOCULAR MUSCLES

- Four recti & two oblique muscles.
- All are supplied by Oculomotor n. except superior oblique (Trochlear n.) & lateral rectus (Abducent n.).



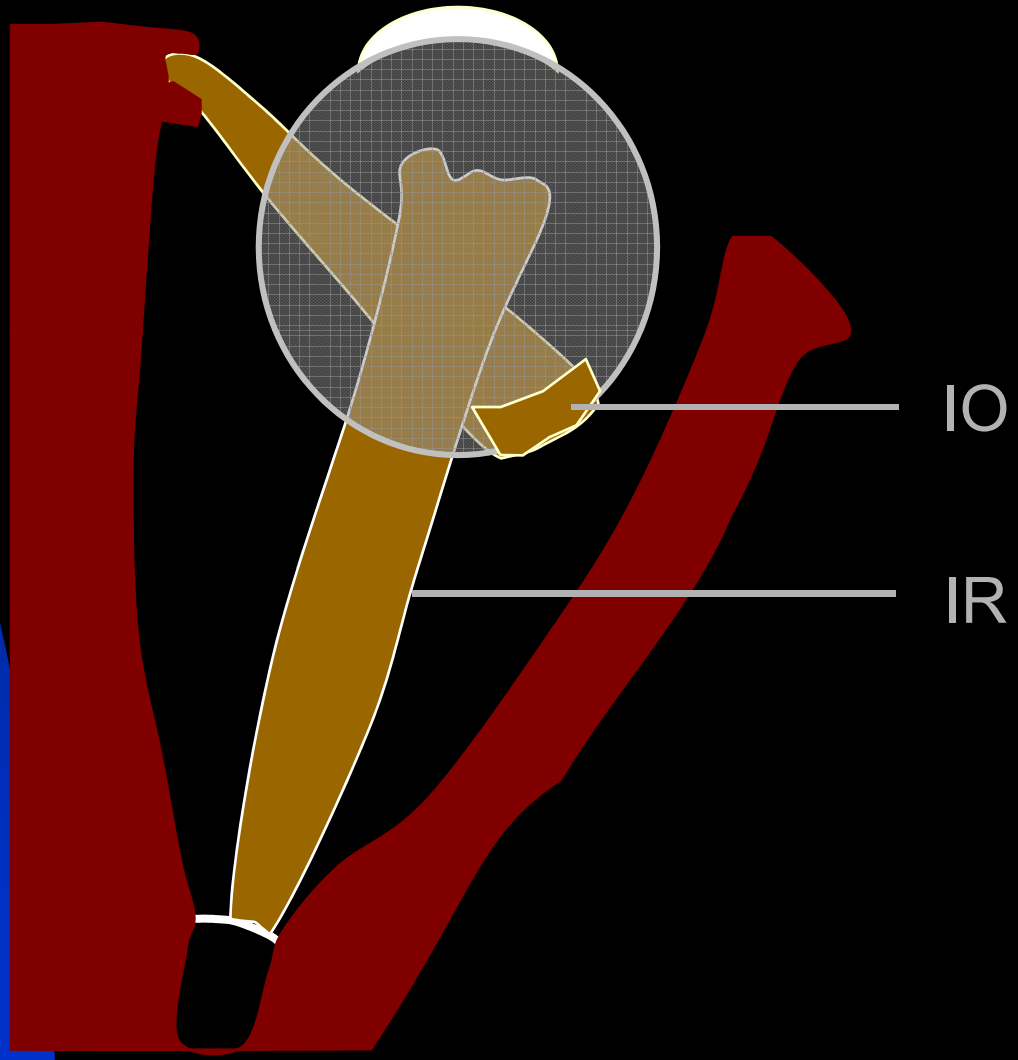

Lateral View
Levator palpebrae superioris muscle
Skull
Eyebrow
Superior rectus muscle
Periorbital fat
chiasm
Pituitary gland
Optic nerve
Cornea
Trochlea
Eyelid
Eyelash
Field
Medial rectus muscle
Inferior rectus muscle
Superior oblique muscle
rain



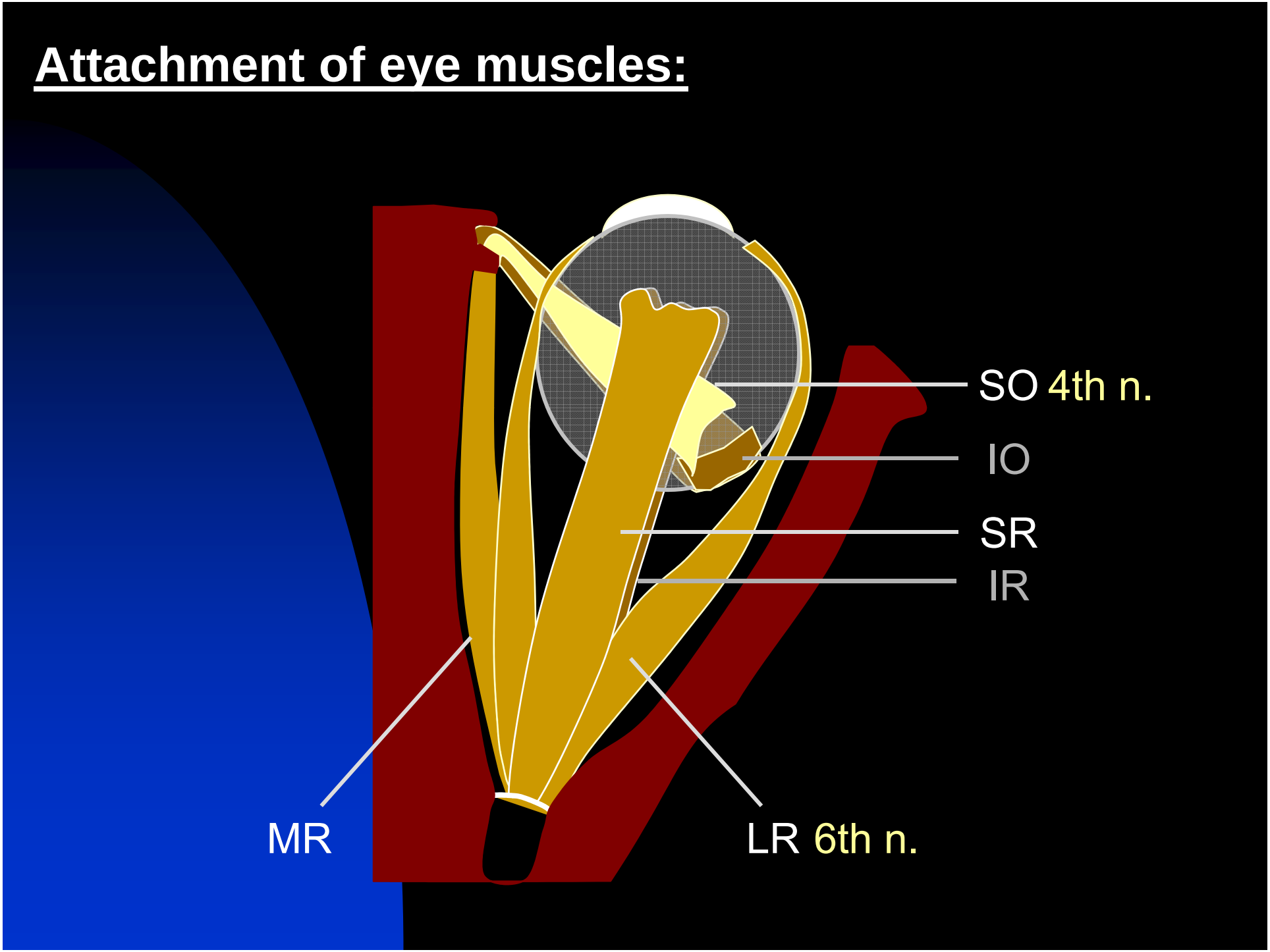

SO
W
W
P
P
W
W
V
V
P
P
V
V
IO

3rd, 4th, 6th cranial nerves

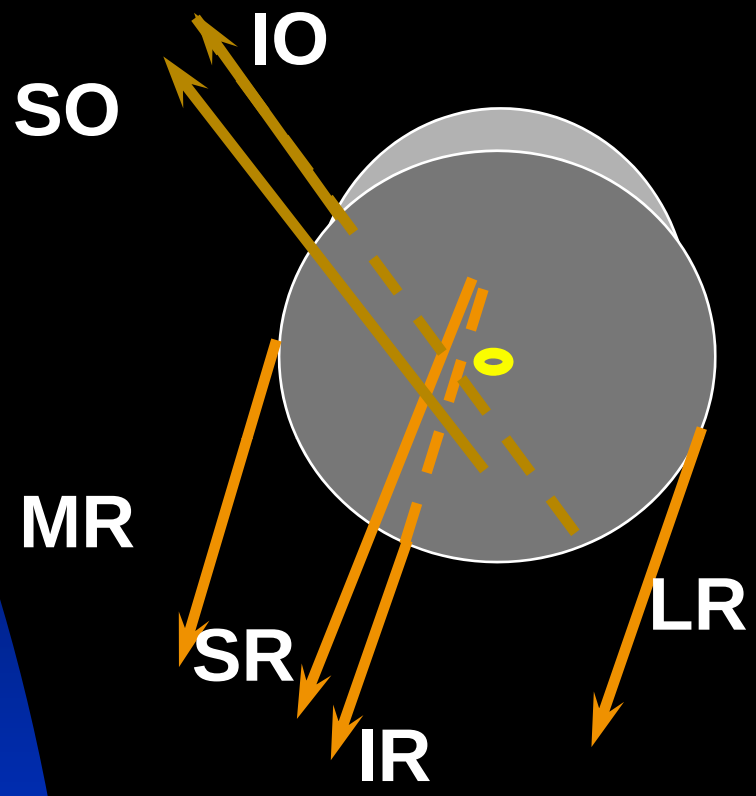
Attachment of eye muscles:

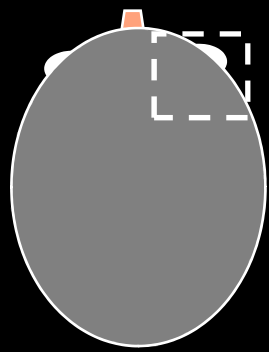


Attachment of eye muscles:



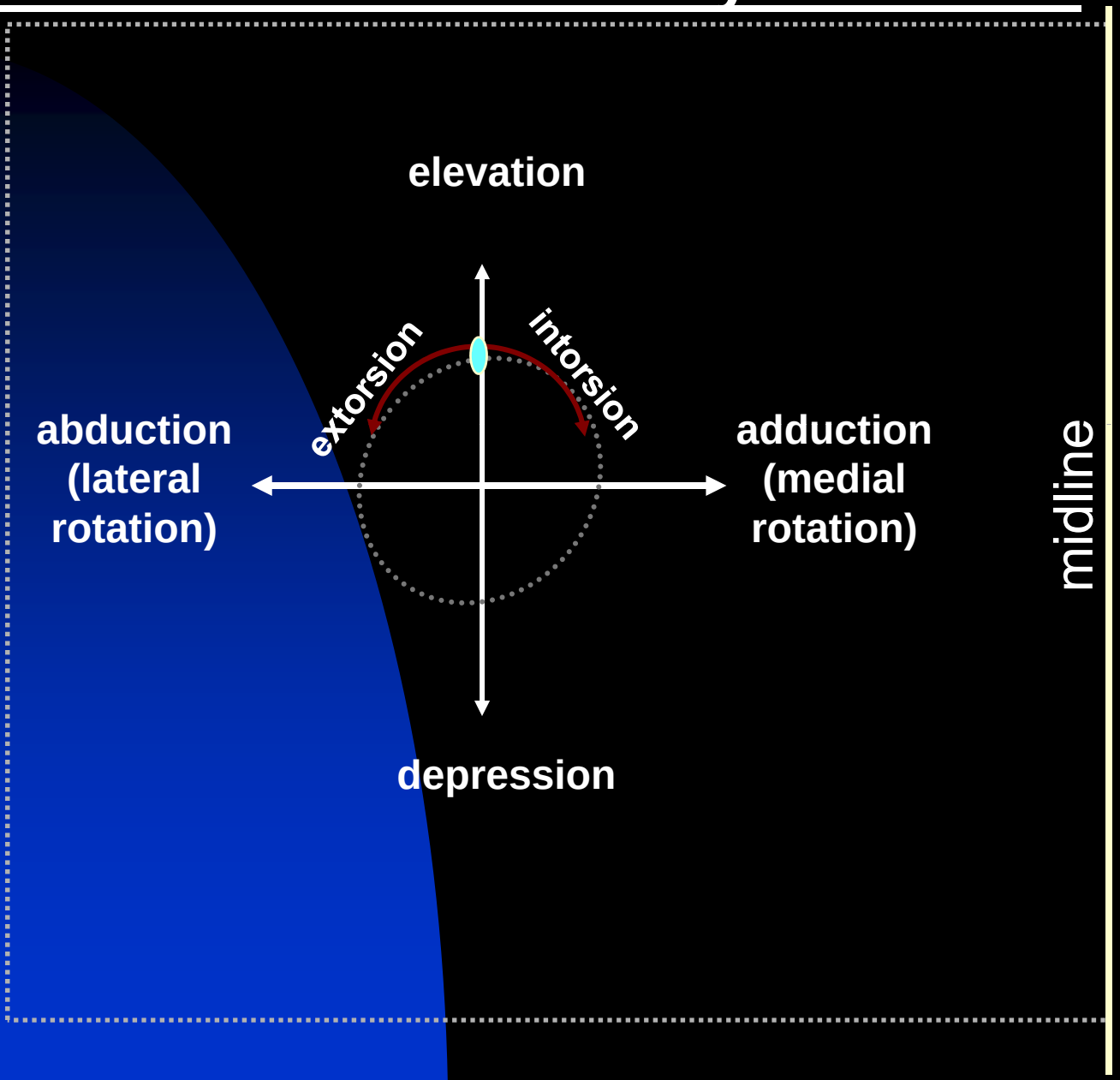
Attachment of eye muscles:

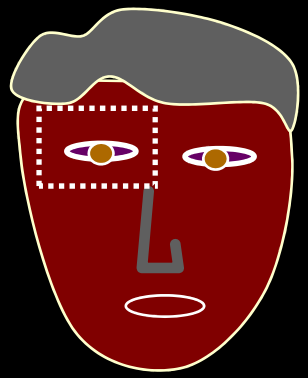




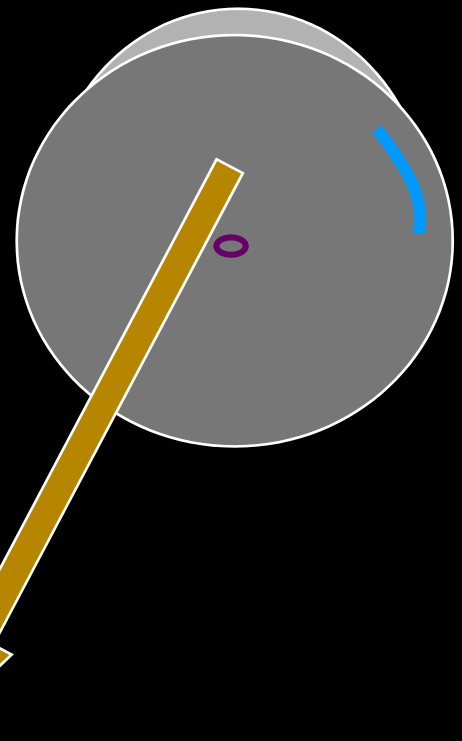
(View from above)

Innervation & action of eye muscles:

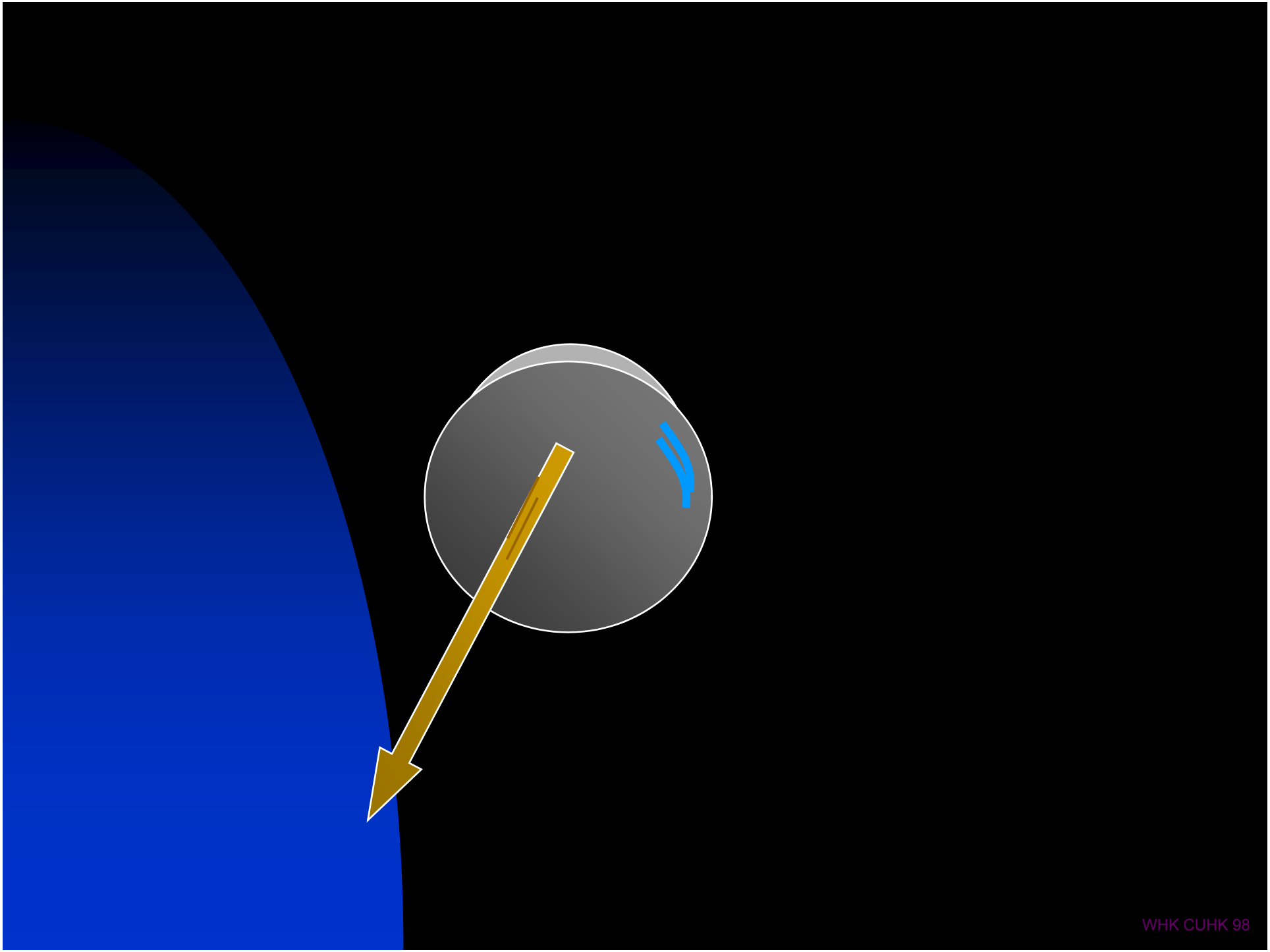


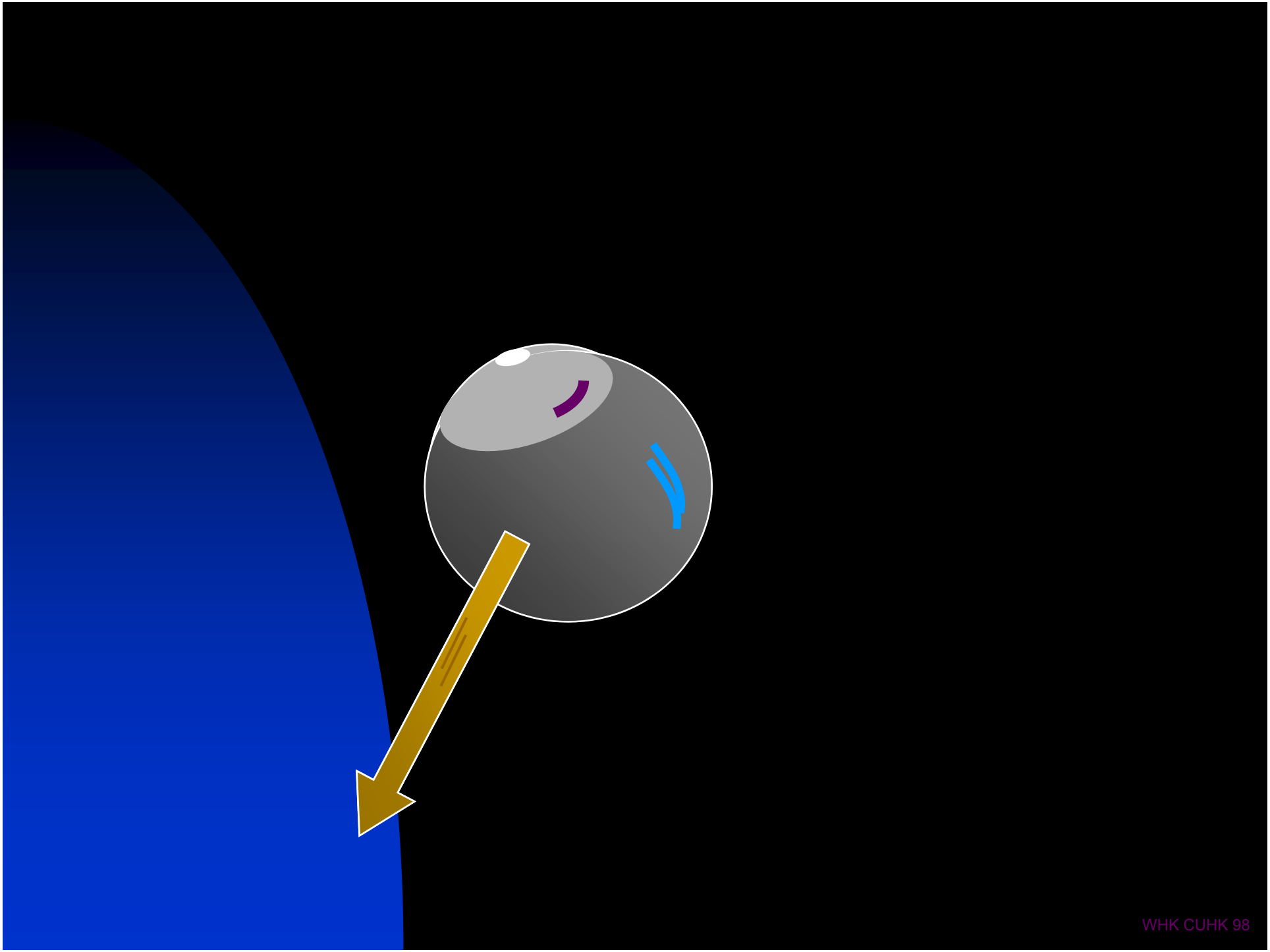


Deduction of action from muscle attachment (E.g.: SR)

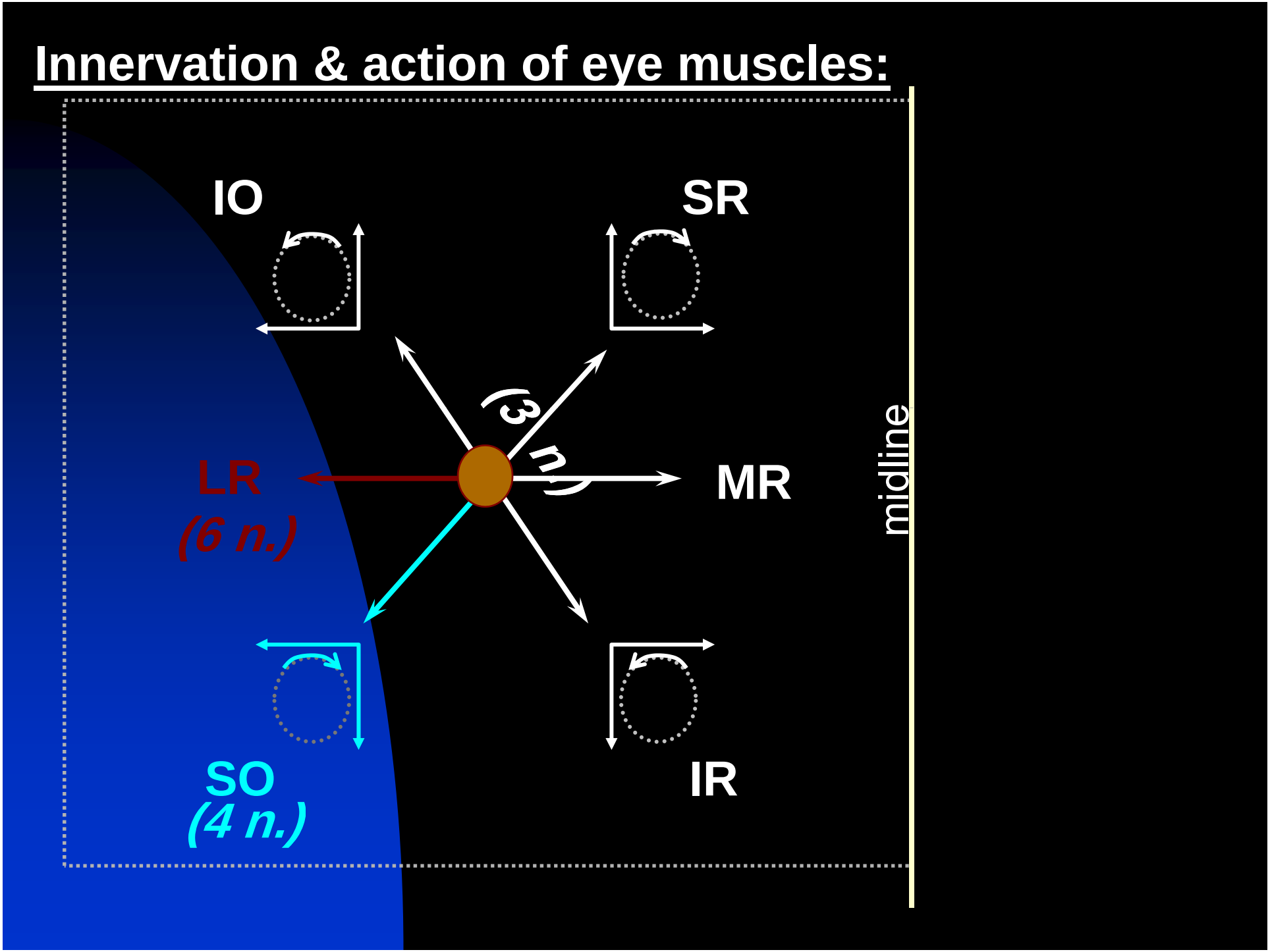


(View from above)

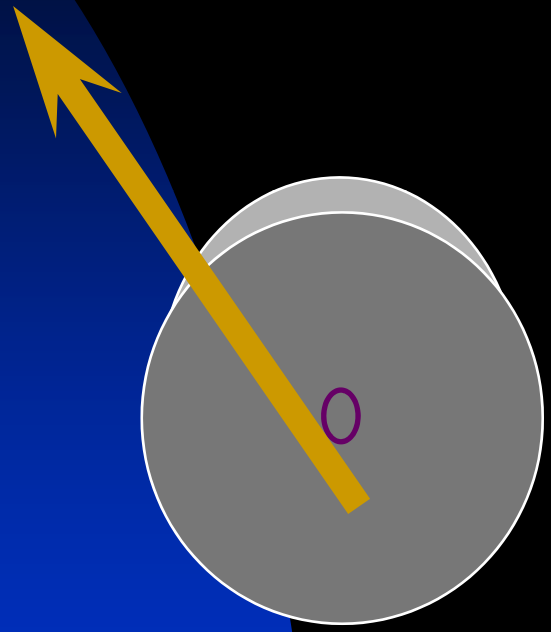


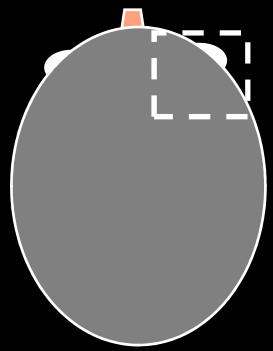


Innervation & action of eye muscles:

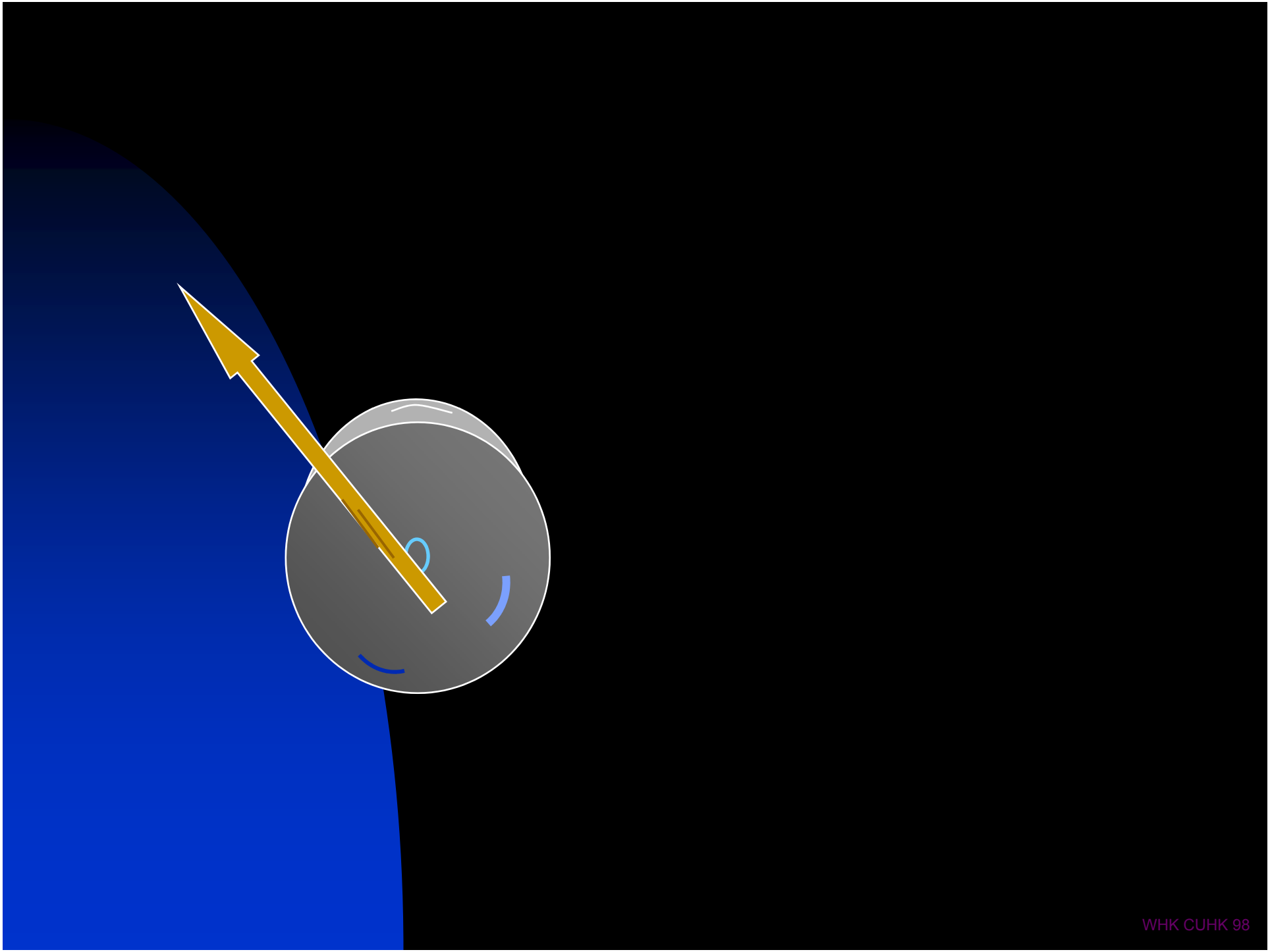


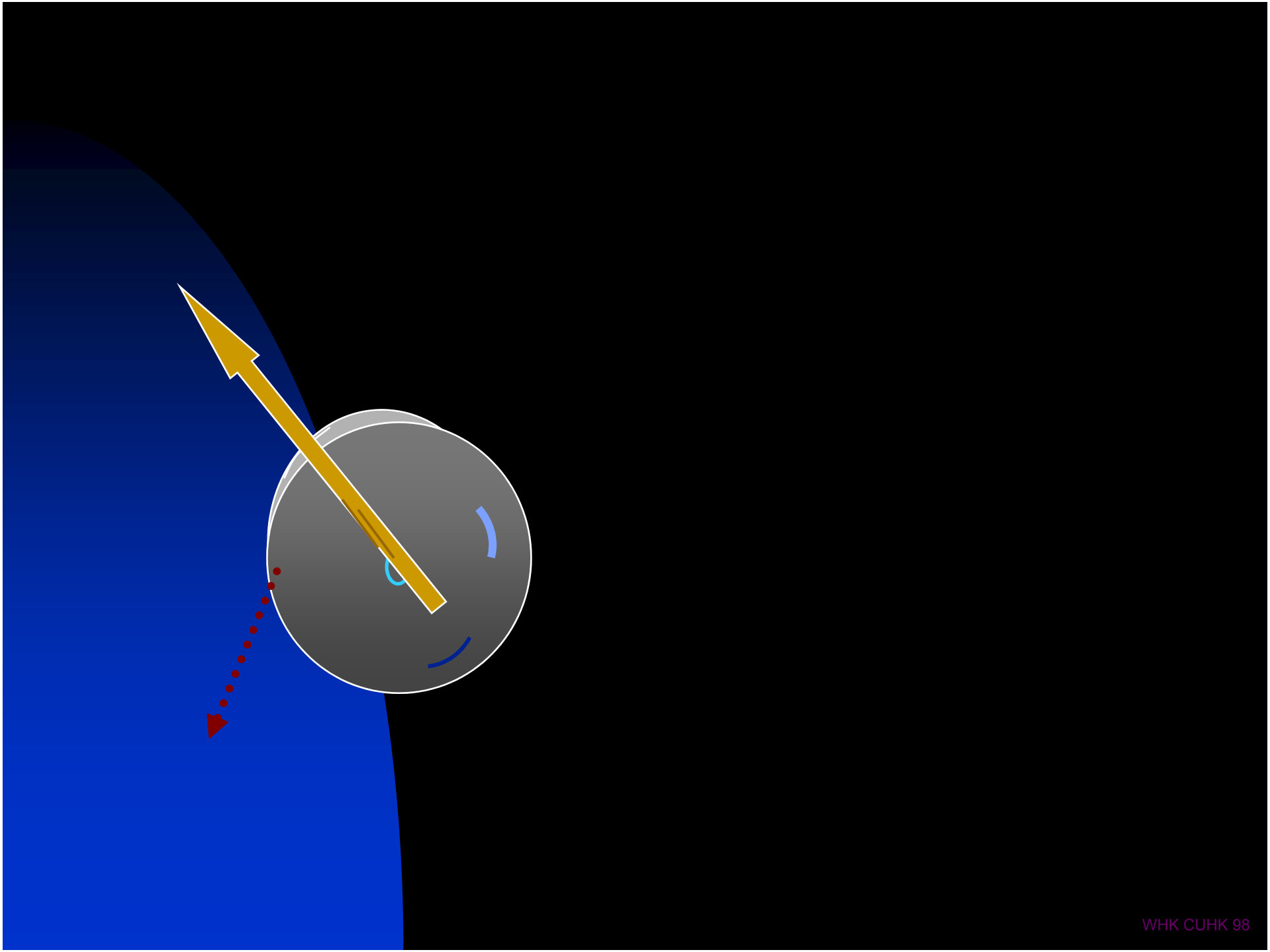
Person to look *medially* & down

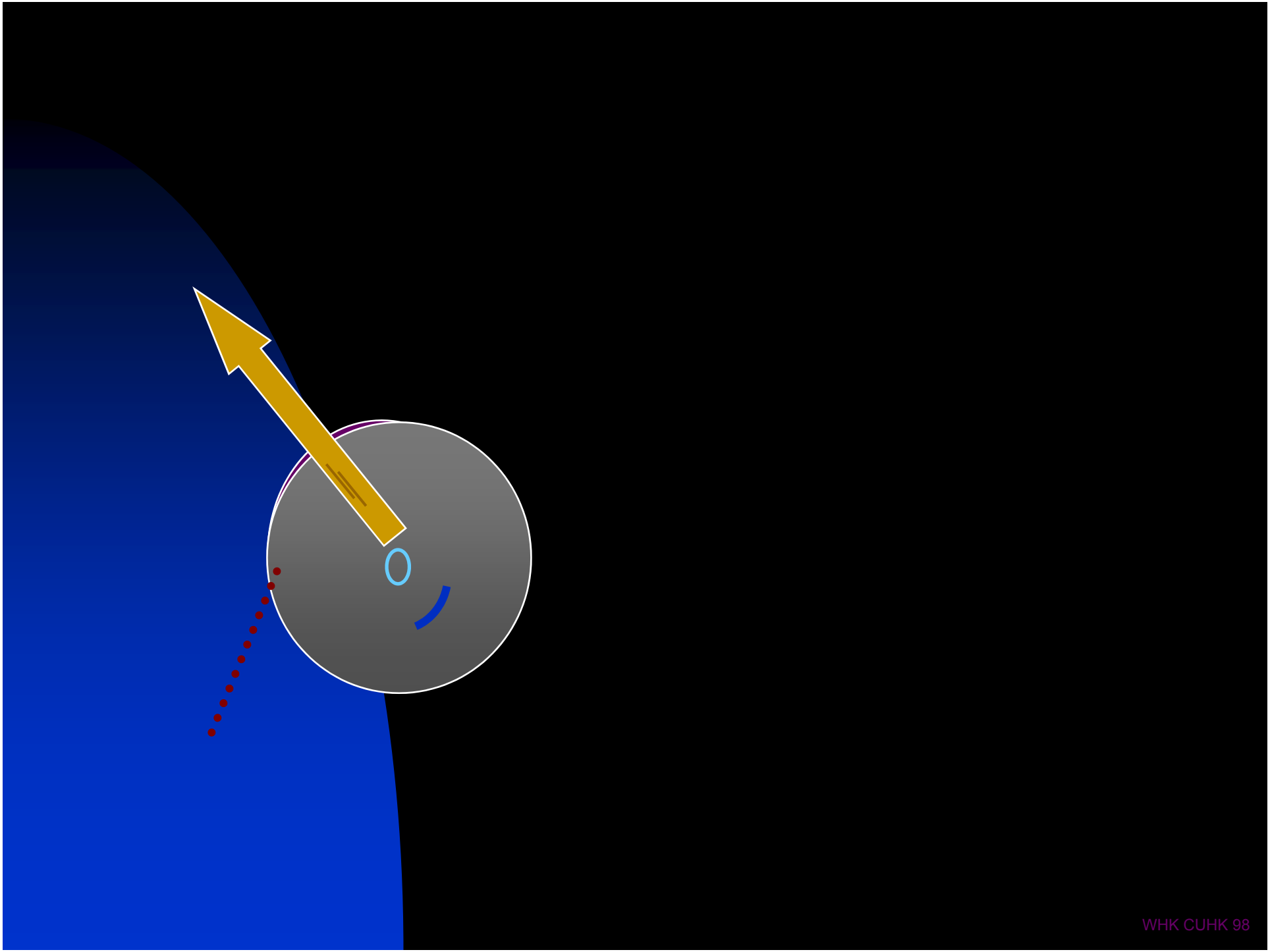




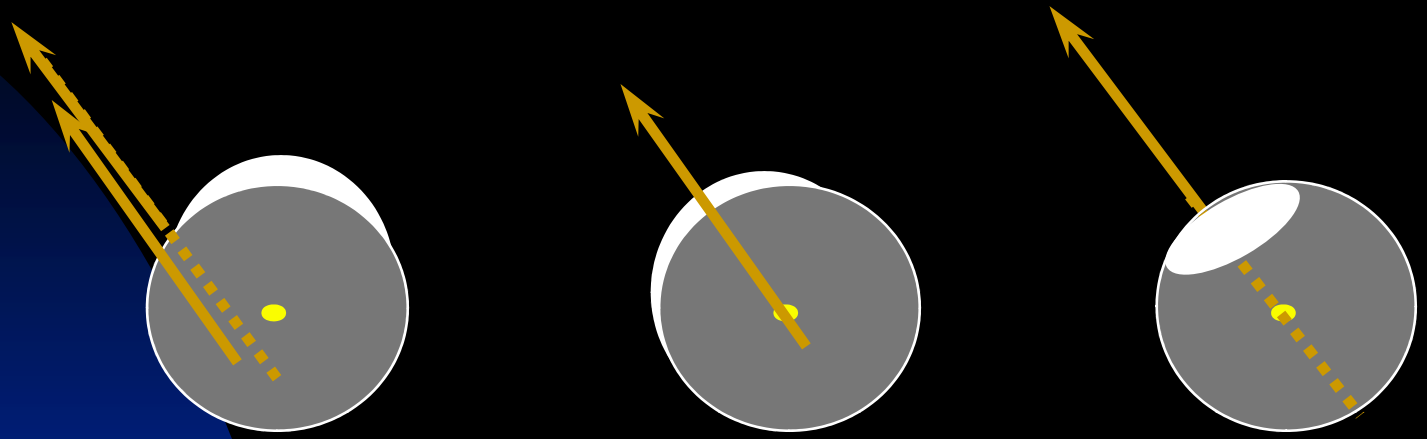
head, from above





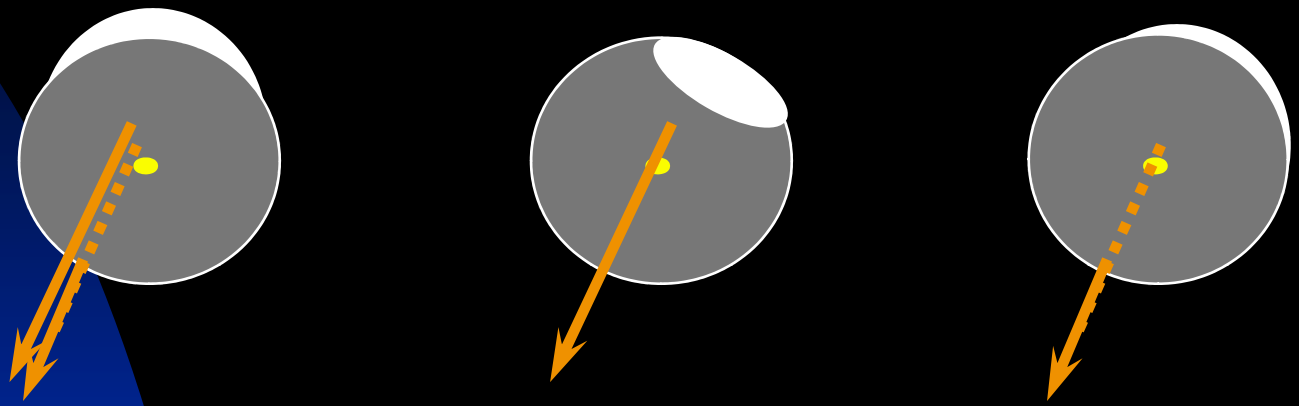


Hence:



- **When eye is adducted:**
  - SO is almost a pure depressor
    (IV n.)
  - IO is almost a pure elevator
    (III n.)

They pull through the centre



- **When eye is abducted:**
  - SR is almost a pure elevator
  - IR is almost a pure depressor

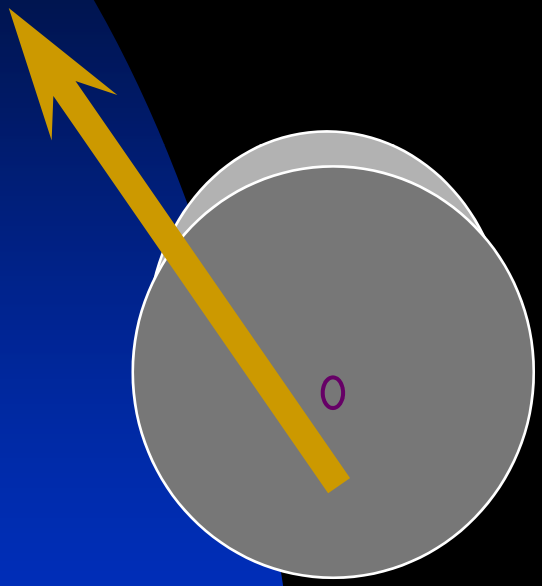
They pull through the centre

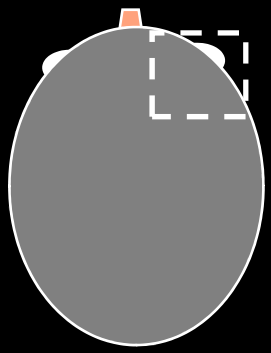
Hence for clinical test :

	Direction to look
• SO	Down and in
• IO	Up and in
• SR	Up and out
• IR	Down and out

How does SO (4th n.) pull the eyeball ?

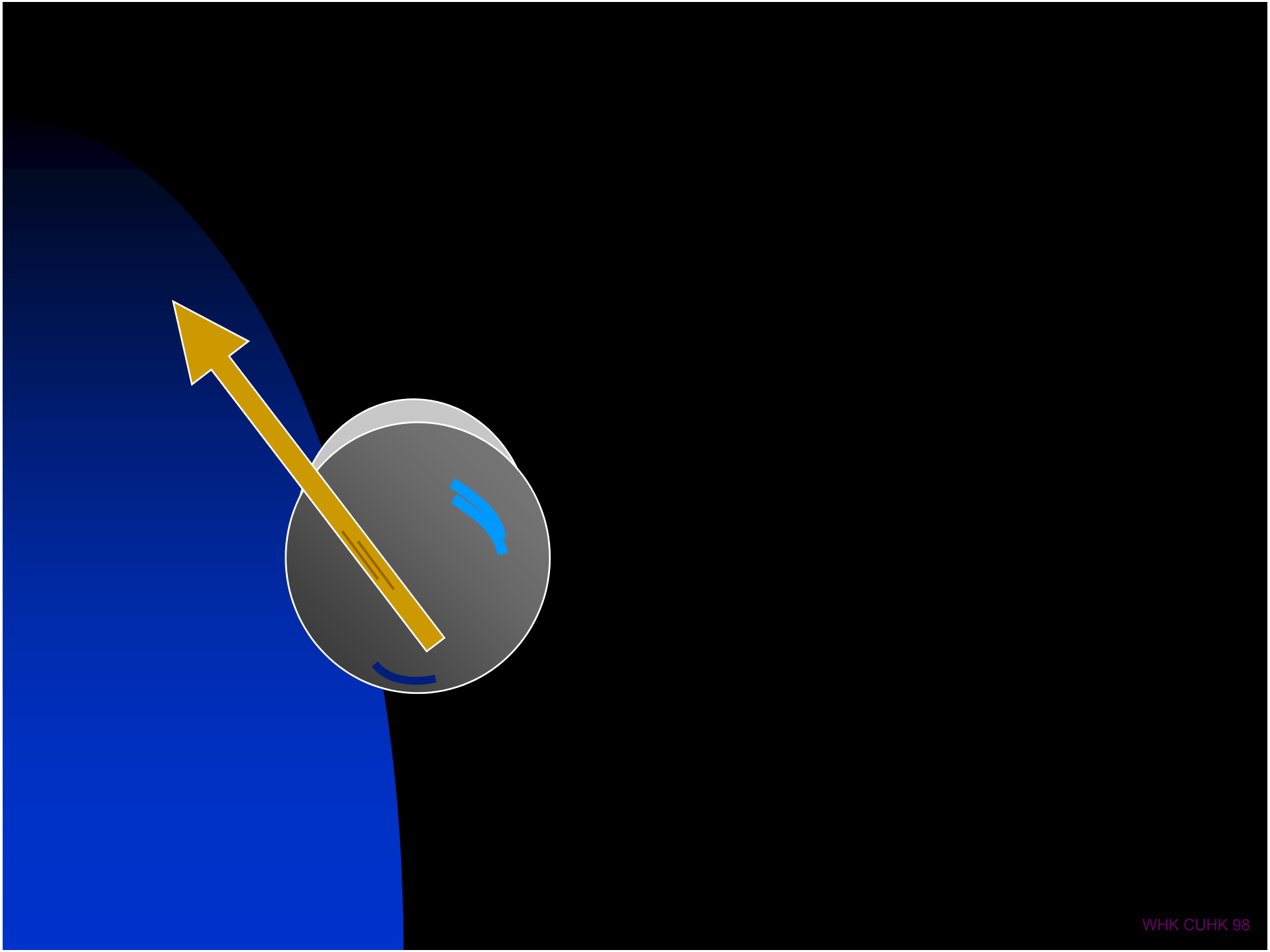
Person to look *laterally* & down

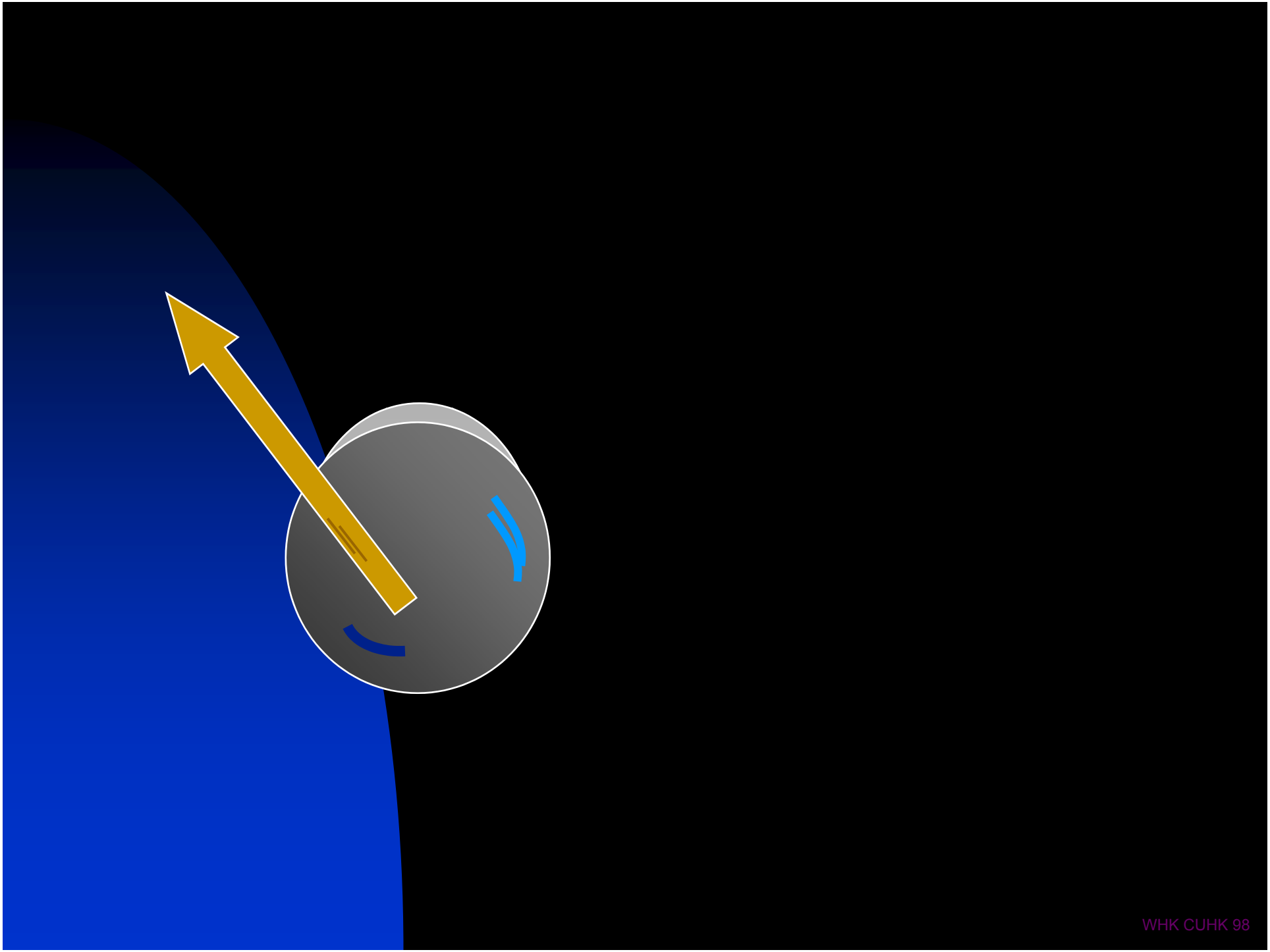


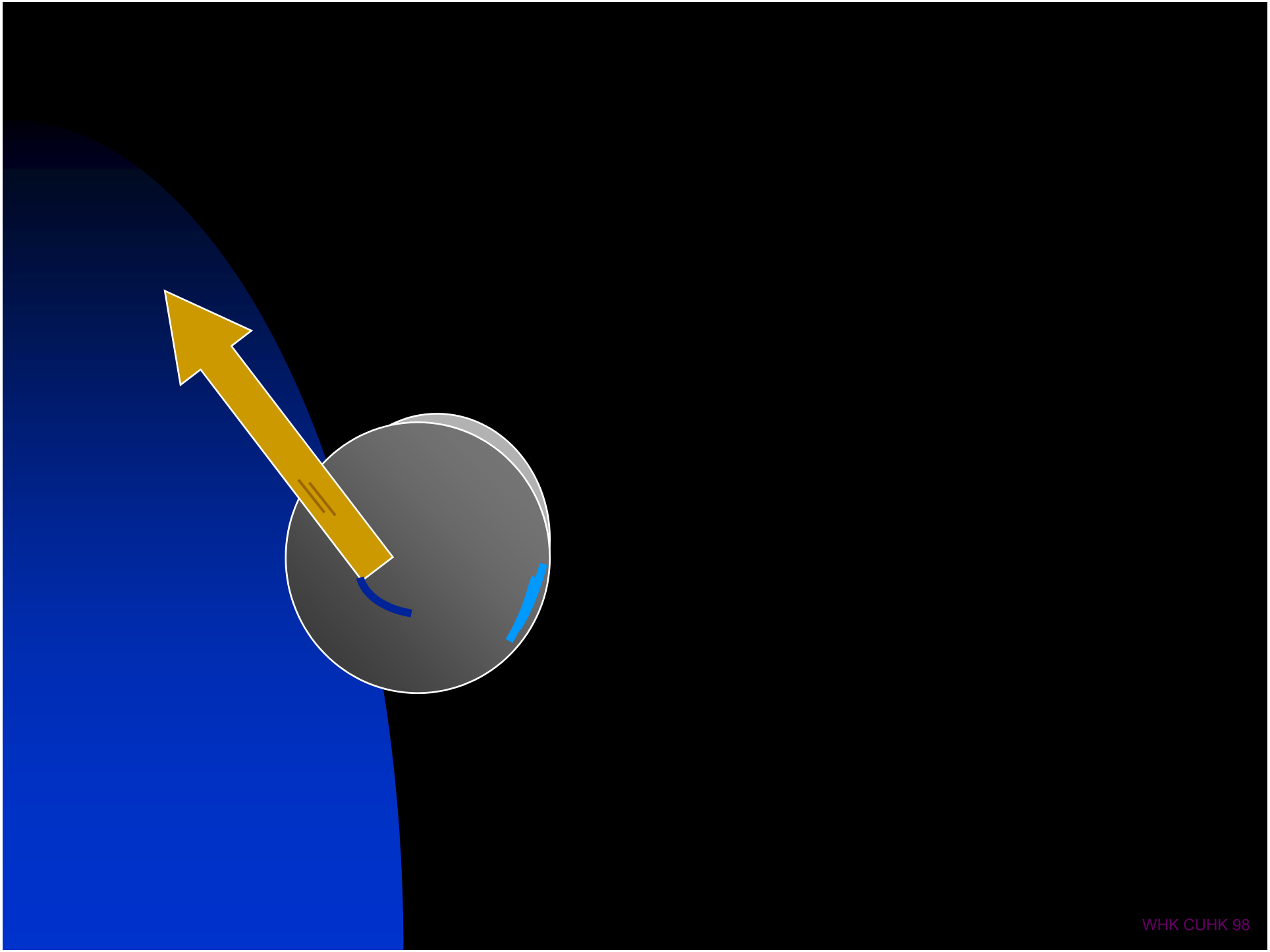


head, from above

this part of SO is tendinous



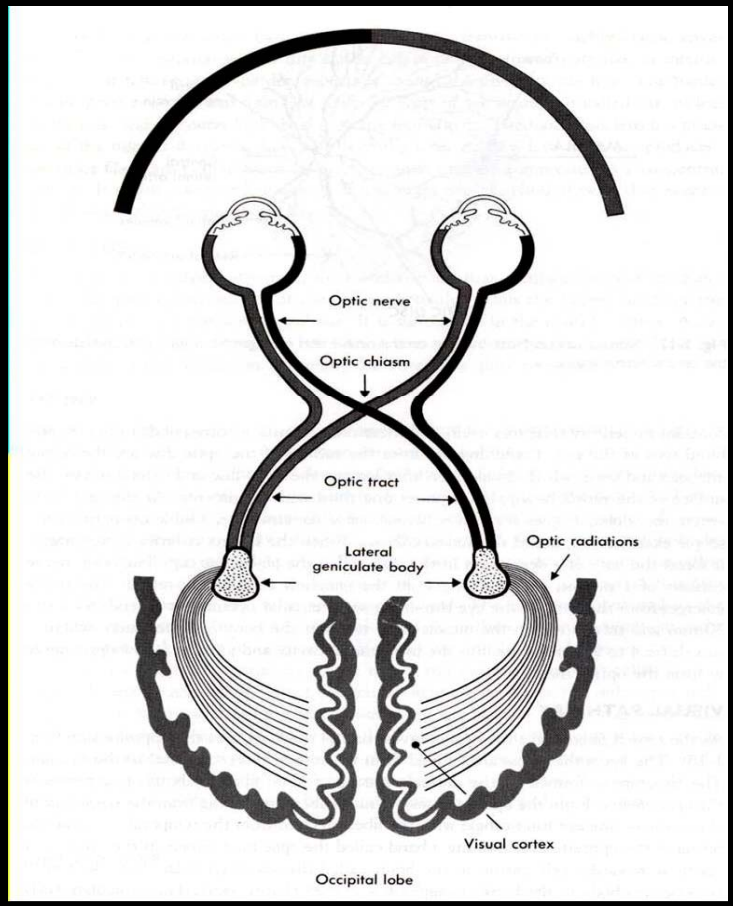




The Visual Pathway

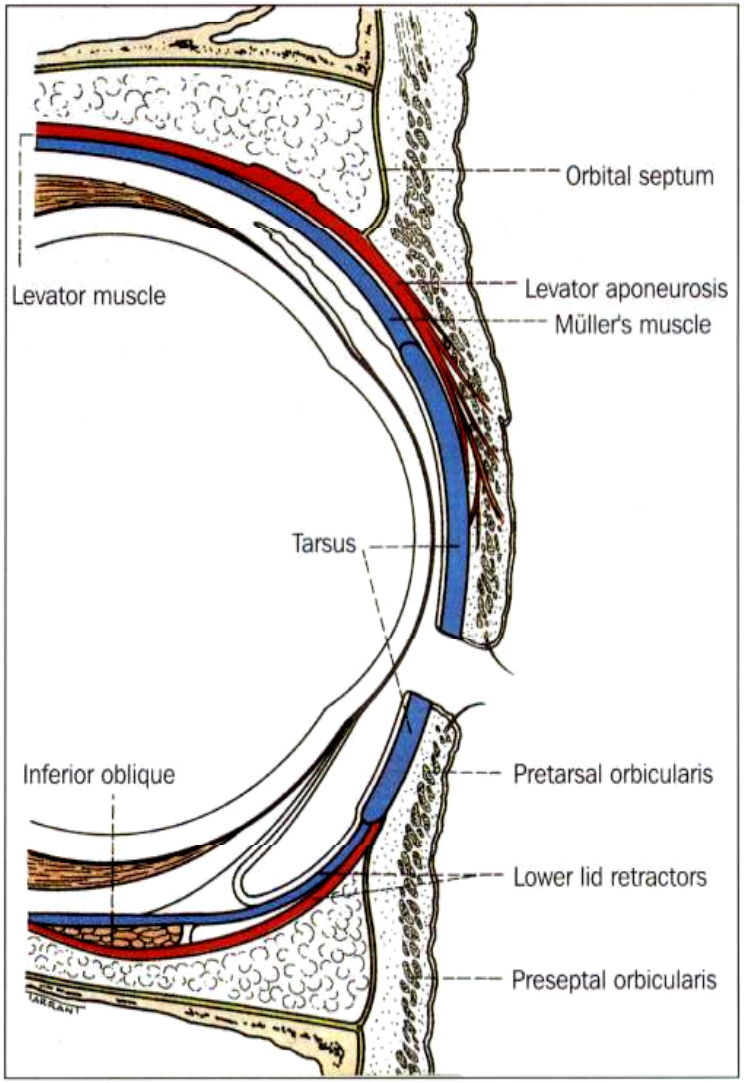
- Visual Pathway: Three neurons

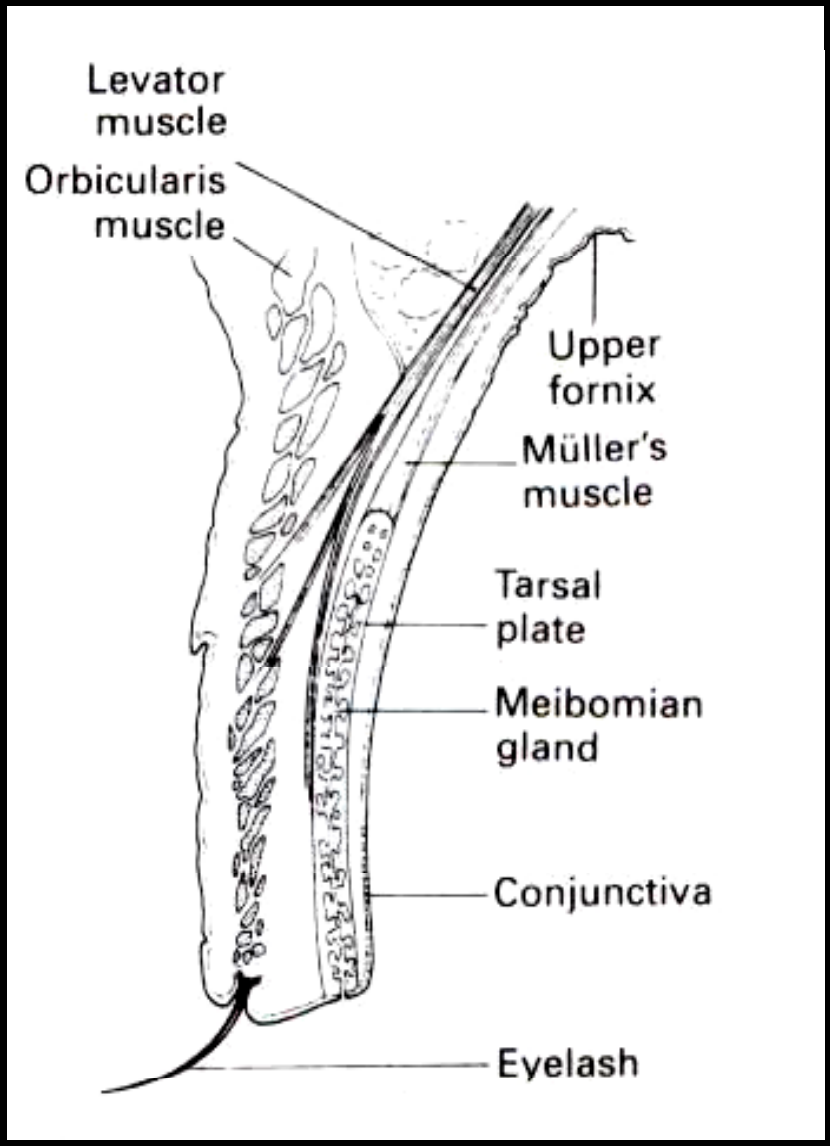
  1. Bipolar cell, lies within the retina.
  2. Ganglion cell, synapse in lateral geniculate body.
  3. Third neuron terminates in visual cortex.

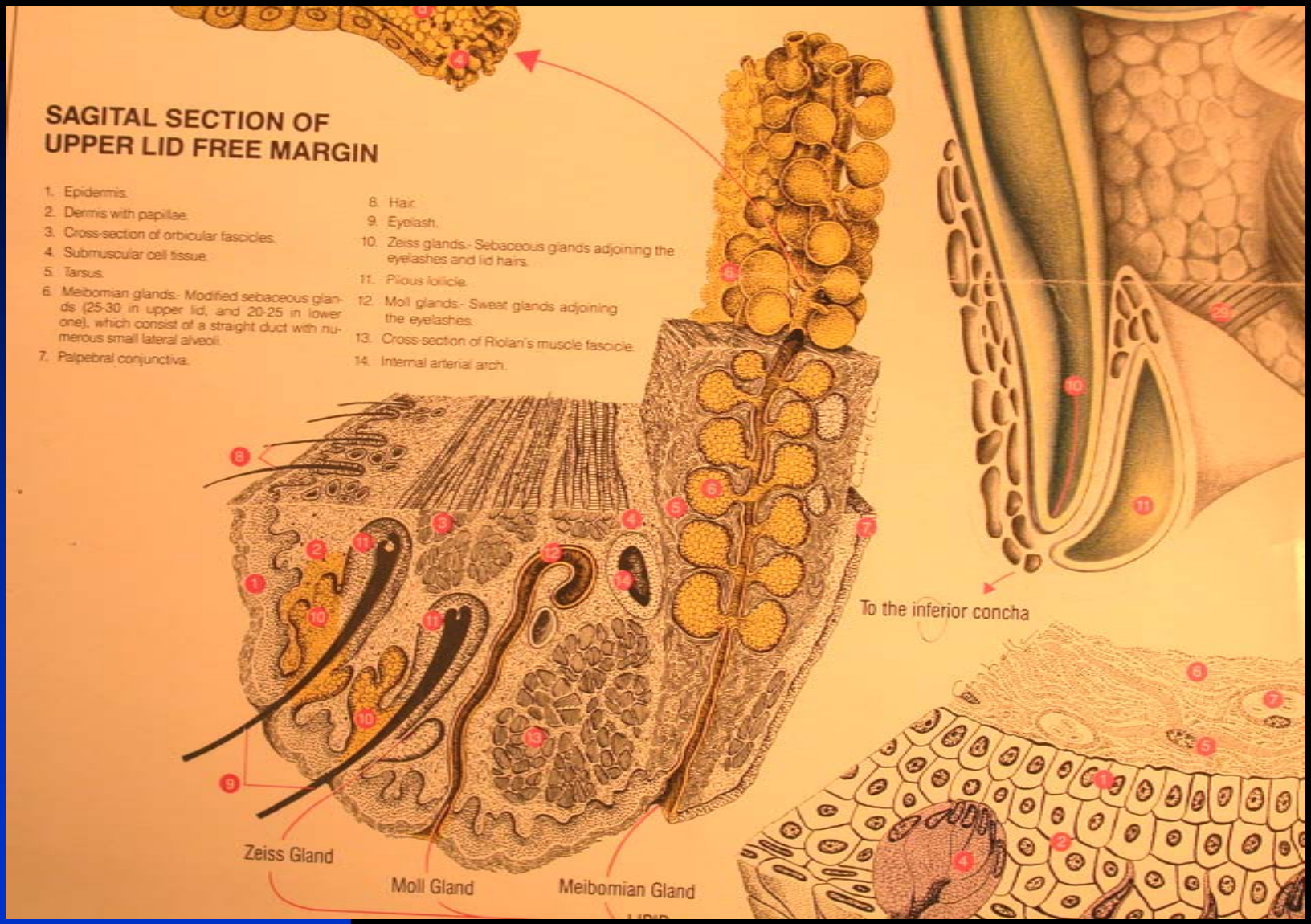


THE EYELIDS

- They provide a protective covering for the eye.
- The lids are closed by Orbicularis oculi muscle (Facial n.) and opened with Levator palpebrae muscle (Oculomotor n.), Muller's muscle (Sympathetic supply) & Lower lid retractors.


Orbital septum
Levator muscle
Levator aponeurosis
Müller's muscle
Tarsus
Inferior oblique
Pretarsal orbicularis
Lower lid retractors
Preseptal orbicularis


Levator muscle
Orbicularis muscle
Upper fornix
Müller's muscle
Tarsal plate
Meibomian gland
Conjunctiva
Eyelash

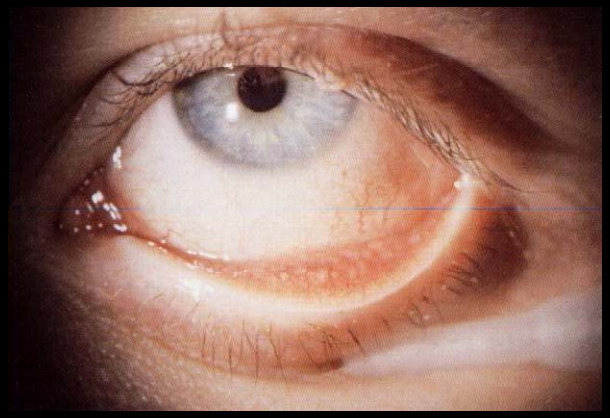

SAGITAL SECTION OF
UPPER LID FREE MARGIN
1. Epidermis.
2. Dermis with papillae.
3. Cross-section of orbicular fascicles.
4. Submuscular cell tissue.
5. Tarsus.
6. Meibomian glands.- Modified sebaceous glands (25-30 in upper lid, and 20-25 in lower one), which consist of a straight duct with numerous small lateral alveoli.
7. Palpebral conjunctiva.
8. Hair.
9. Eyelash.
10. Zeiss glands.- Sebaceous glands adjoining the eyelashes and lid hairs.
11. Pilous follicle.
12. Moll glands.- Sweat glands adjoining the eyelashes.
13. Cross-section of Riolan's muscle fascicle.
14. Internal arterial arch.
To the inferior concha
Zeiss Gland
Moll Gland
Meibomian Gland

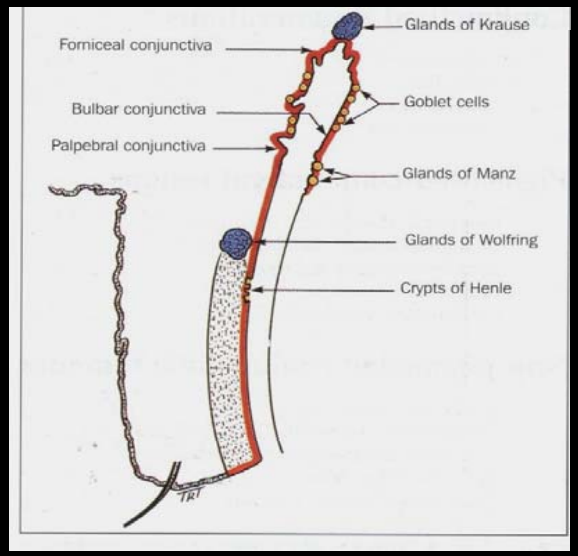
CONJUNCTIVA

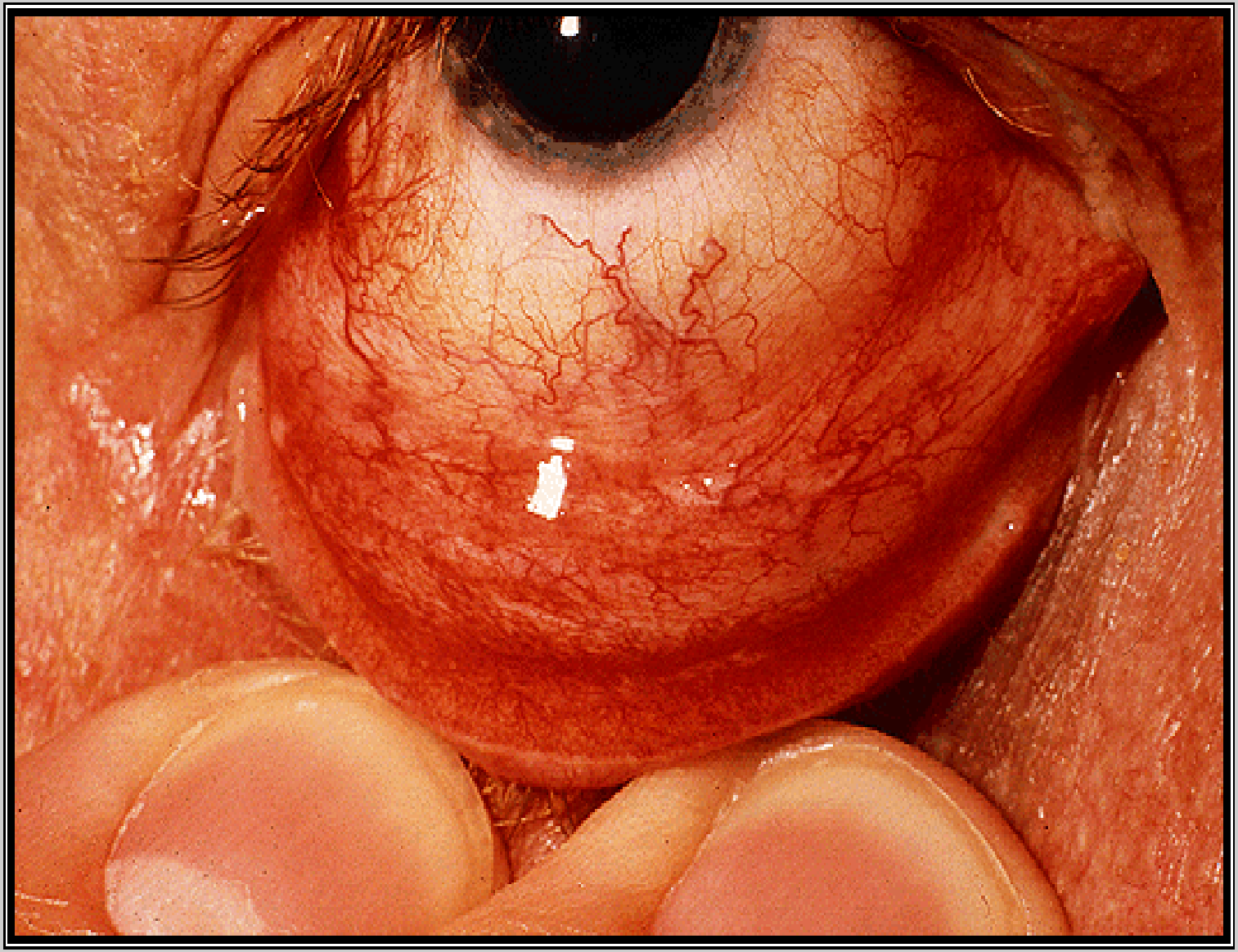
- **Three parts:**

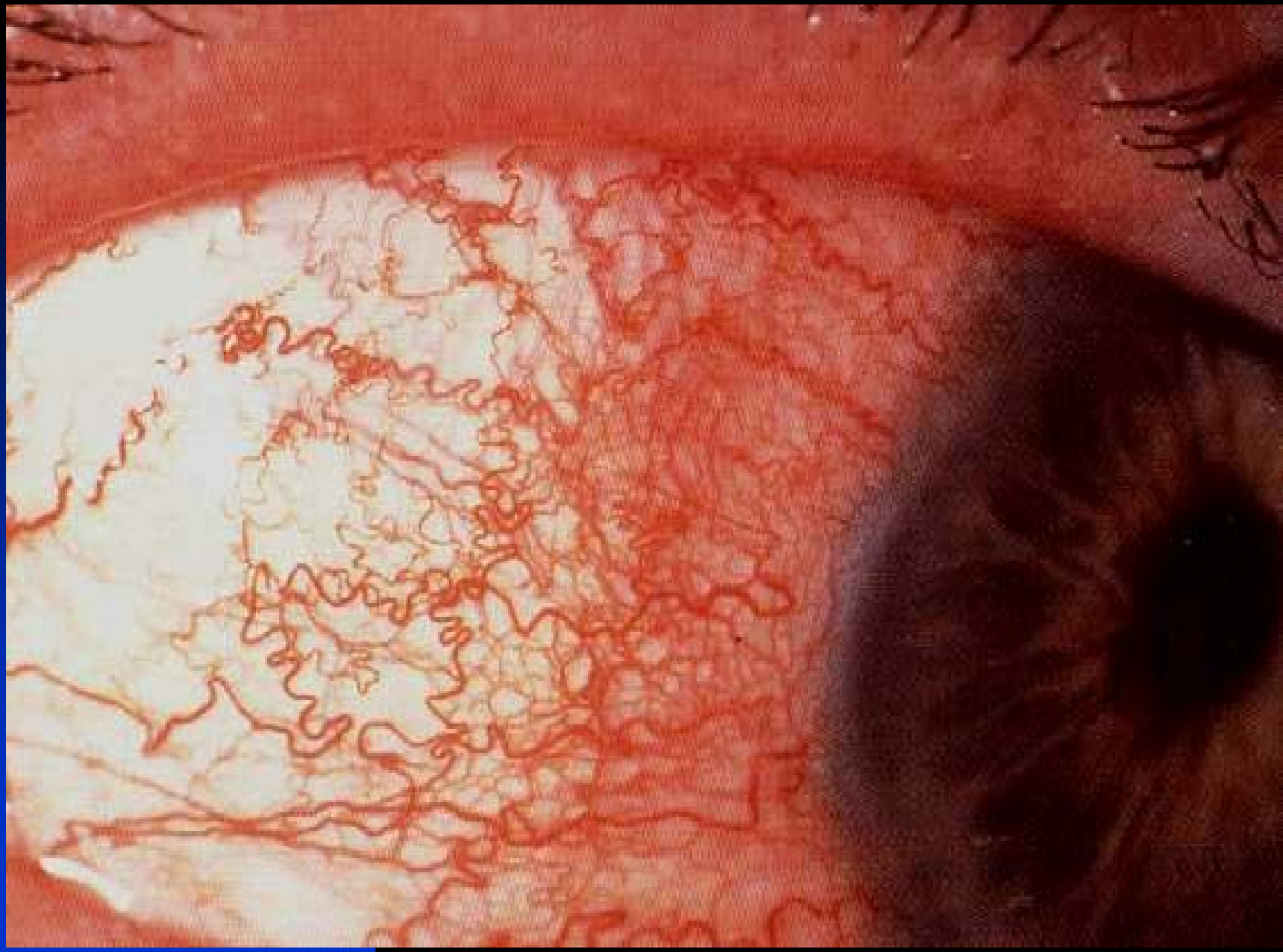
1. Bulbar conjunctiva.
2. Palpebral conjunctiva.
3. Forniceal conjunctiva.

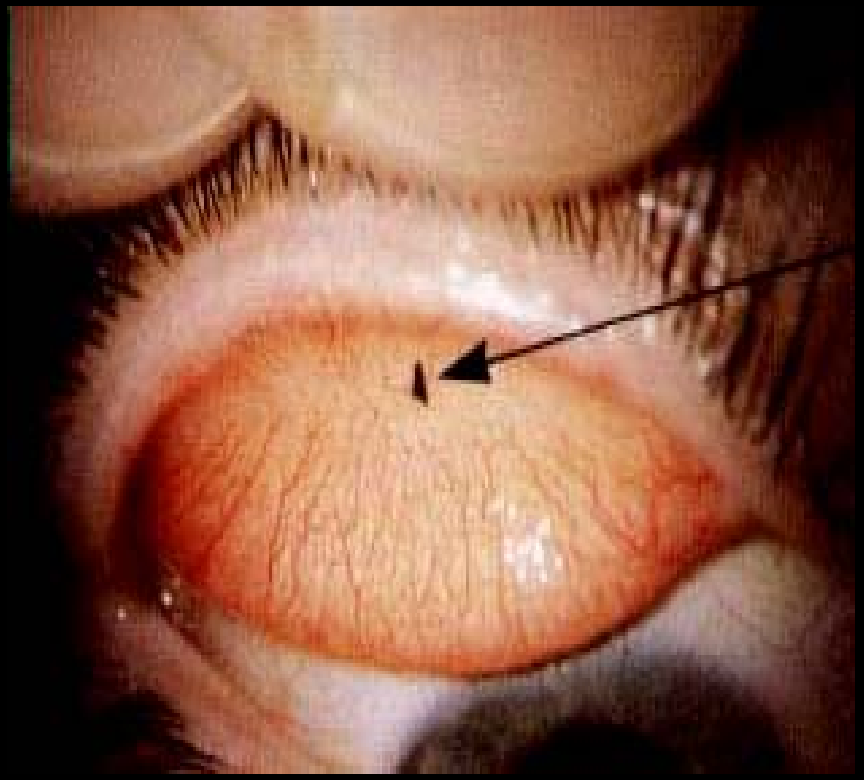
- **The stroma (no adenoid tissues until 3 months after birth).**
- **Follicles & Papillae.**
- **Injection and chemosis.**
- **Limbus.**





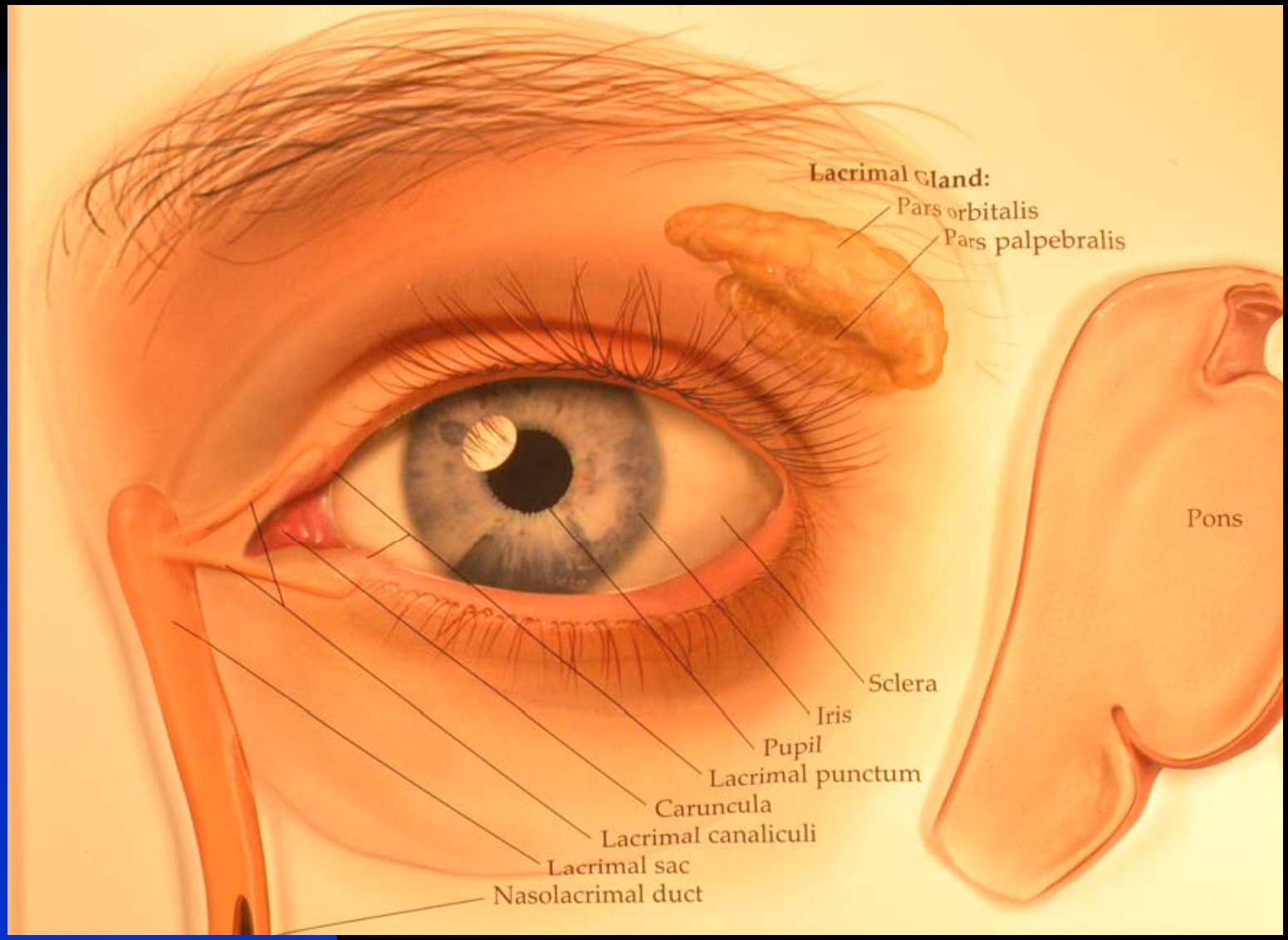


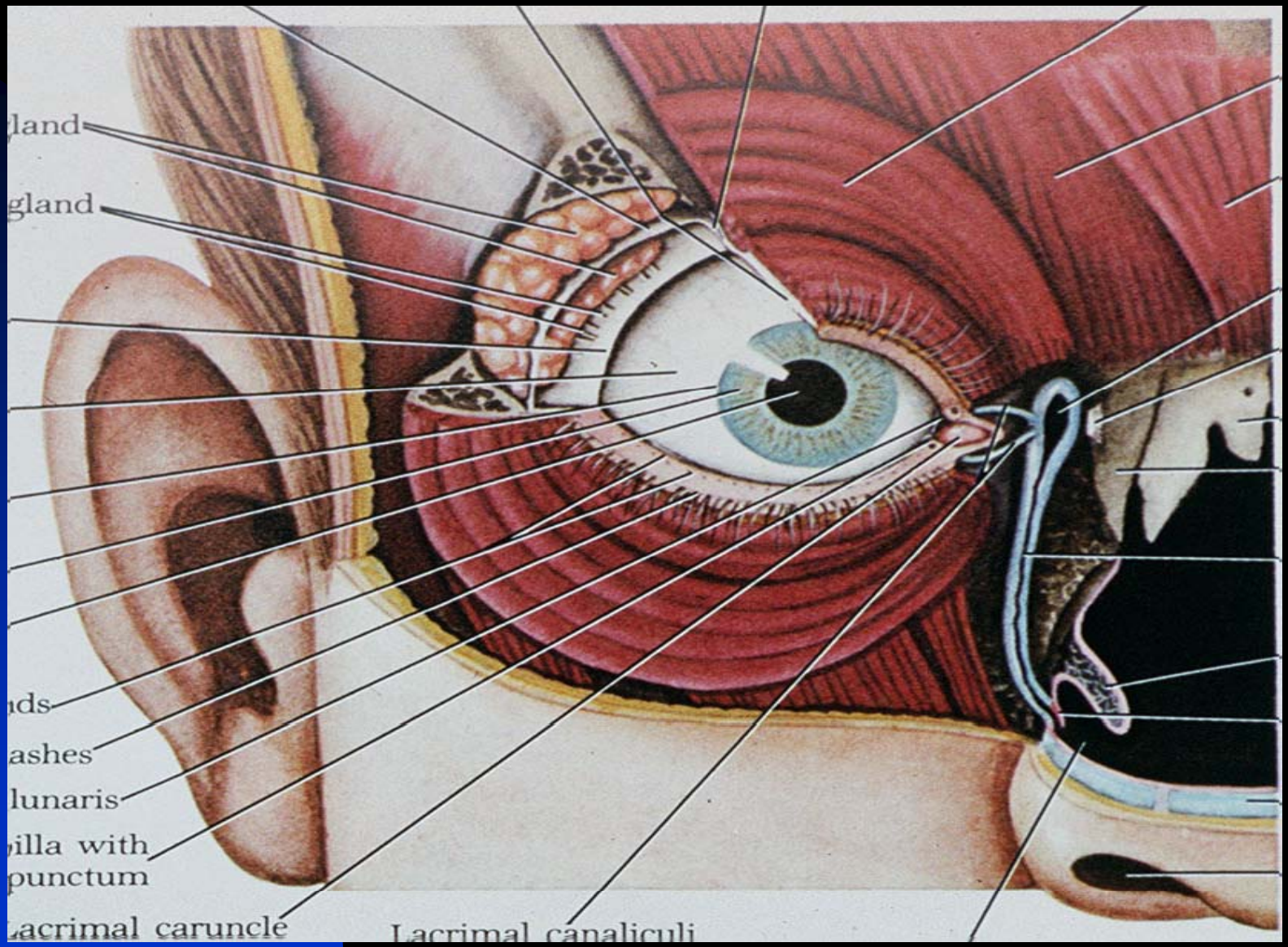


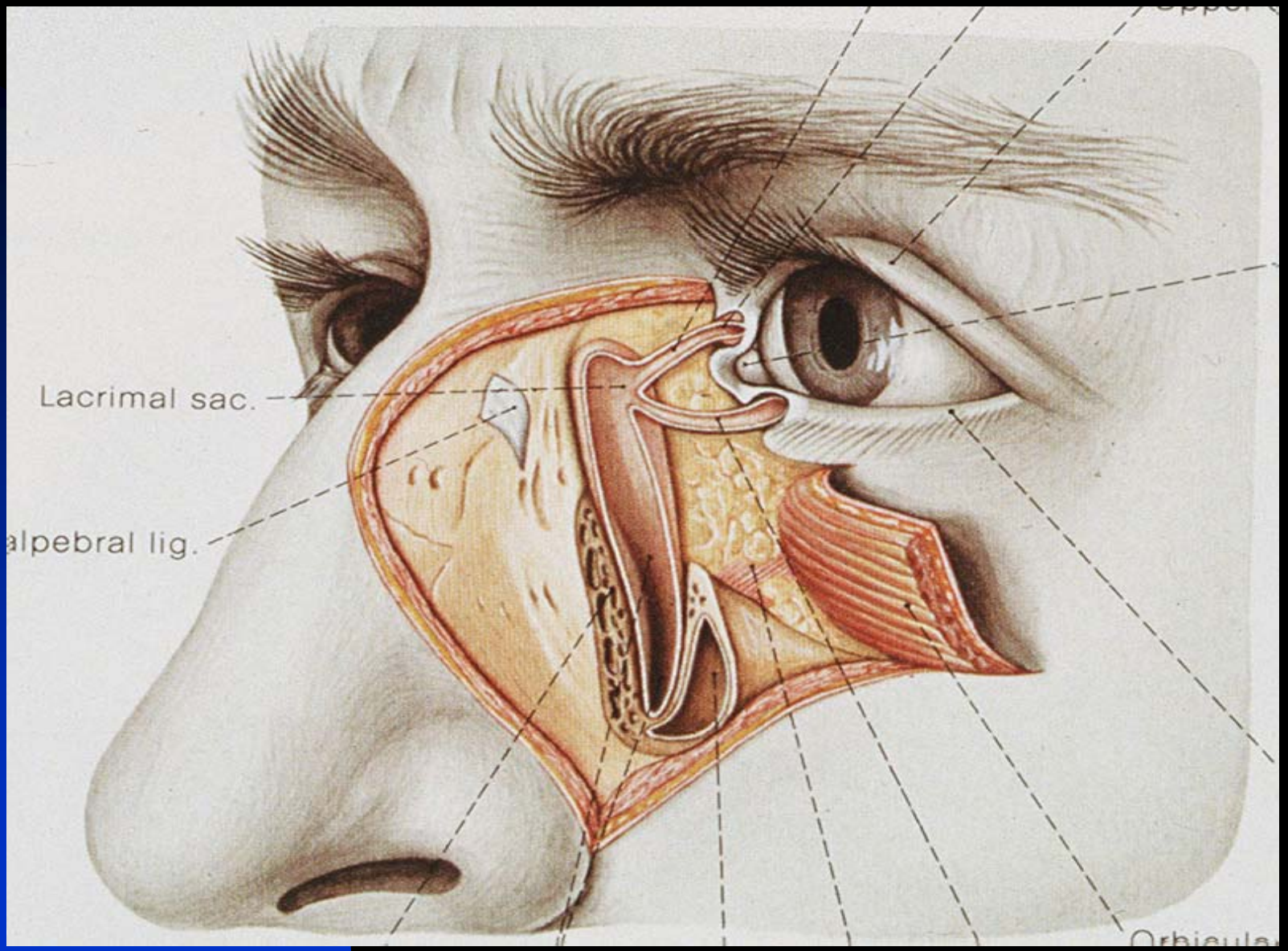


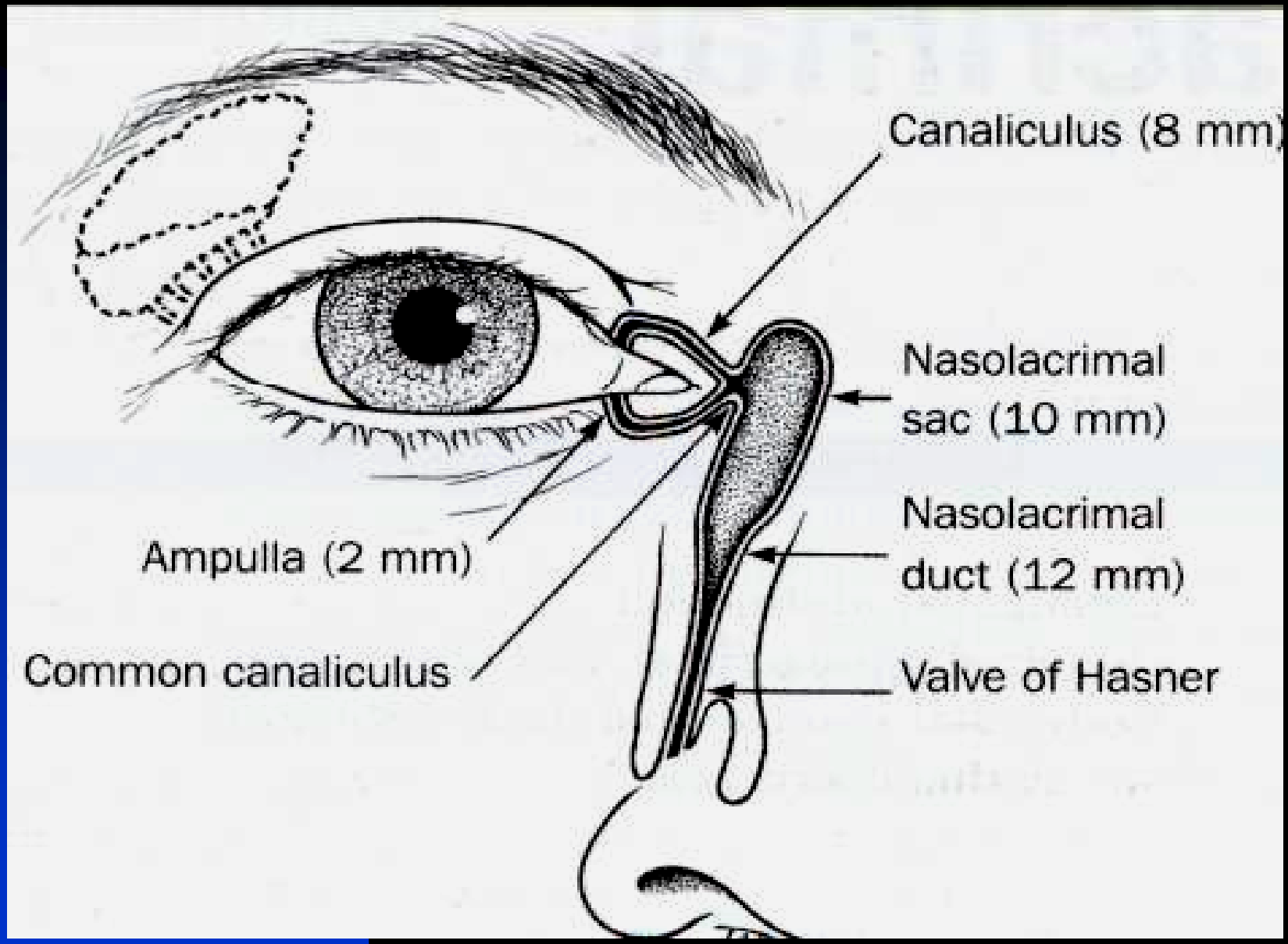
THE LACRIMAL APPARATUS

- Lacrimal gland secrets tears into the upper fornix of the conjunctival sac which are spread over the surface of the cornea as a tear film by blinking of the lids.
- Tears accumulate at the inner canthus and drain into the lacrimal sac via the puncta & canaliculi.
- The sac is continuous inferiorly with the nasolacrimal duct which opens into the nasal cavity just beneath the inferior turbinate.


Lacrimal Gland:
Pars orbitalis
Pars palpebralis
Pons
Sclera
Iris
Pupil
Lacrimal punctum
Caruncula
Lacrimal canaliculi
Lacrimal sac
Nasolacrimal duct


gland
gland
ids
ashes
lunaris
illa with
punctum
Lacrimal caruncle
Lacrimal canaliculi

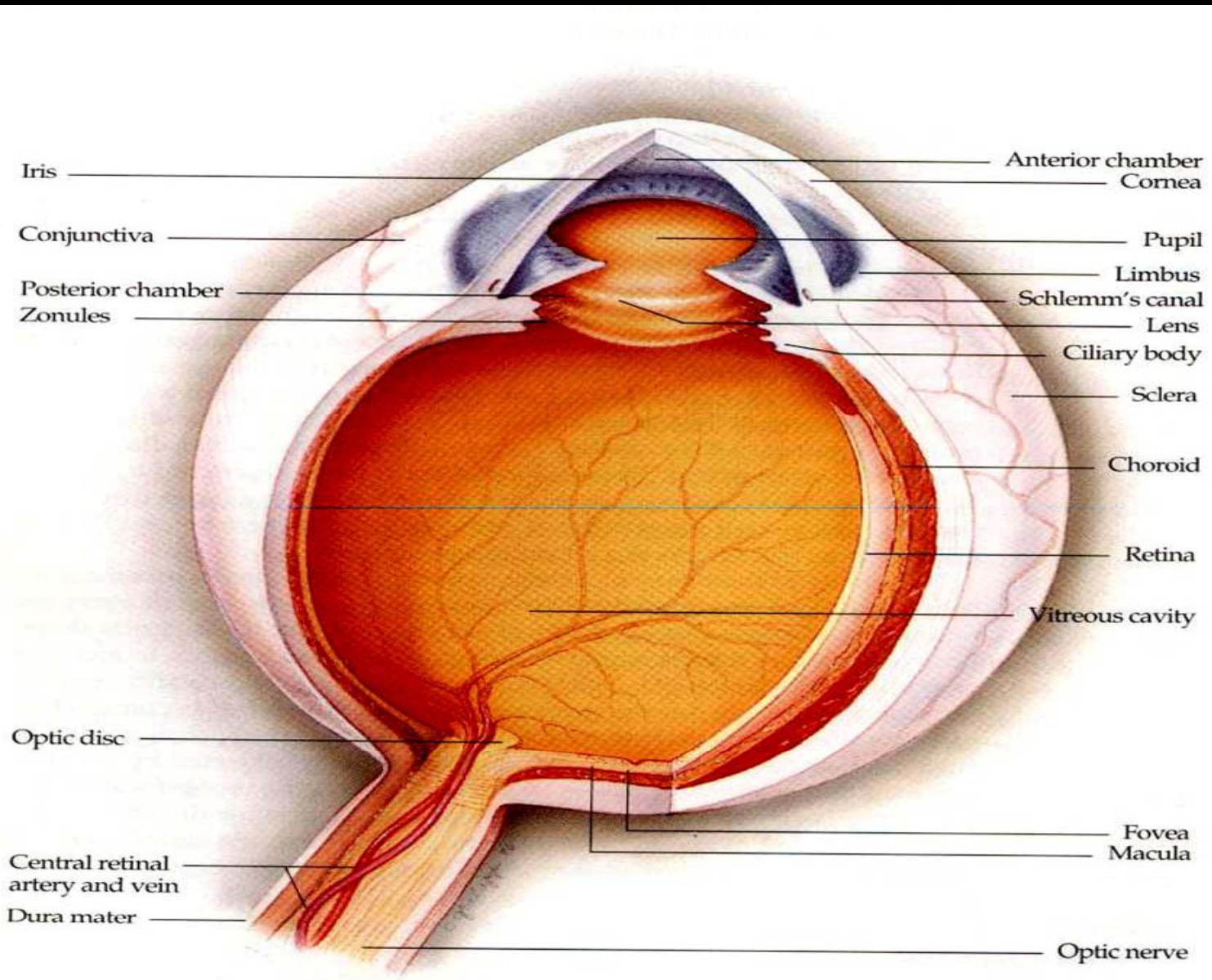

Lacrimal sac.
alpebral lig.


Canaliculus (8 mm)
Nasolacrimal sac (10 mm)
Nasolacrimal duct (12 mm)
Valve of Hasner
Ampulla (2 mm)
Common canaliculus

THE EYE (GLOBE)

- Two spheres with different radii:
  - Cornea, window of the eye.
  - Sclera, opaque shell.

*** The eye measures approximately 24 mm in all its main diameters.

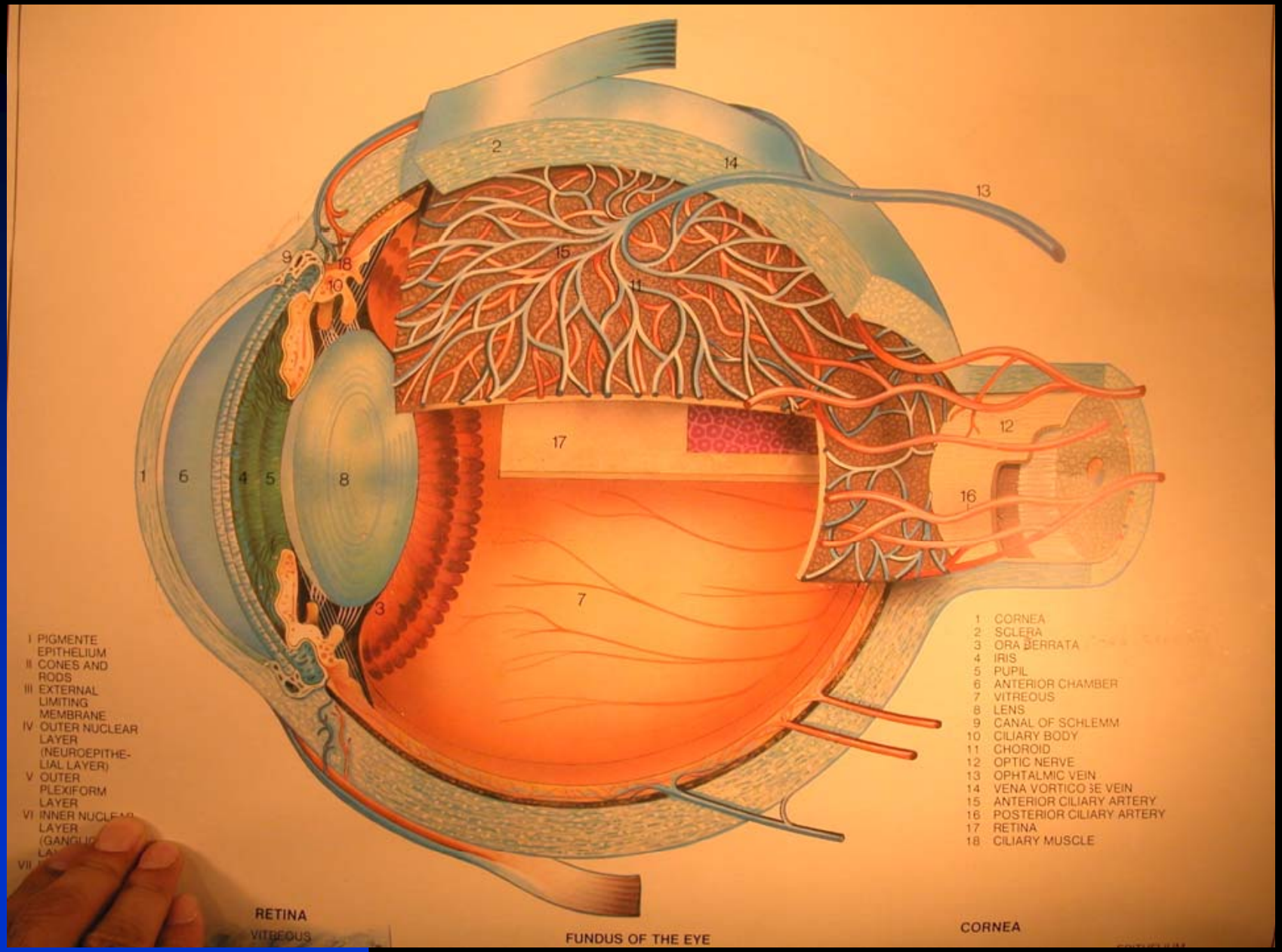

Iris
Conjunctiva
Posterior chamber
Zonules
Optic disc
Central retinal artery and vein
Dura mater
Anterior chamber
Cornea
Pupil
Limbus
Schlemm's canal
Lens
Ciliary body
Sclera
Choroid
Retina
Vitreous cavity
Fovea
Macula
Optic nerve

The coats of the eye

*** **<u>Three layers:</u>**

- The outer: inelastic coat, transparent cornea and opaque sclera.
- The middle, vascular coat, The Uvea:

  choroid, ciliary body and iris.
- The inner: The Retina, extends forwards to within 6 mm of the limbus.


I PIGMENTE EPITHELIUM
II CONES AND RODS
III EXTERNAL LIMITING MEMBRANE
IV OUTER NUCLEAR LAYER (NEUROEPITHELIAL LAYER)
V OUTER PLEXIFORM LAYER
VI INNER NUCLEAR LAYER (GANGLIONIC LAYER)
VII
RETINA
VITREOUS
FUNDUS OF THE EYE
1 CORNEA
2 SCLERA
3 ORA SERRATA
4 IRIS
5 PUPIL
6 ANTERIOR CHAMBER
7 VITREOUS
8 LENS
9 CANAL OF SCHLEMM
10 CILIARY BODY
11 CHOROID
12 OPTIC NERVE
13 OPHTALMIC VEIN
14 VENA VORTICOSE VEIN
15 ANTERIOR CILIARY ARTERY
16 POSTERIOR CILIARY ARTERY
17 RETINA
18 CILIARY MUSCLE
CORNEA

The Chambers of The Eye

***<u>**Three optically clear spaces:**</u>

- The anterior chamber, in front of the iris
- The posterior chamber, immediately behind the iris. These two chambers which communicate through the pupil are filled with clear aqueous humour.
- The vitreous cavity: filled by gel-like structure, The Vitreous.

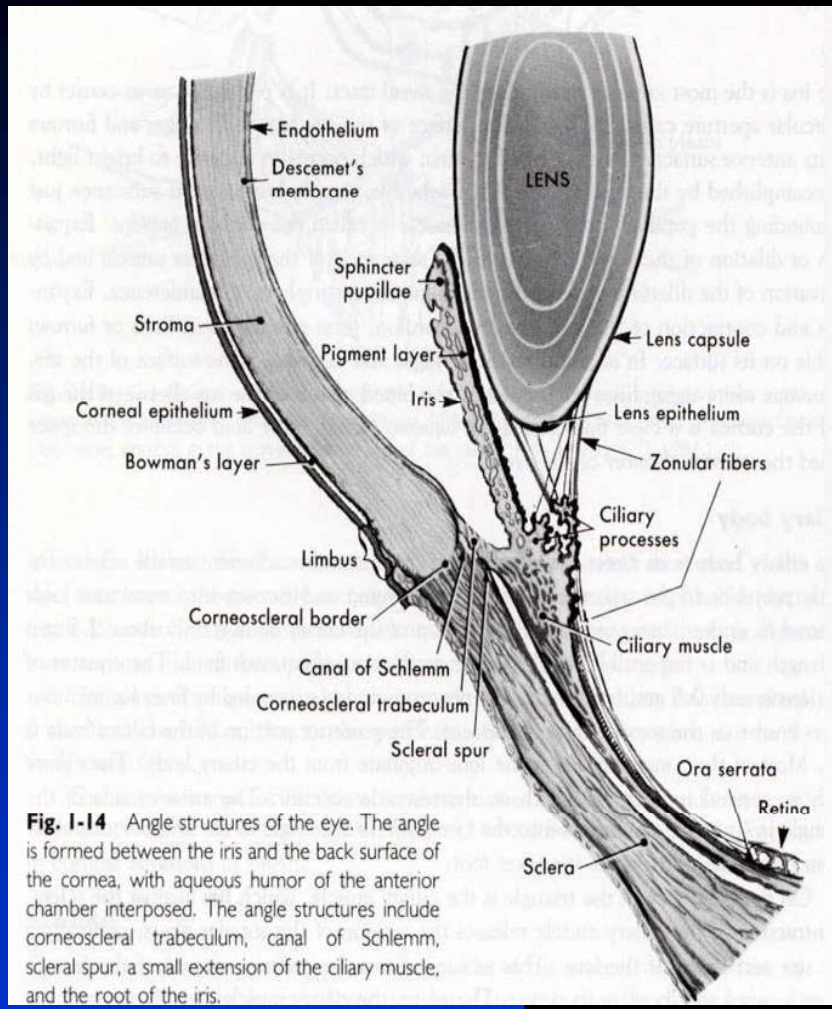
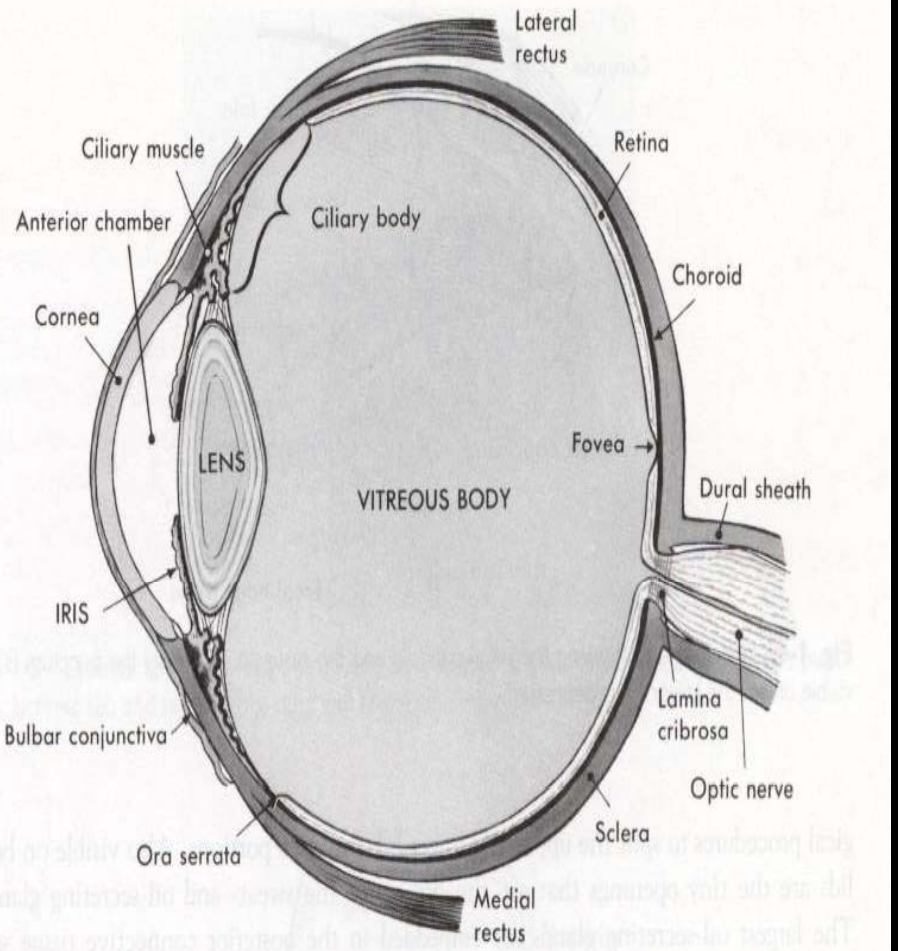
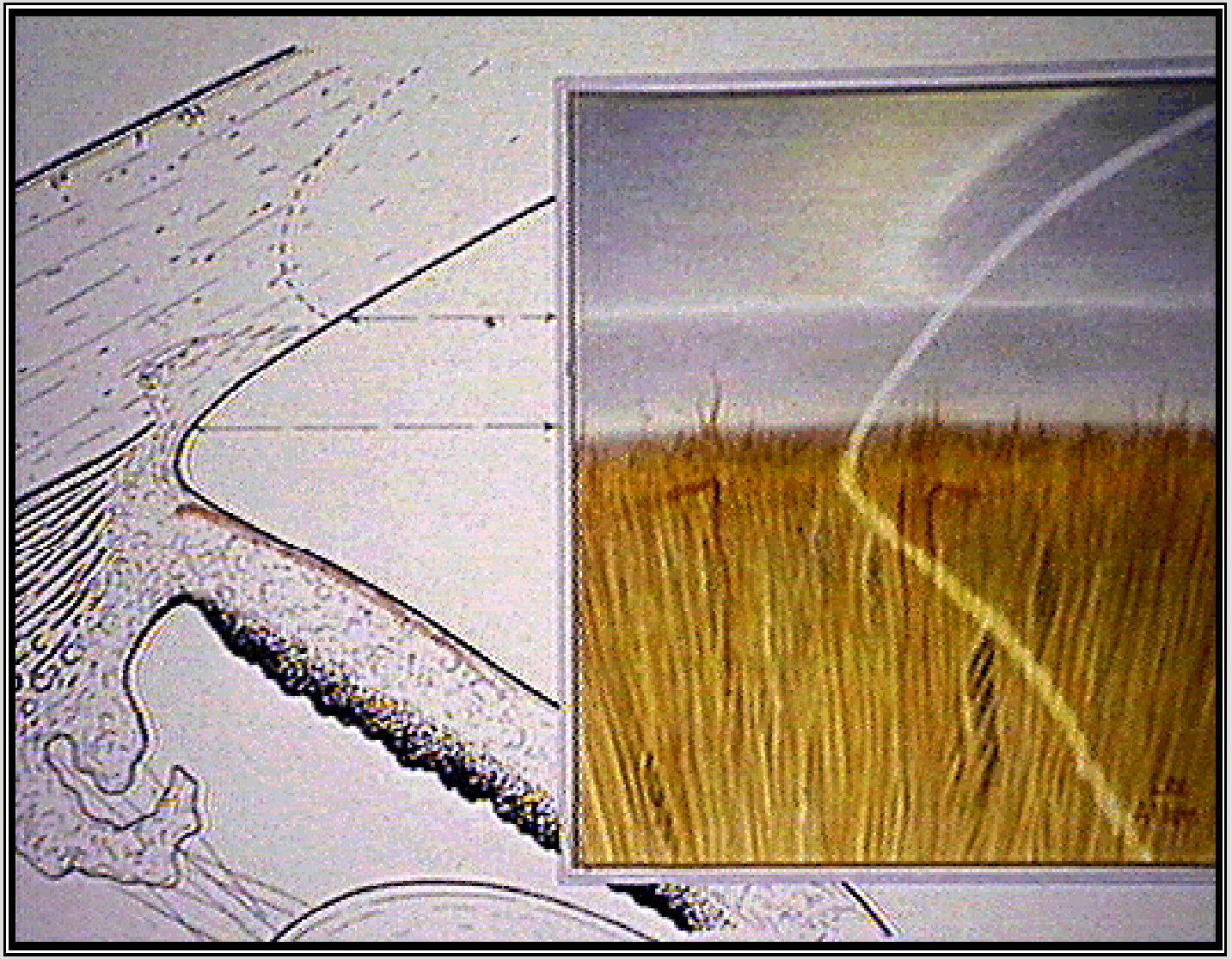


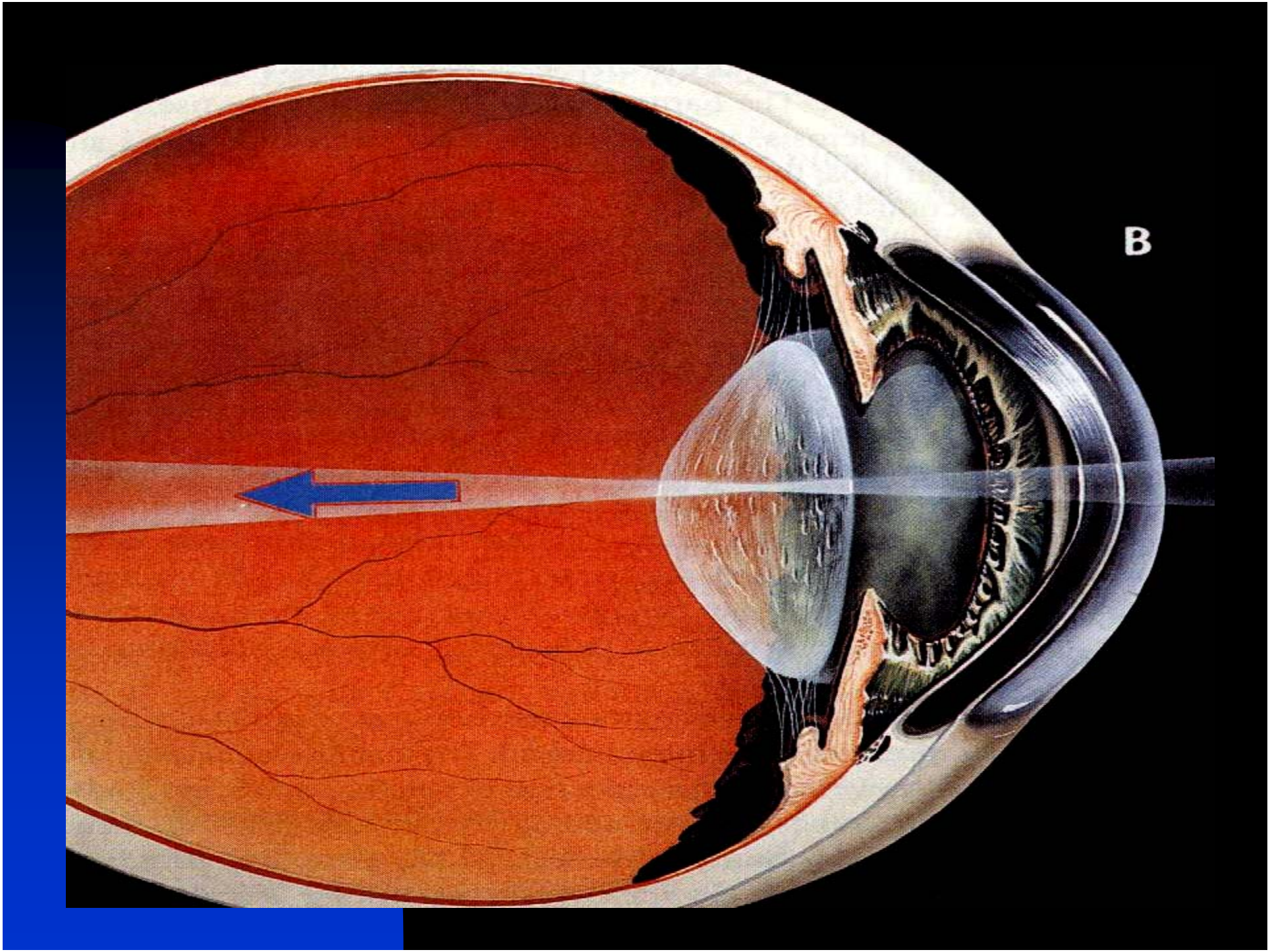
Fig. 1-14 Angle structures of the eye. The angle is formed between the iris and the back surface of the cornea, with aqueous humor of the anterior chamber interposed. The angle structures include corneoscleral trabeculum, canal of Schlemm, scleral spur, a small extension of the ciliary muscle, and the root of the iris.

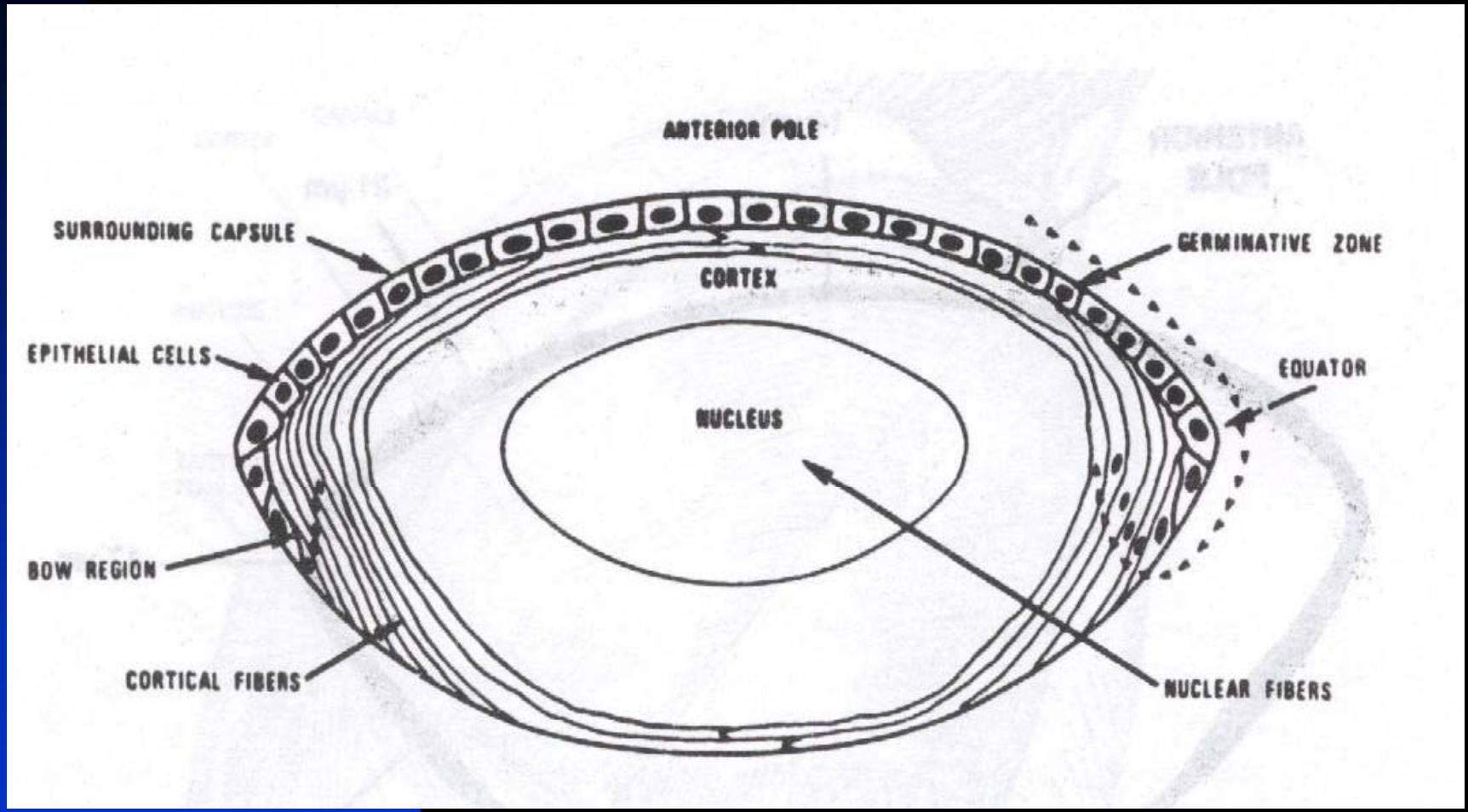


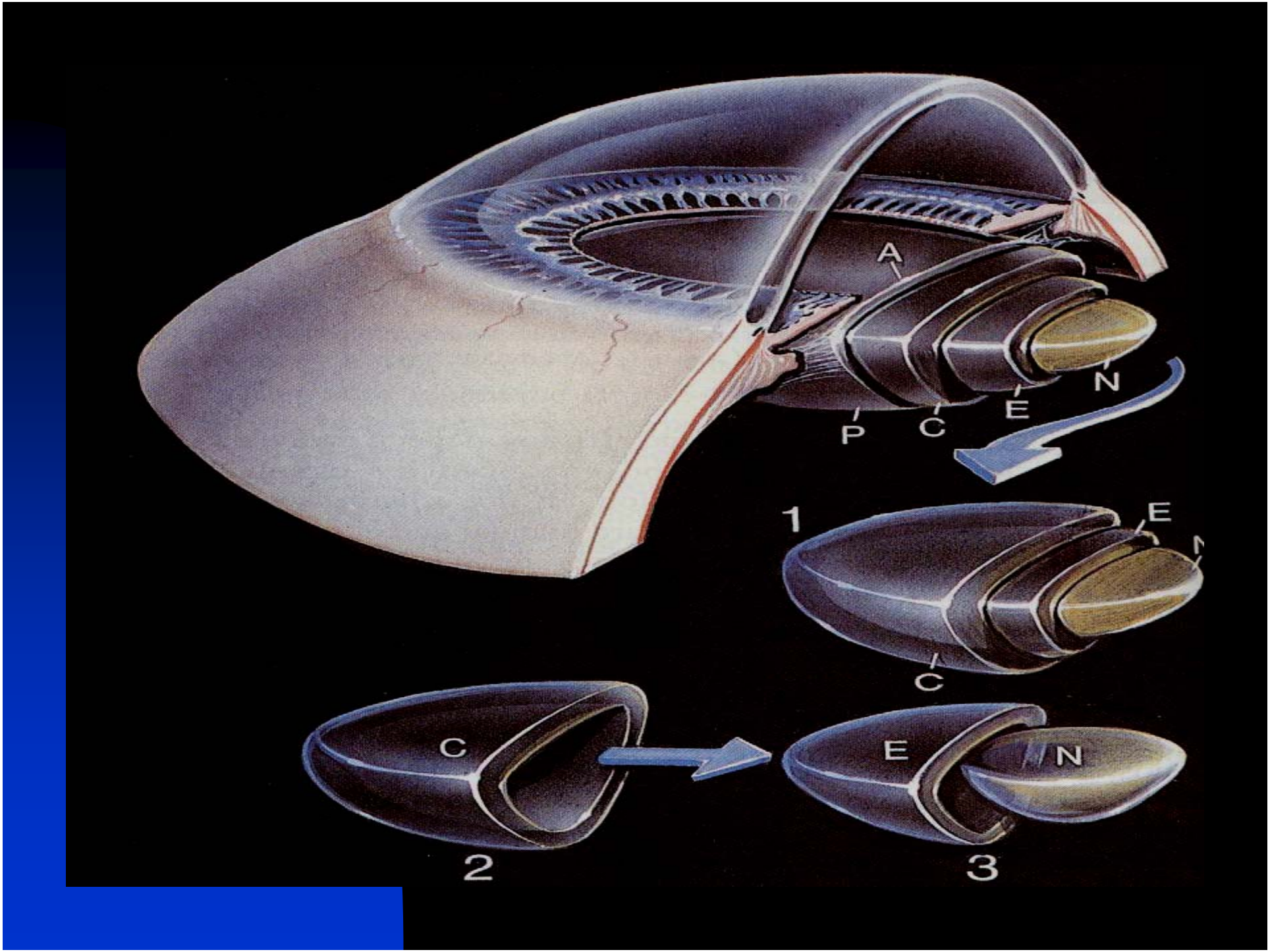


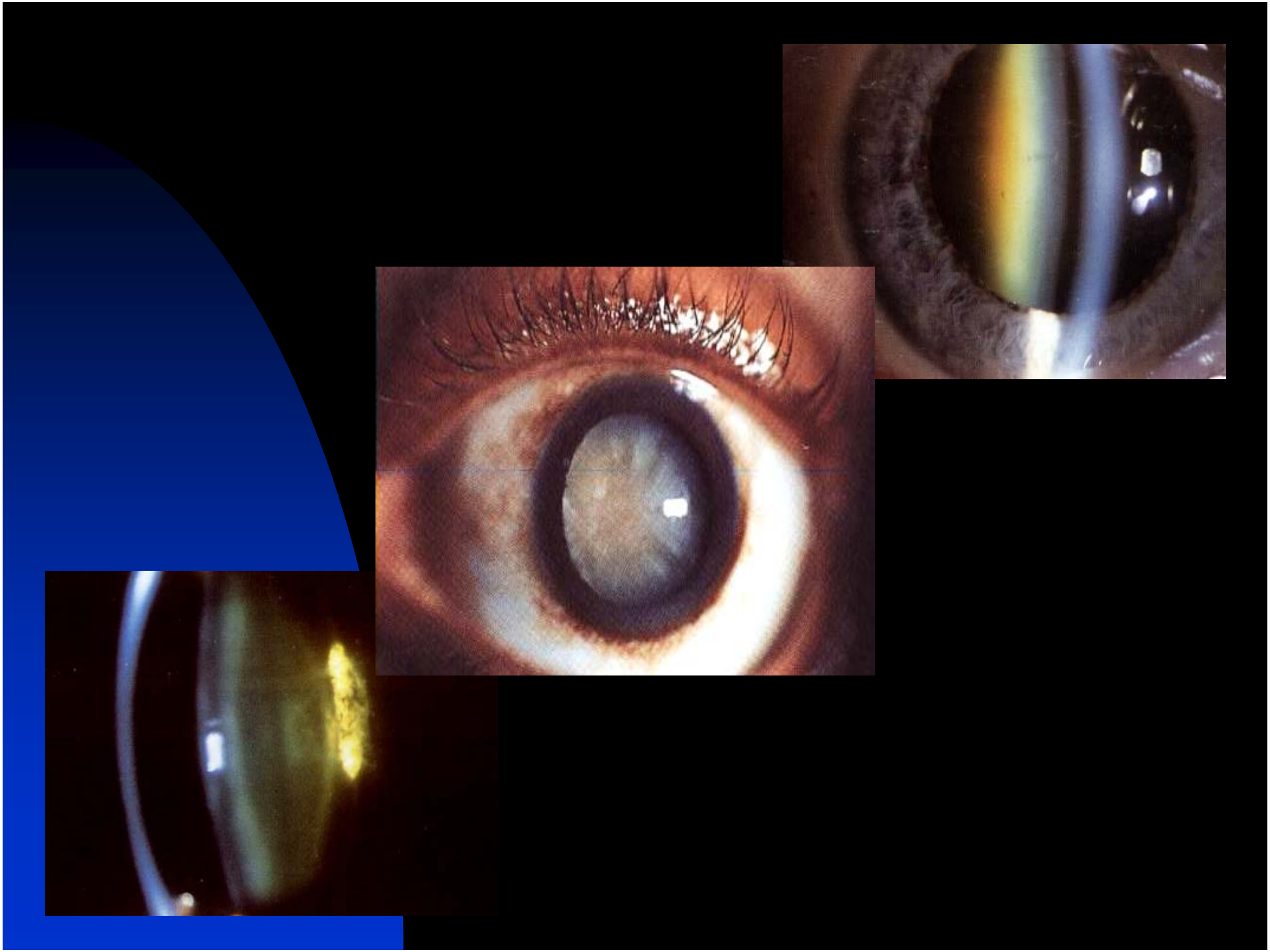
The Lens

- The crystalline lens is the only structure continuously growing throughout the life.
- Changeable refractive media.
- Capsule, epithelium and lens fibers.
- Congenital anomalies and effect of systemic diseases.
- Cataract.


B

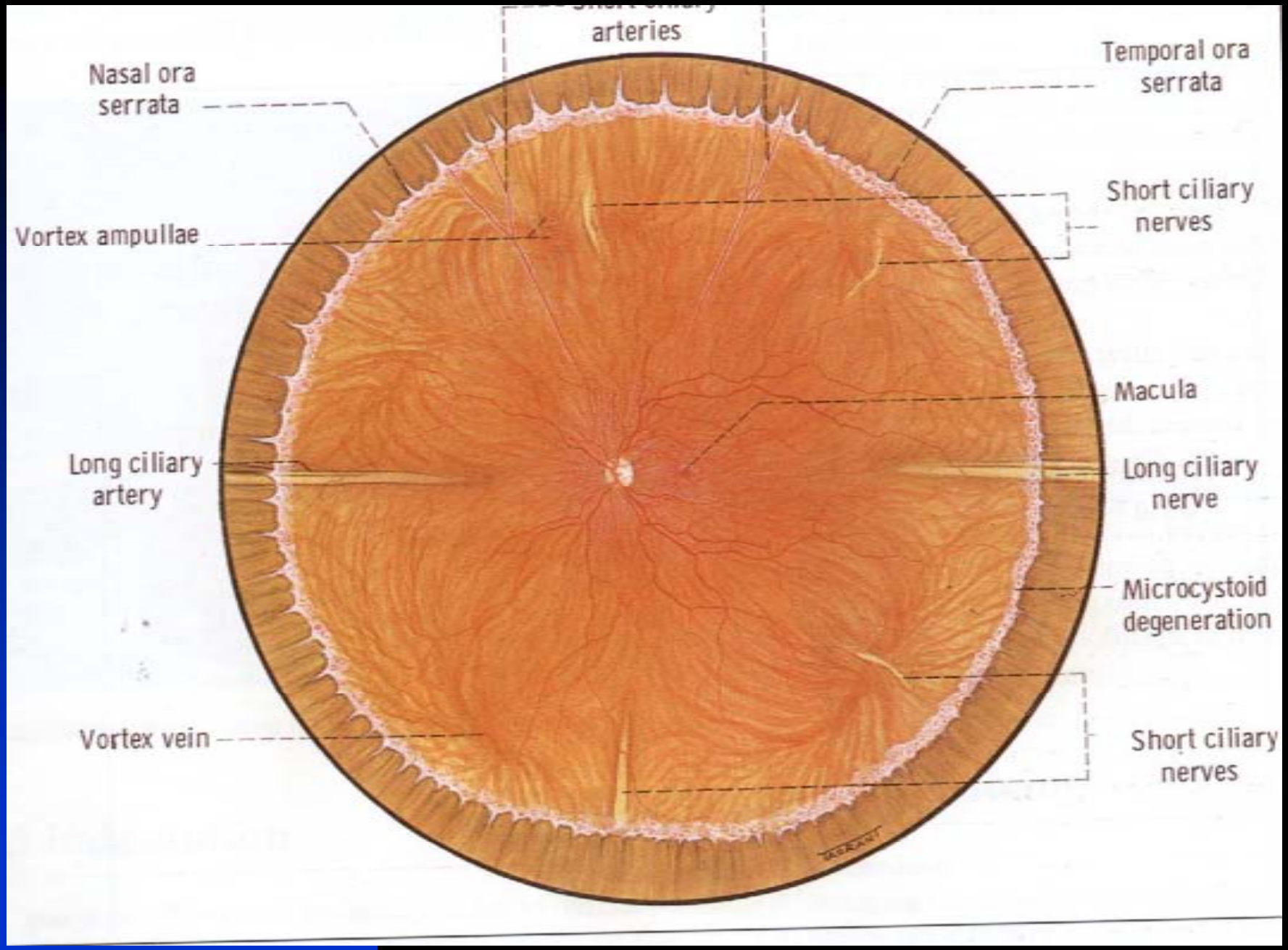

ANTERIOR POLE
SURROUNDING CAPSULE
CORTEX
GERMINATIVE ZONE
EPITHELIAL CELLS
EQUATOR
NUCLEUS
BOW REGION
CORTICAL FIBERS
NUCLEAR FIBERS

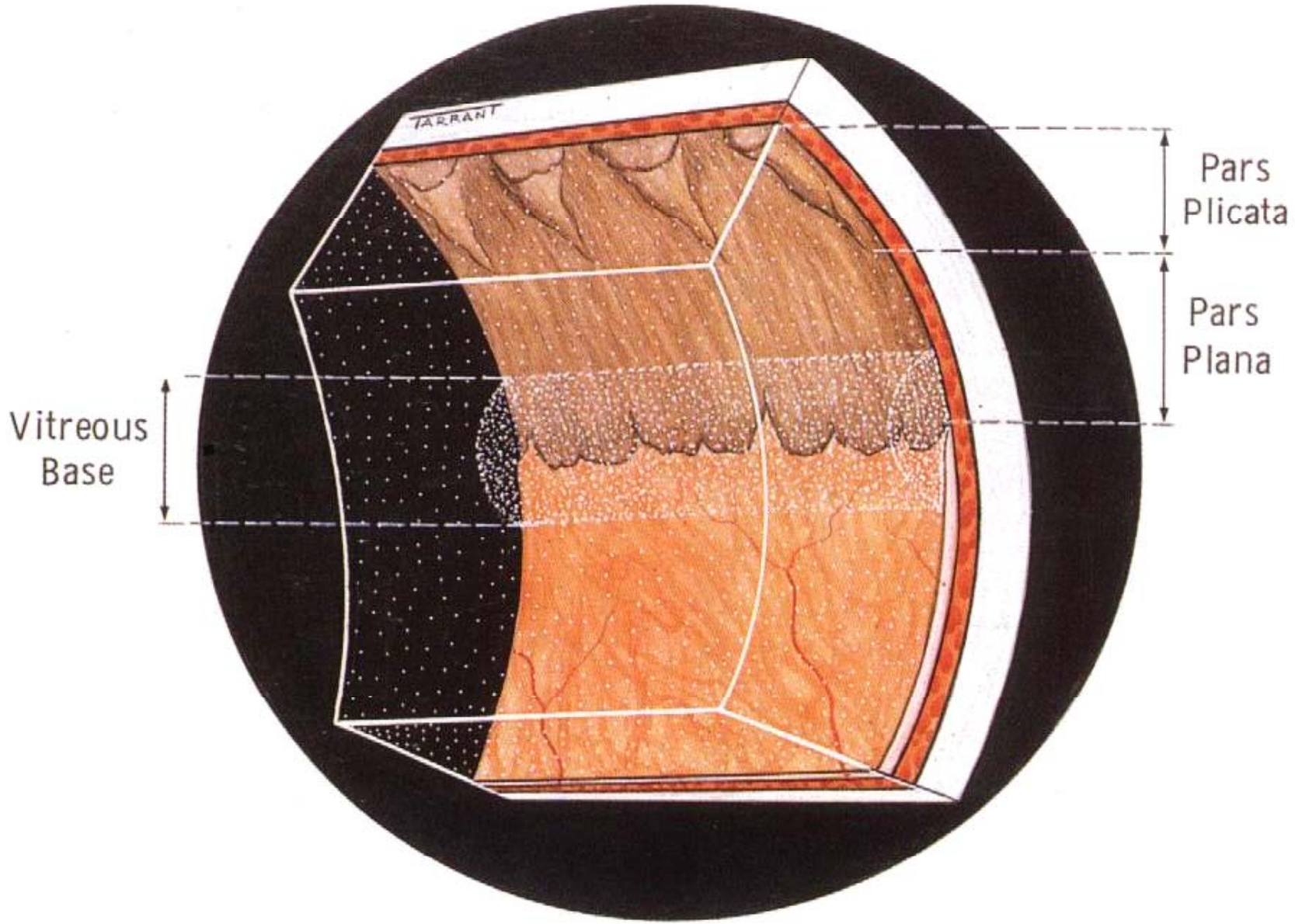

A
P
C
E
N
1
E
C
C
E
N
2
3

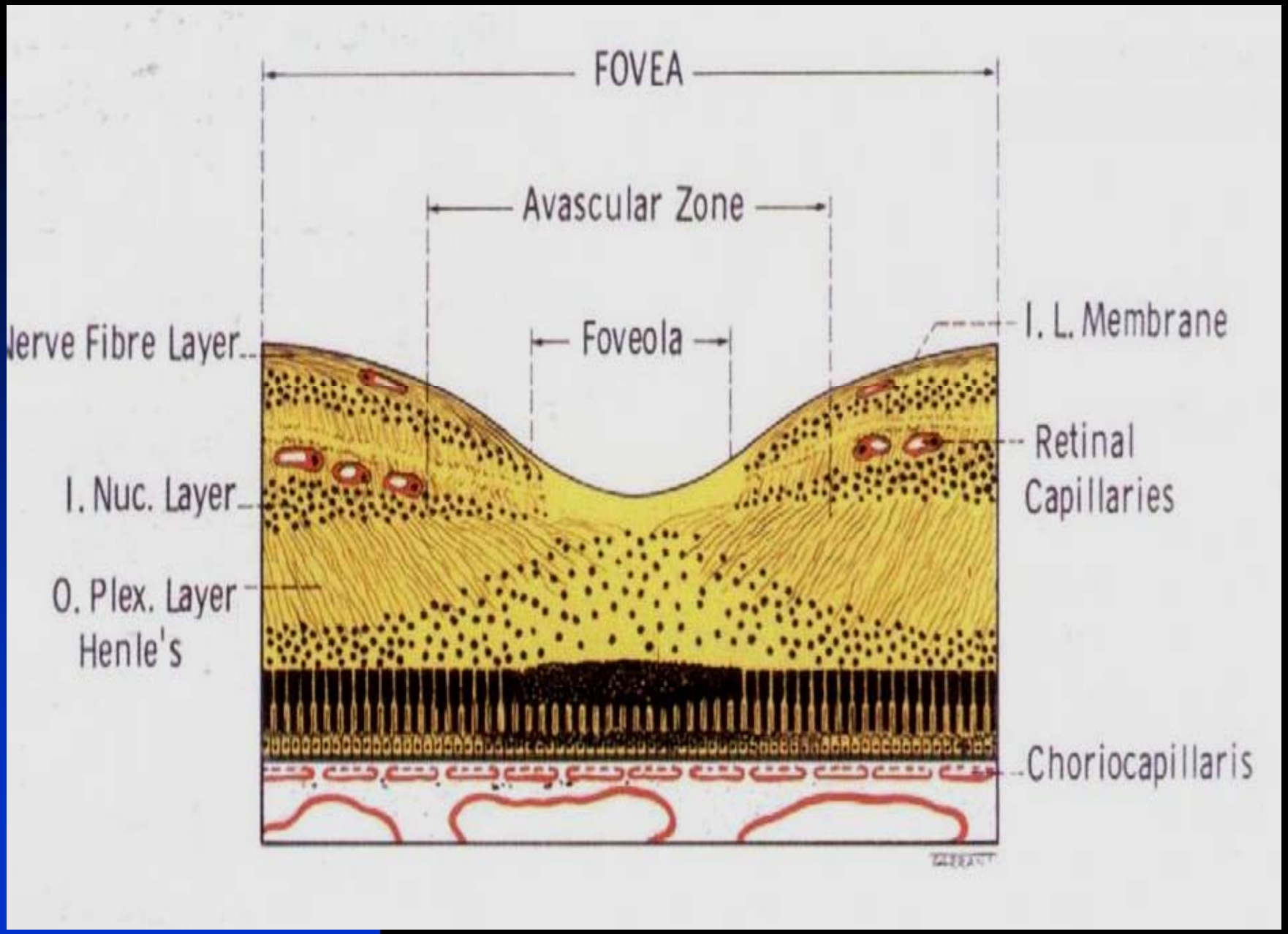


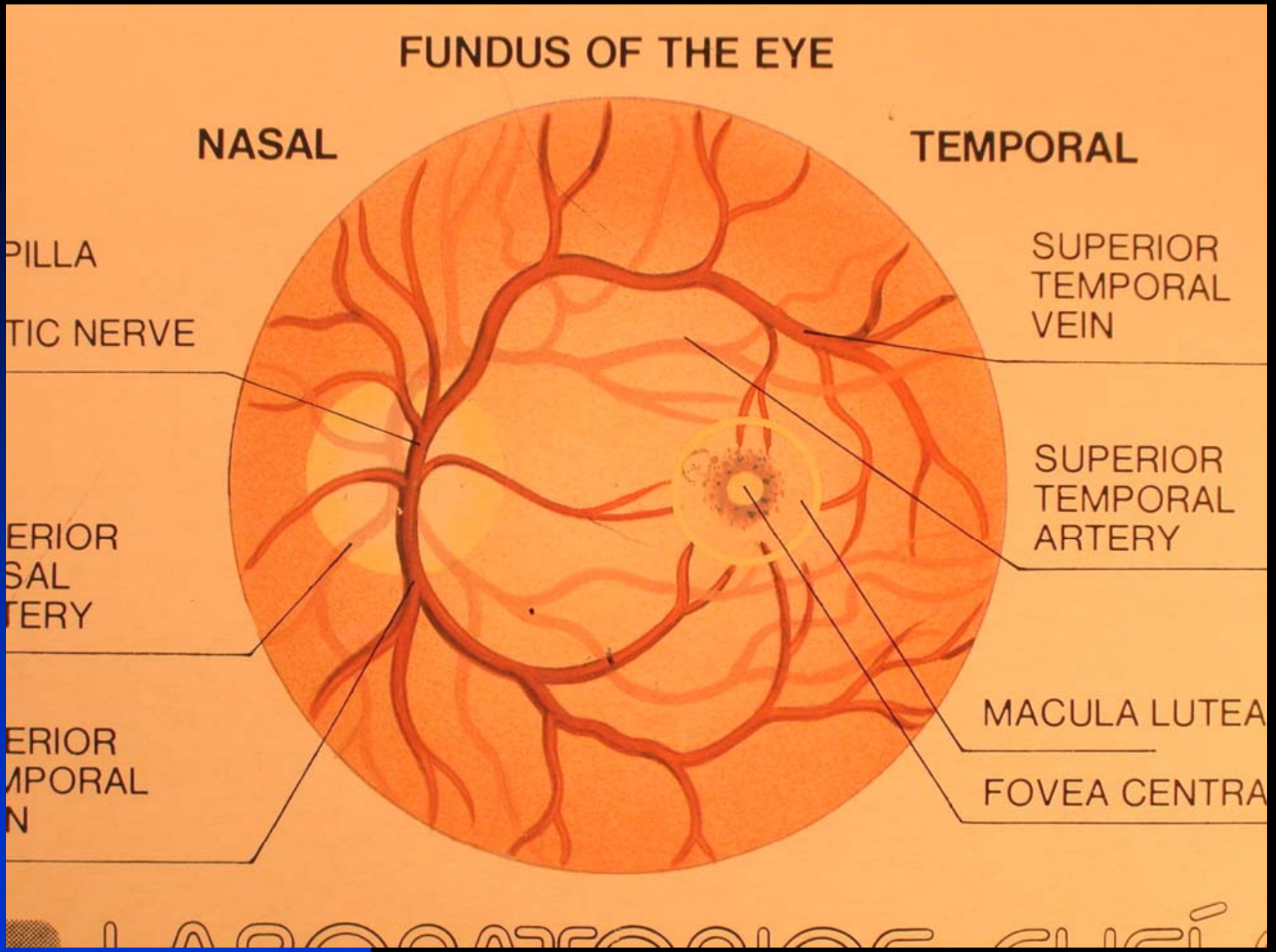
Retina and Vitreous

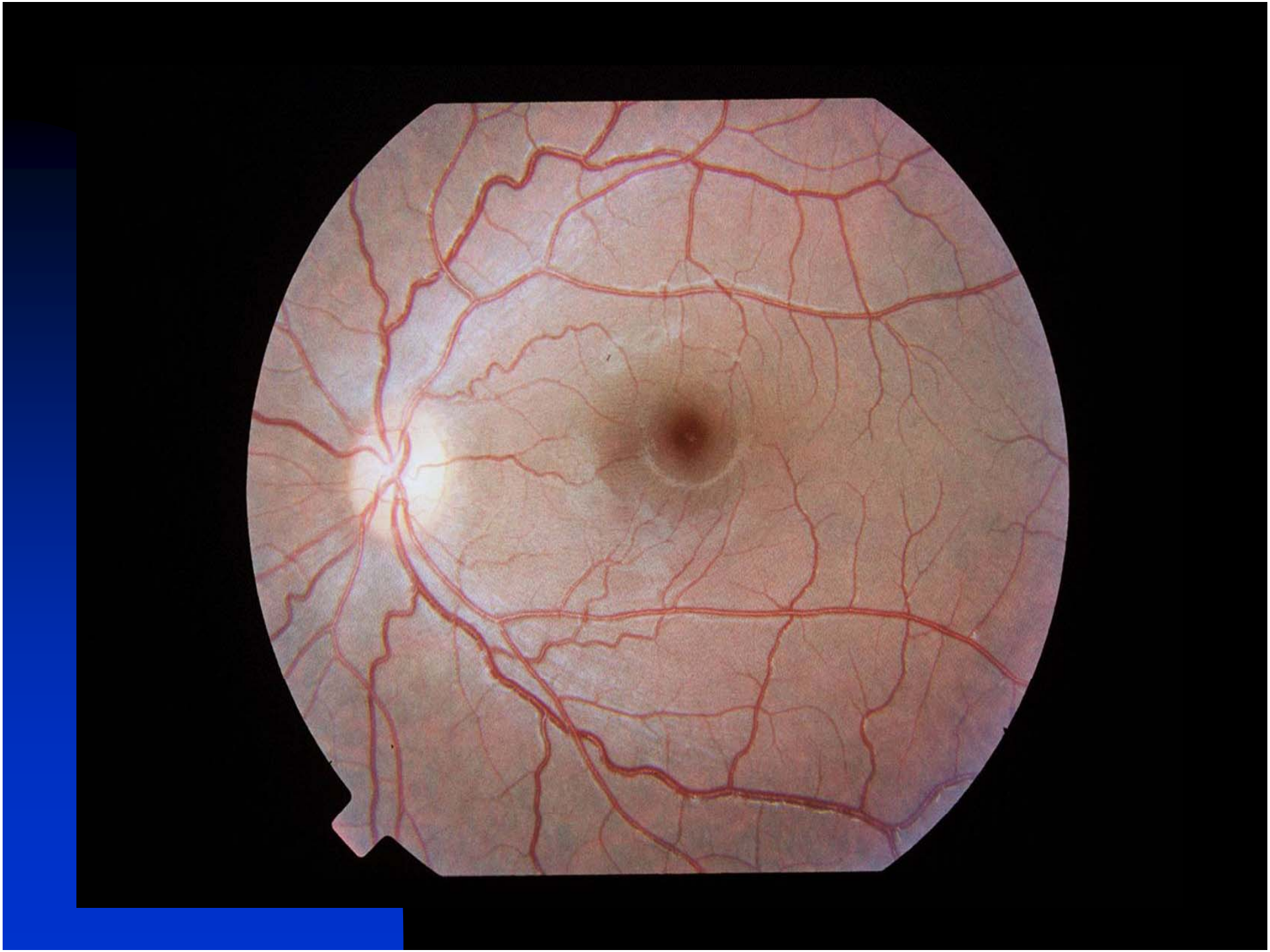
- Vitreous attachment.
- Optic nerve head, macula, fovea, retinal background, Ora serrata, and retinal vasculature.
- Effect of systemic diseases.
- Retinal detachment.

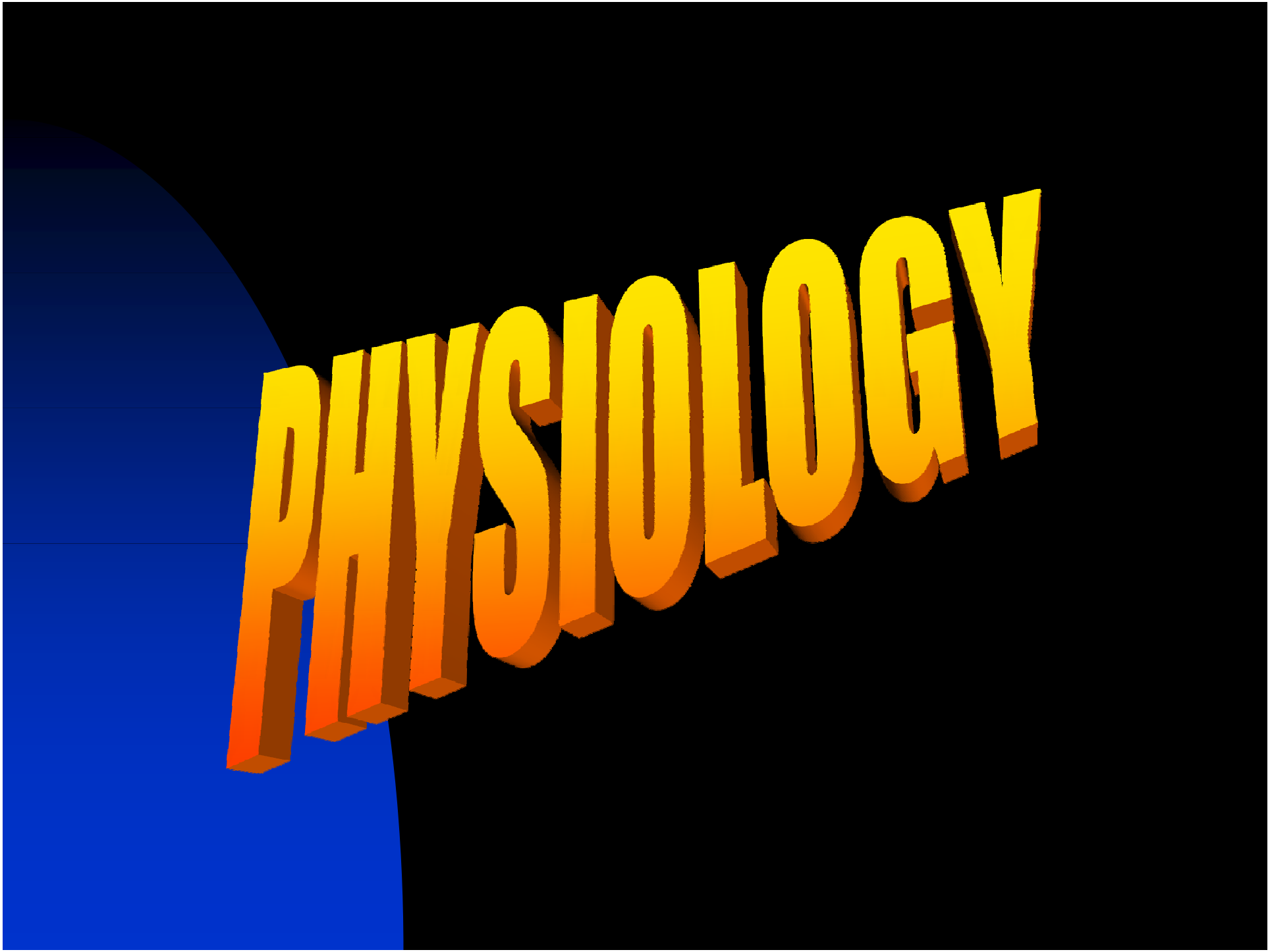

arteries
Nasal ora serrata
Temporal ora serrata
Short ciliary nerves
Vortex ampullae
Macula
Long ciliary artery
Long ciliary nerve
Microcystoid degeneration
Vortex vein
Short ciliary nerves


TARRANT
Pars
Plicata
Pars
Plana
Vitreous
Base


FOVEA
Avascular Zone
Foveola
lerve Fibre Layer
I. L. Membrane
Retinal
Capillaries
I. Nuc. Layer
O. Plex. Layer
Henle's
Choriocapillaris

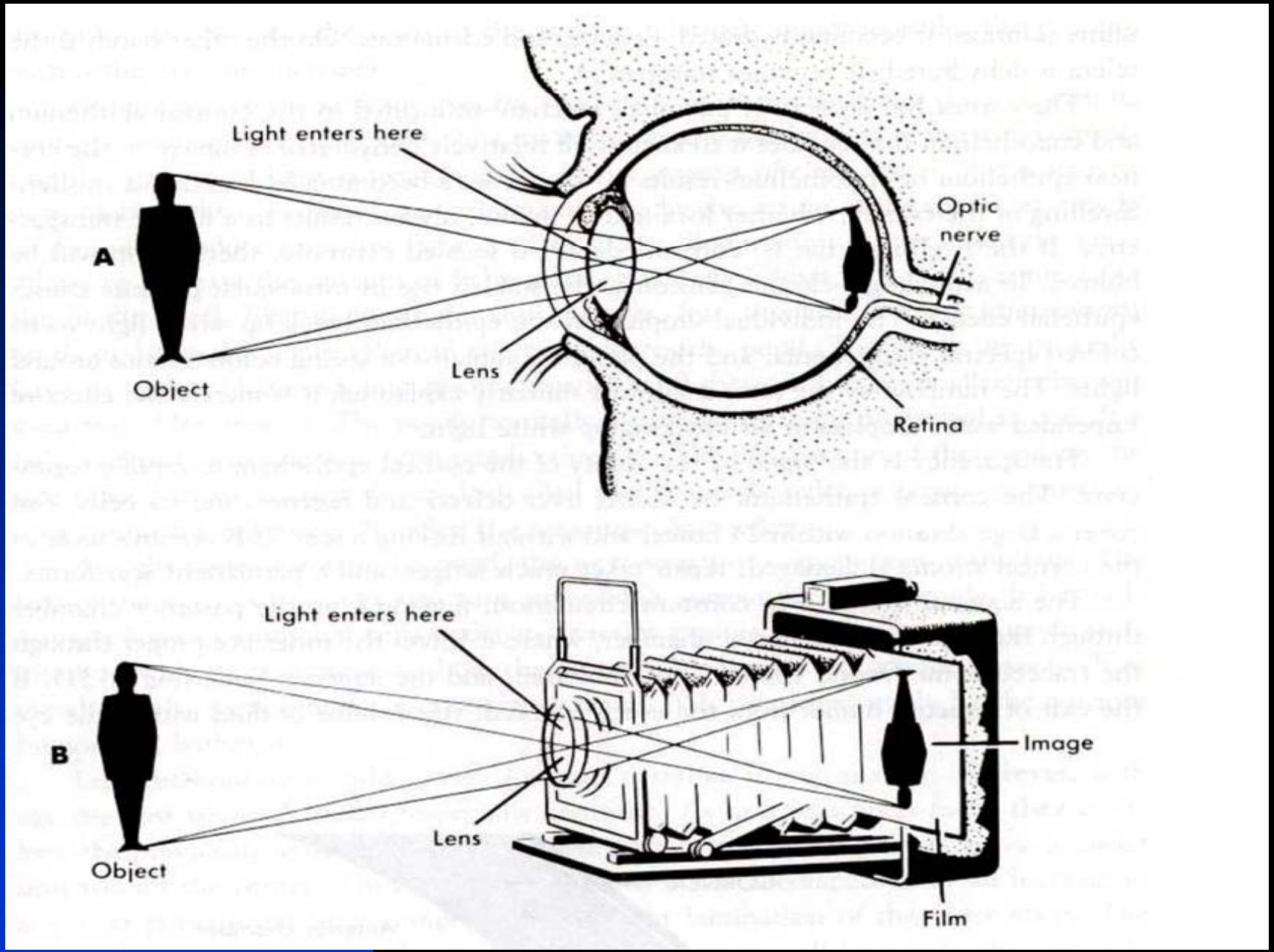

FUNDUS OF THE EYE
NASAL
TEMPORAL
PILLA
TIC NERVE
ERIOR
SAL
TERY
ERIOR
MPORAL
N
SUPERIOR
TEMPORAL
VEIN
SUPERIOR
TEMPORAL
ARTERY
MACULA LUTEA
FOVEA CENTRA




PHYSIOLOGY

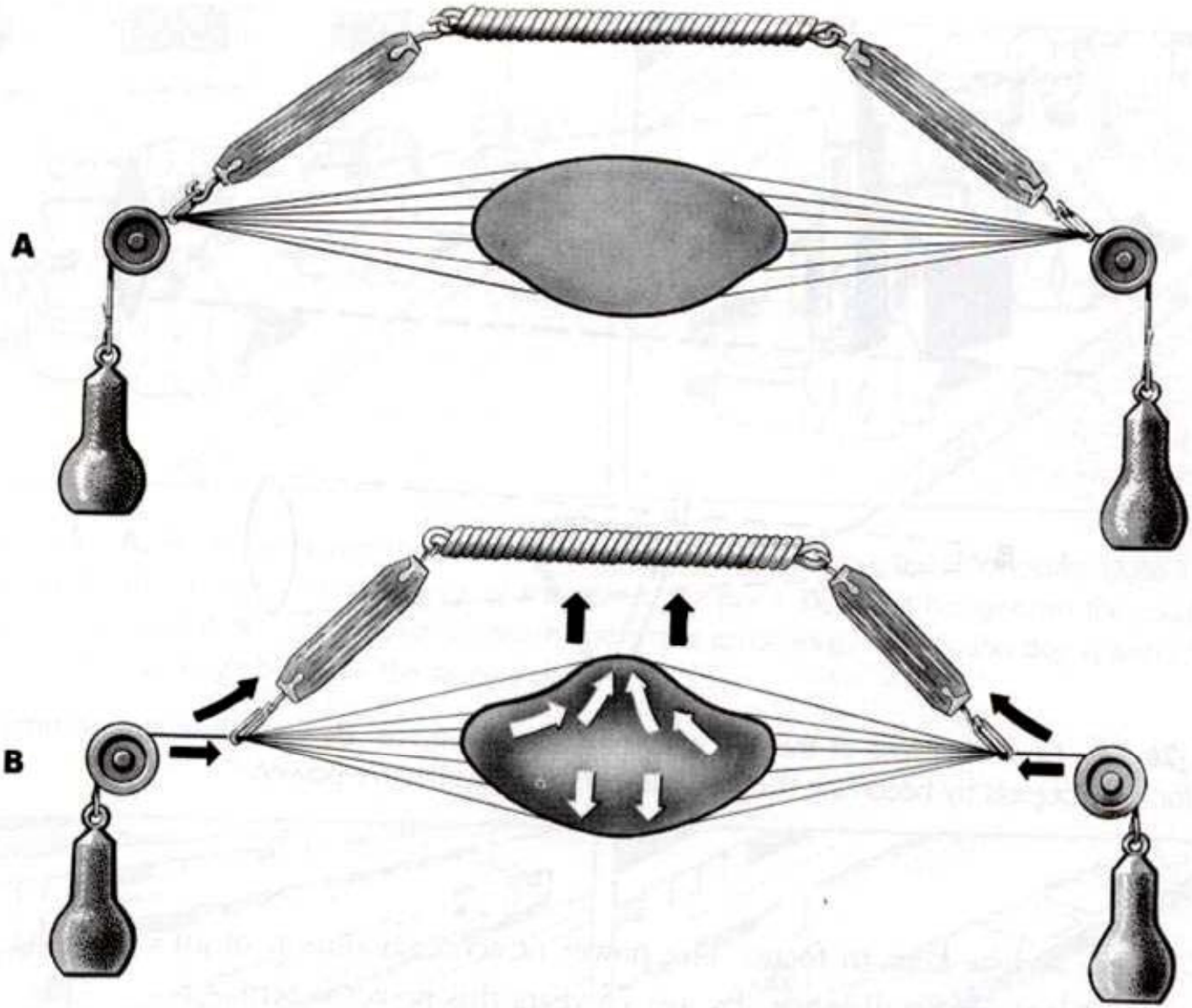
Optics of the Eye

- The eye is like a camera. Light must have a clearly pathway to be clearly focused on the sensory receptors of the retina, i.e., Clear cornea, anterior chamber, lens and vitreous cavity.
- The Refractive power of the eye is about ± 58 dioptres.

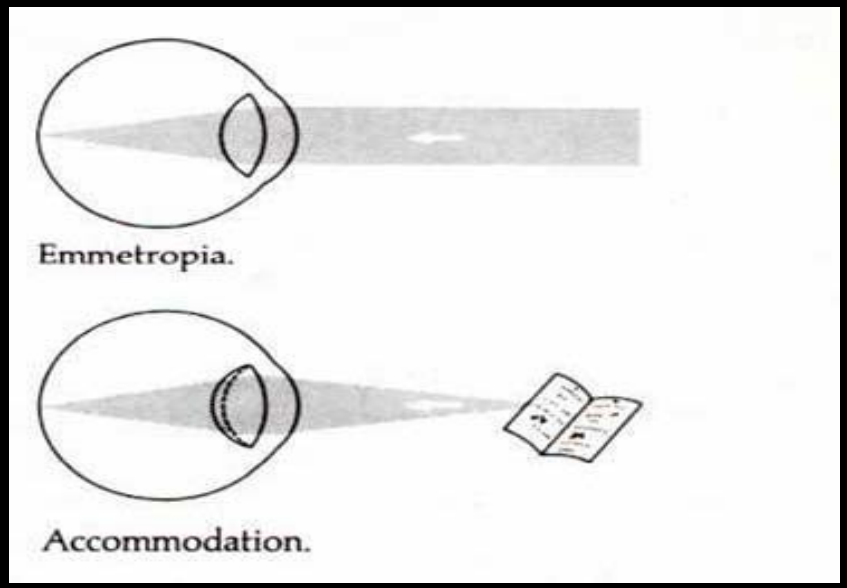

A
Light enters here
Optic nerve
Lens
Object
Retina
B
Light enters here
Image
Lens
Object
Film

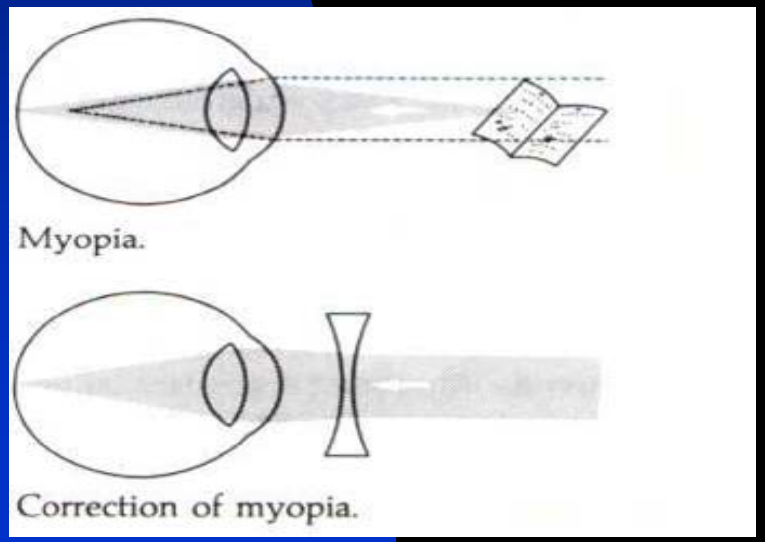
Optics of the Eye (cont.)

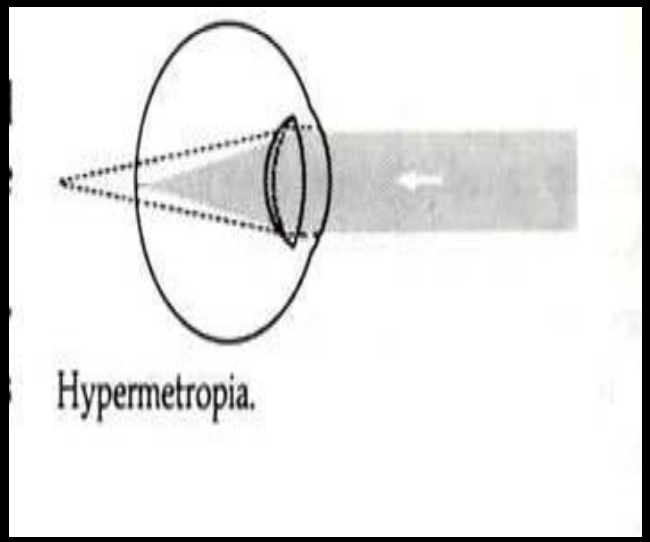
- The cornea is the major refracting element of the eye with a power of approximately 40 dioptres. If the curvature is greater in one meridian than the other→ Astigmatism
- The refractive power of the lens is about 17 dioptres at rest. Accommodation able to change the power of the lens markedly depends on age.


A
B

- ***Emmetropia***: Optically normal eye in which rays of light from a distant object are focused on the retina without accommodation.
- ***Myopia***: Light focused on front of the retina, corrected by concave lens.
- ***Hypermetropia (hyperopia):*** Light focused behind the retina, corrected by convex lens.


Emmetropia.
Accommodation.


Myopia.
Correction of myopia.


Hypermetropia.

The intraocular pressure

- The pressure within the eye is maintained at a steady level by continuous formation & drainage of aqueous.
- Aqueous is secreted by the ciliary epithelium → posterior chamber → anterior chamber (through the pupil) → drained through the anterior chamber angle.
- The intraocular pressure, (IOP), is normally 10 – 21 mmHg; increased IOP called Glaucoma.
- High IOP almost always due to an obstruction of aqueous outflow.

VISION

- ***The retina:***

  - The central retina contains yellow pigment, Xanthophyll, the so called macula lutea (yellow spot).

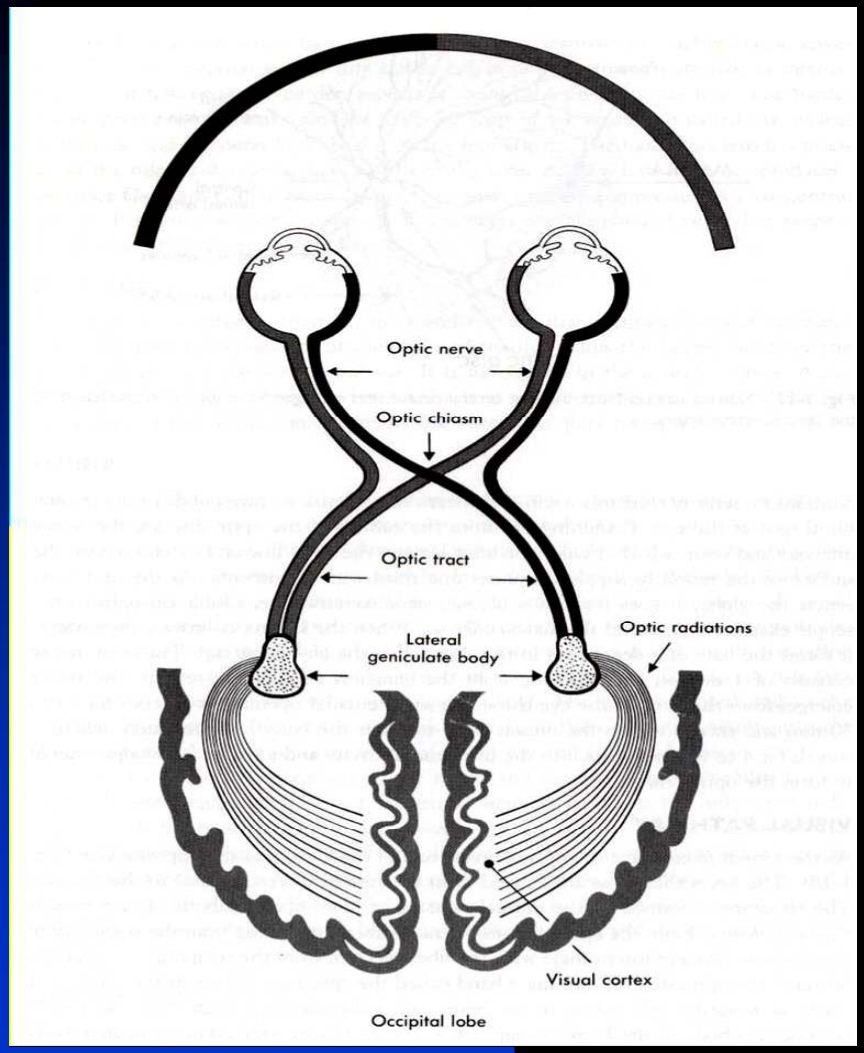
  - It is divided into retinal pigment epithelium & neurosensory retina.

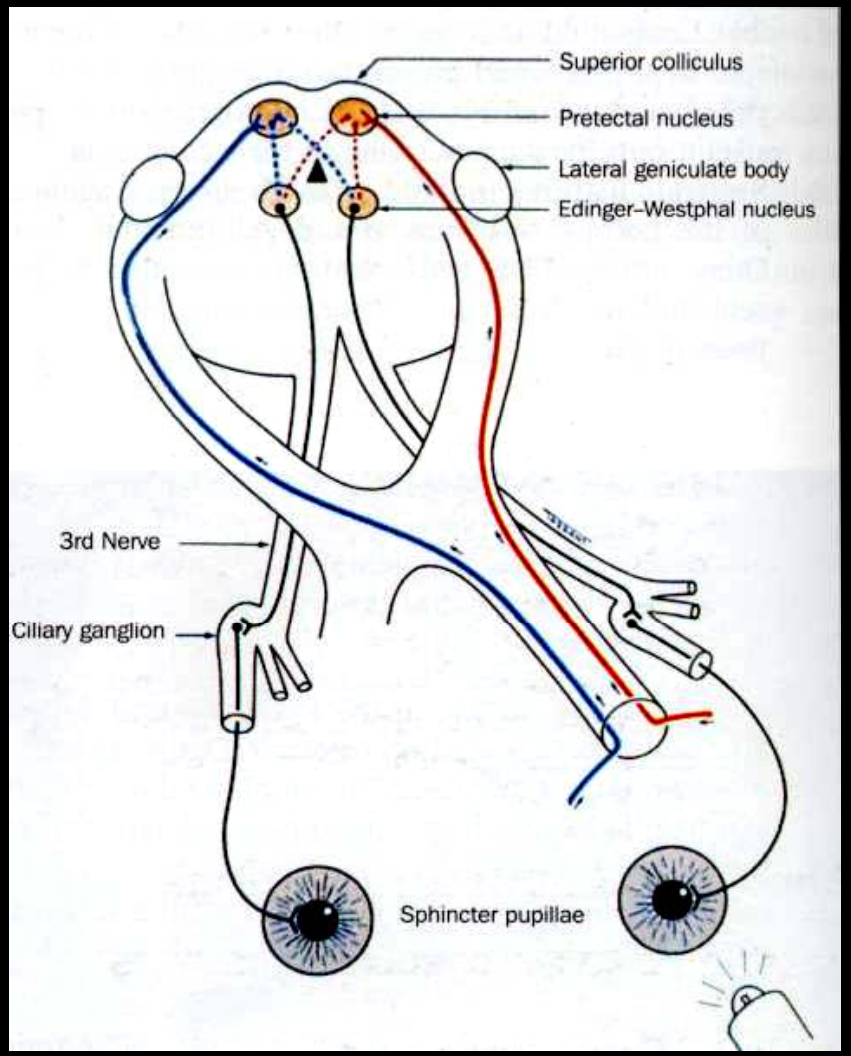
  - Photoreceptors contains visual pigment which consists of a large protein (opsin) attached to retinal (vitamin A aldehyde).

VISION (cont.)

- Light splits the opsin from the retinal with initiation of a graded electrical potential → Transmitted through the visual pathway to be processed in the visual cortex (occipital lobe) → vision sense.
- Visual Pathway: Three neurons

1. Bipolar cell, lies within the retina.
2. Ganglion cell, synapse in lateral geniculate body.
3. Third neuron terminates in visual cortex.


Optic nerve
Optic chiasm
Optic tract
Lateral geniculate body
Optic radiations
Visual cortex
Occipital lobe


Superior colliculus
Pretectal nucleus
Lateral geniculate body
Edinger–Westphal nucleus
3rd Nerve
Ciliary ganglion
Sphincter pupillae

Lacrimal Apparatus

- Tear secretion.
- Layers of precorneal tear film.
- Drainage of tear.