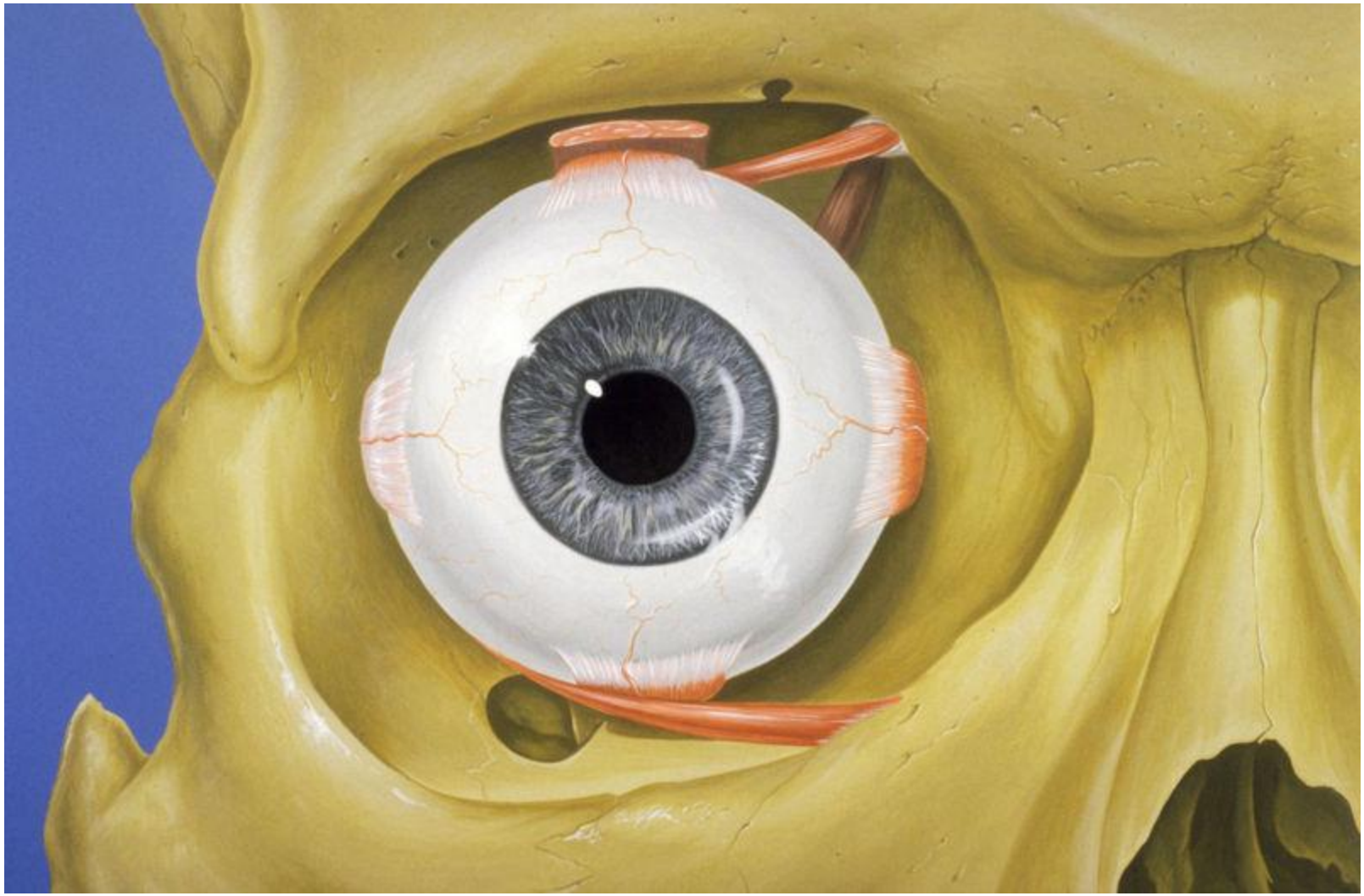
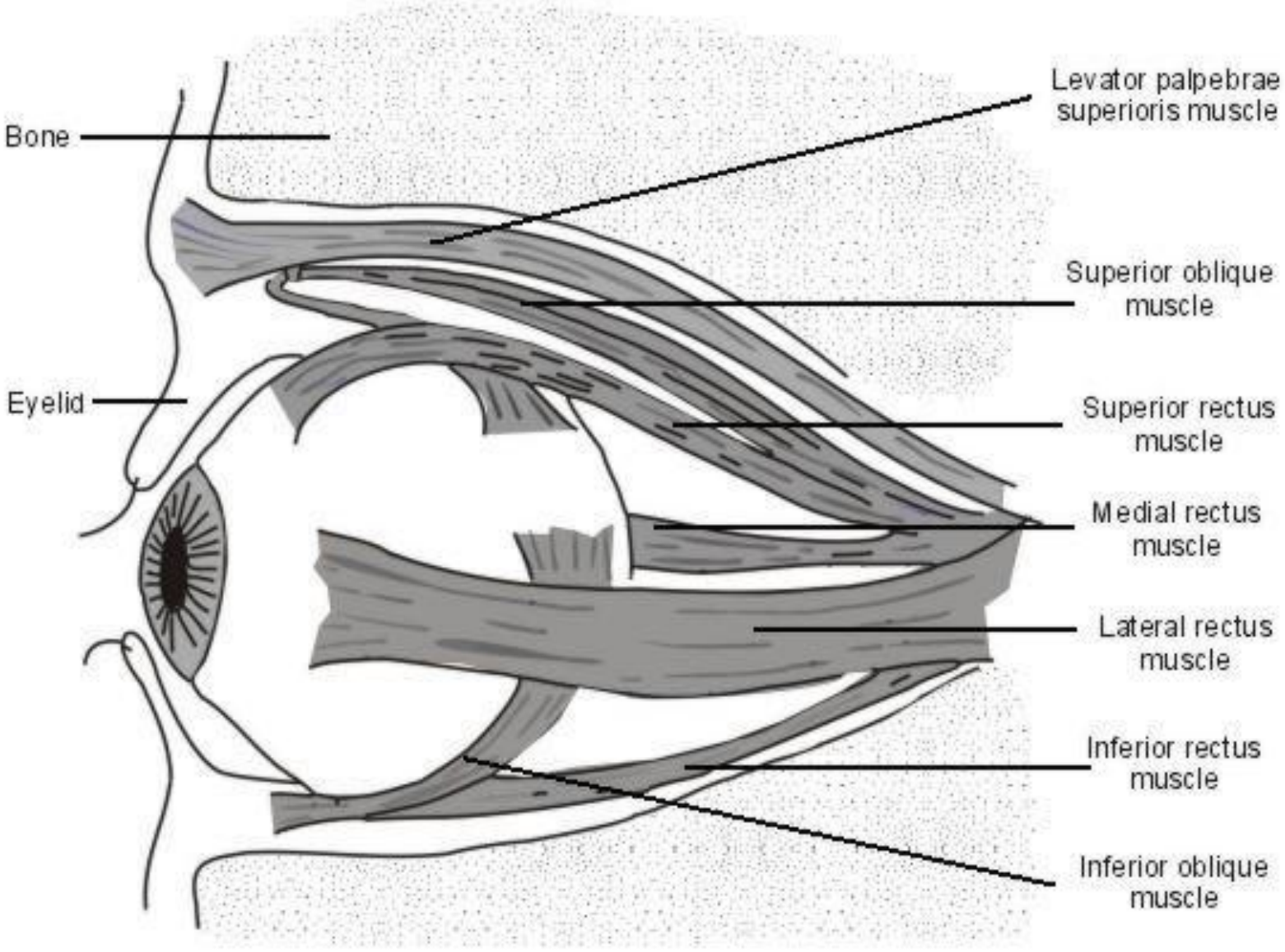
Ocular movements

Adolfo M. Bronstein
Consultant Neurologist & Professor of Neuro-otology
Imperial College London

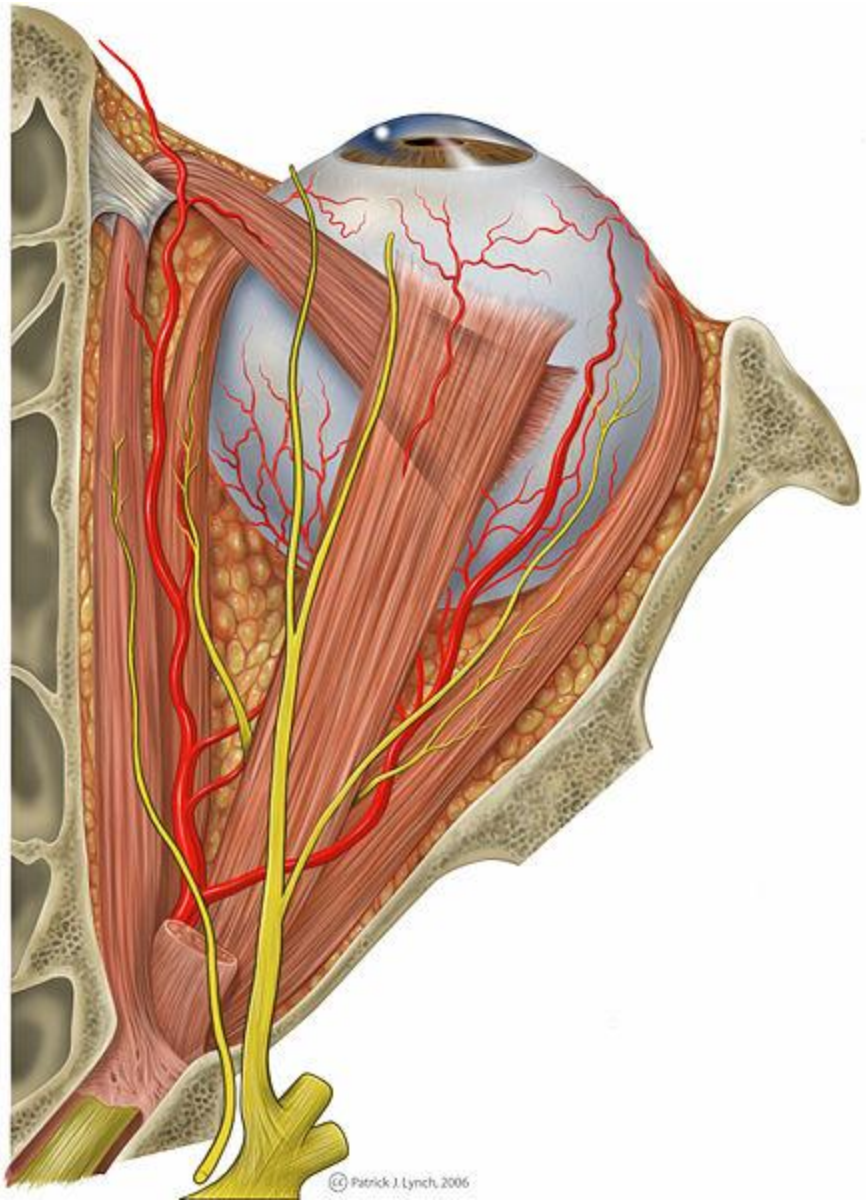
Types of eye movements: mono vs binocular

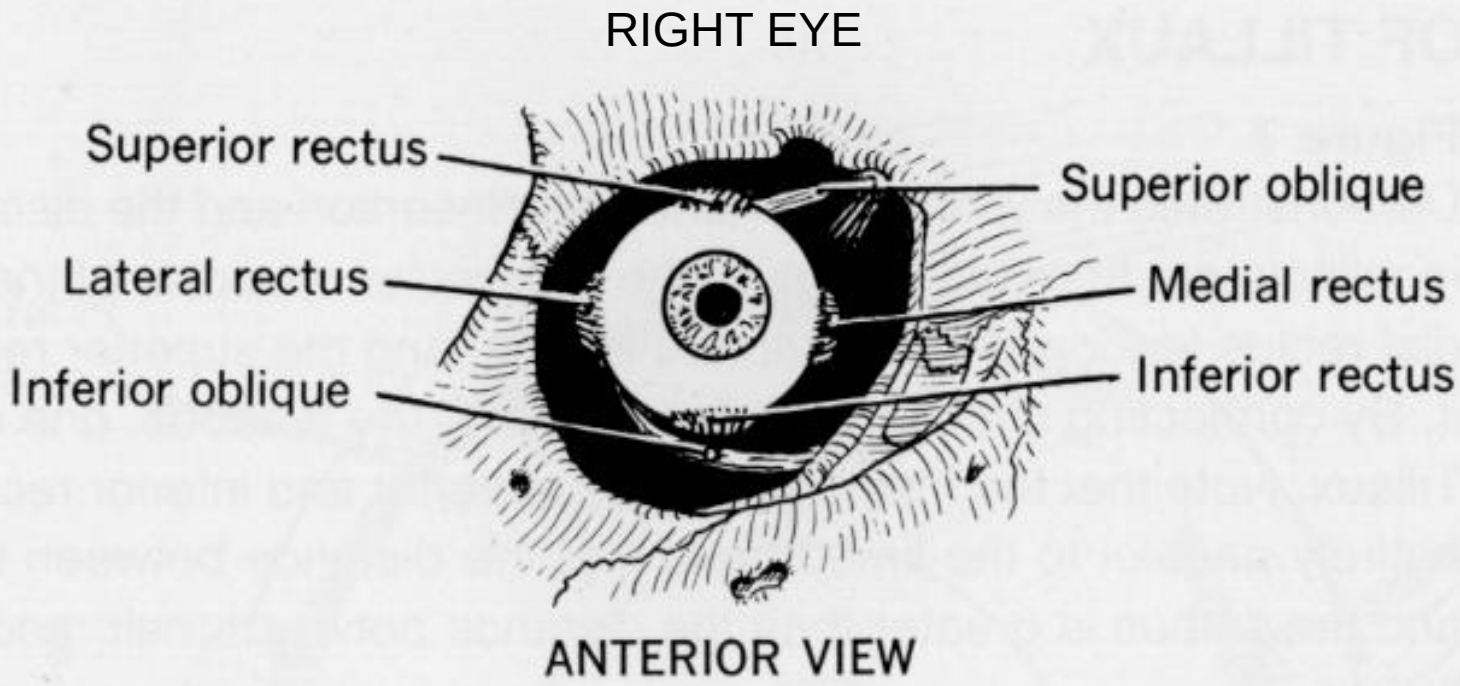
- Conjugate movements: versions
  – binocular examination
    - midbrain -> Vertical movements
    - pons -> Horizontal movements
- Monocular examination: ductions: III, IV, VI
- Vergence: convergence - divergence



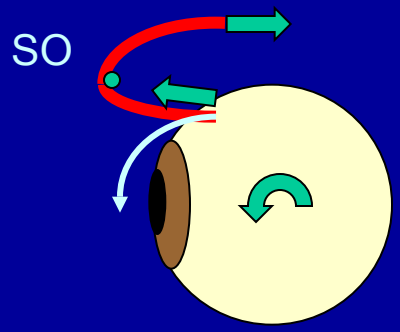


Muscles of the left eye looking from the side

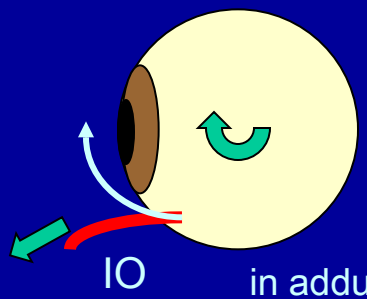

© Patrick J. Lynch, 2006



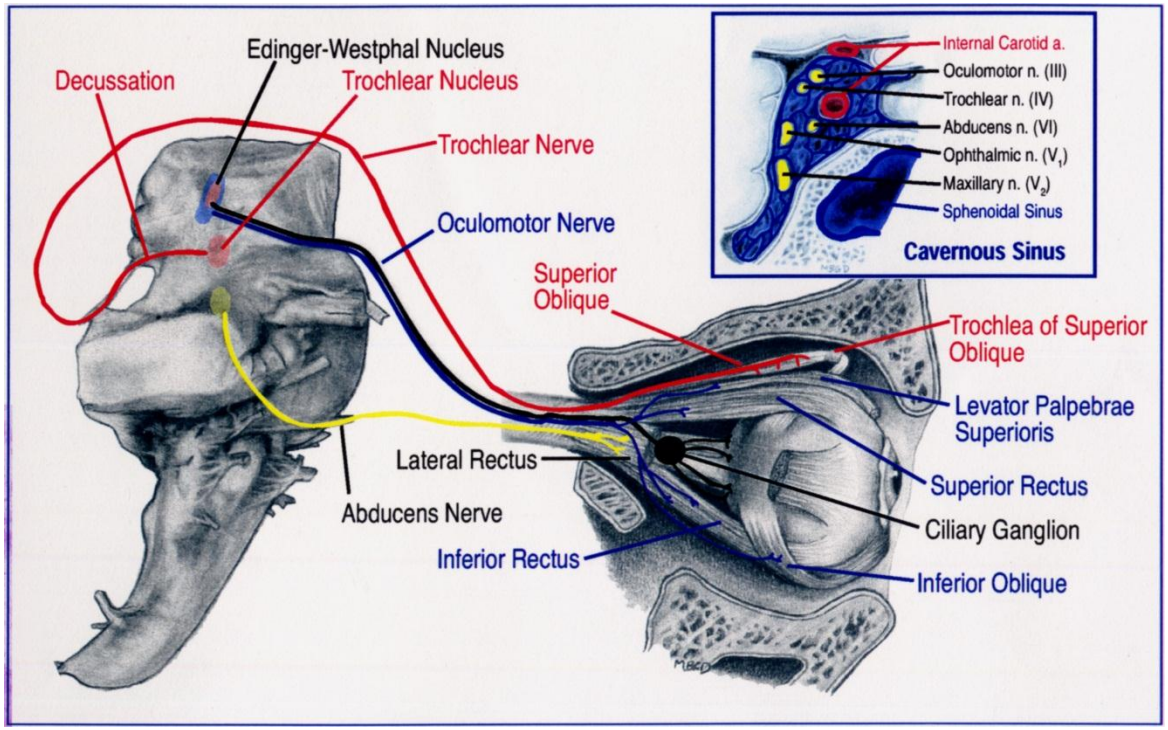
*tip ***O***bliques originate from the ***O***lfactorium



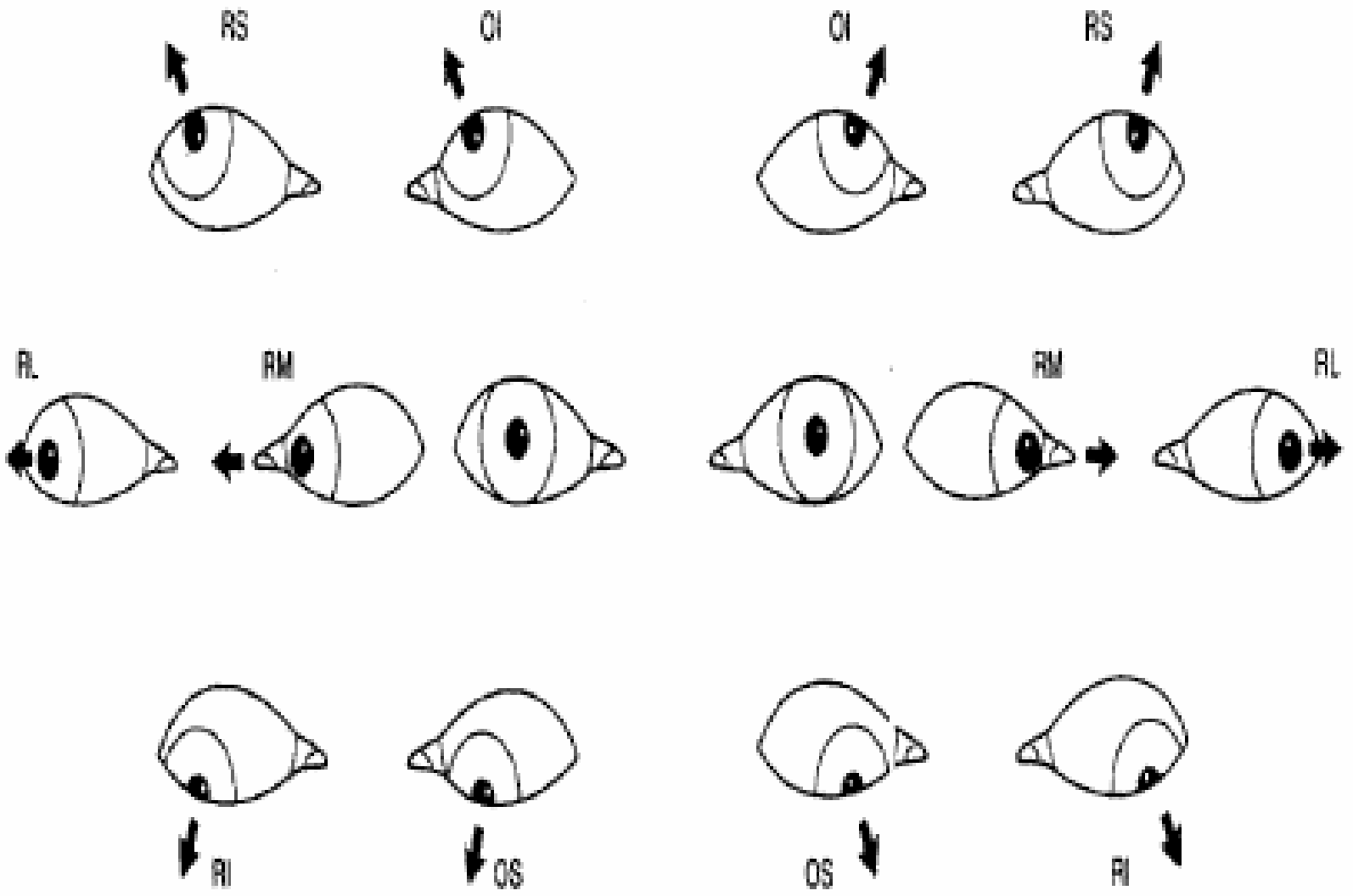
in adduction SO is a depressor



in adduction IO is an elevator


Edinger-Westphal Nucleus
Decussation
Trochlear Nucleus
Trochlear Nerve
Oculomotor Nerve
Superior Oblique
Trochlea of Superior Oblique
Levator Palpebrae Superioris
Lateral Rectus
Superior Rectus
Abducens Nerve
Ciliary Ganglion
Inferior Rectus
Inferior Oblique
Internal Carotid a.
Oculomotor n. (III)
Trochlear n. (IV)
Abducens n. (VI)
Ophthalmic n. (V_1)
Maxillary n. (V_2)
Sphenoidal Sinus
Cavernous Sinus

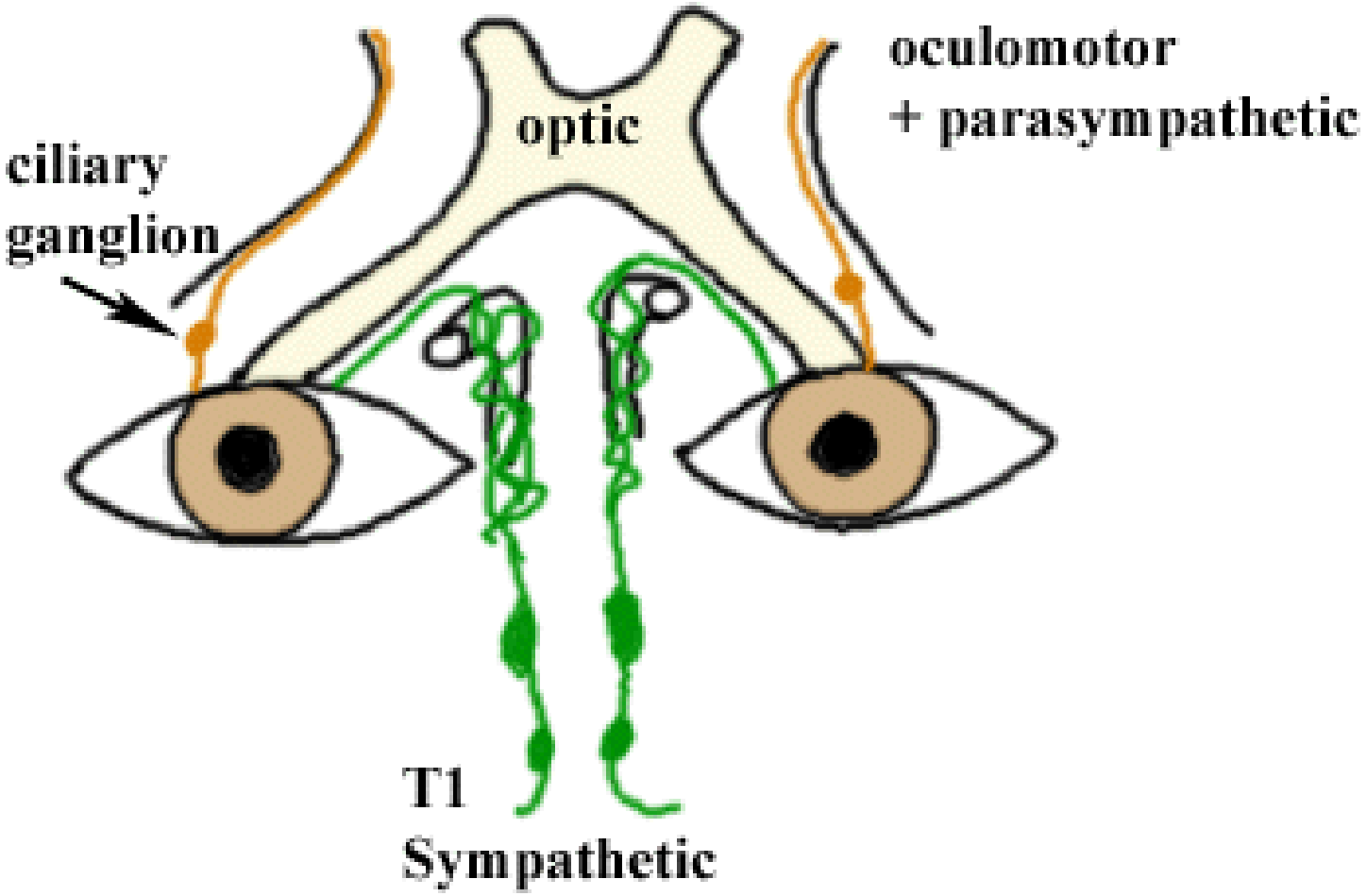
Examining III, IV, VI:
the six cardinal positions of gaze

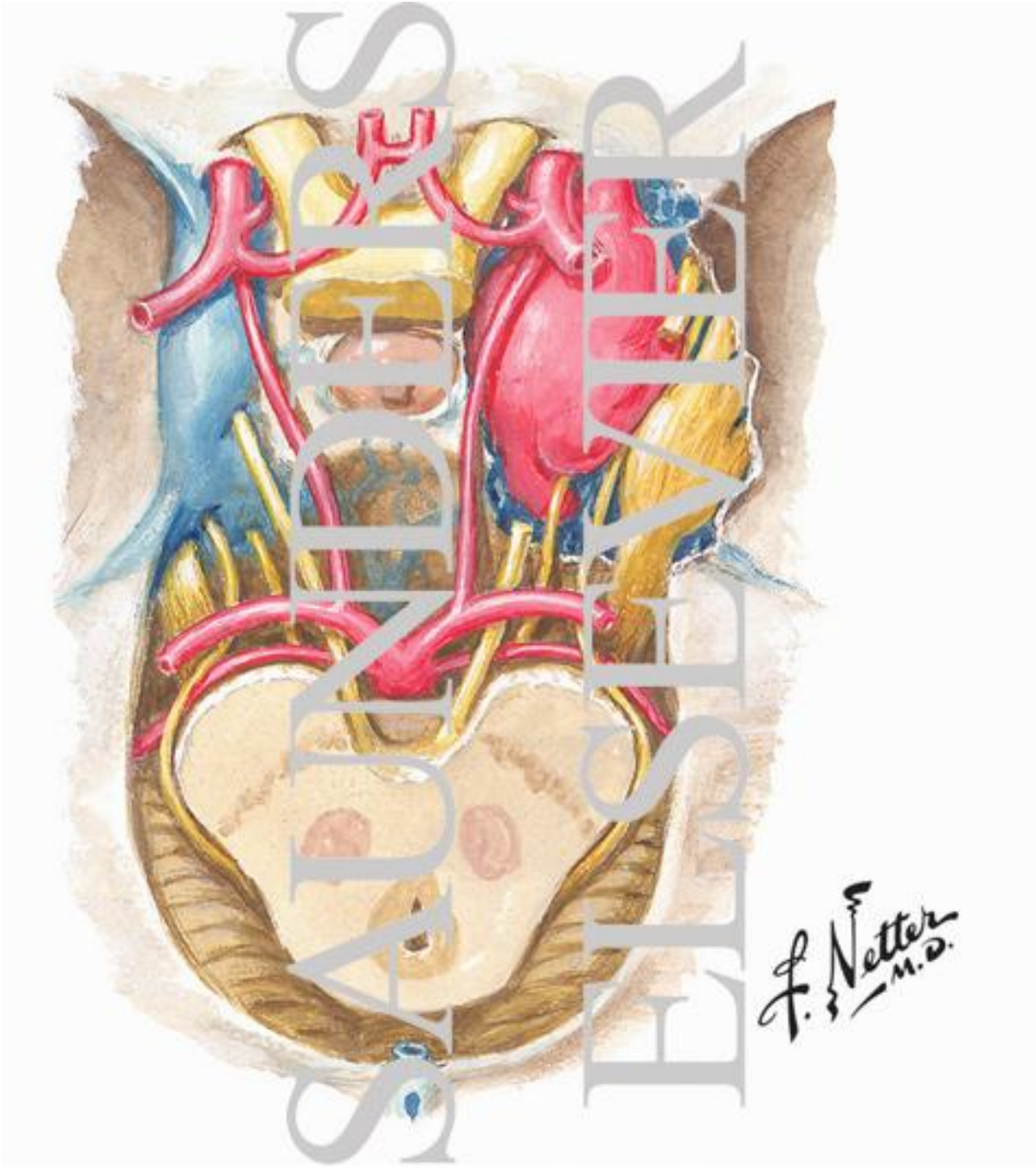


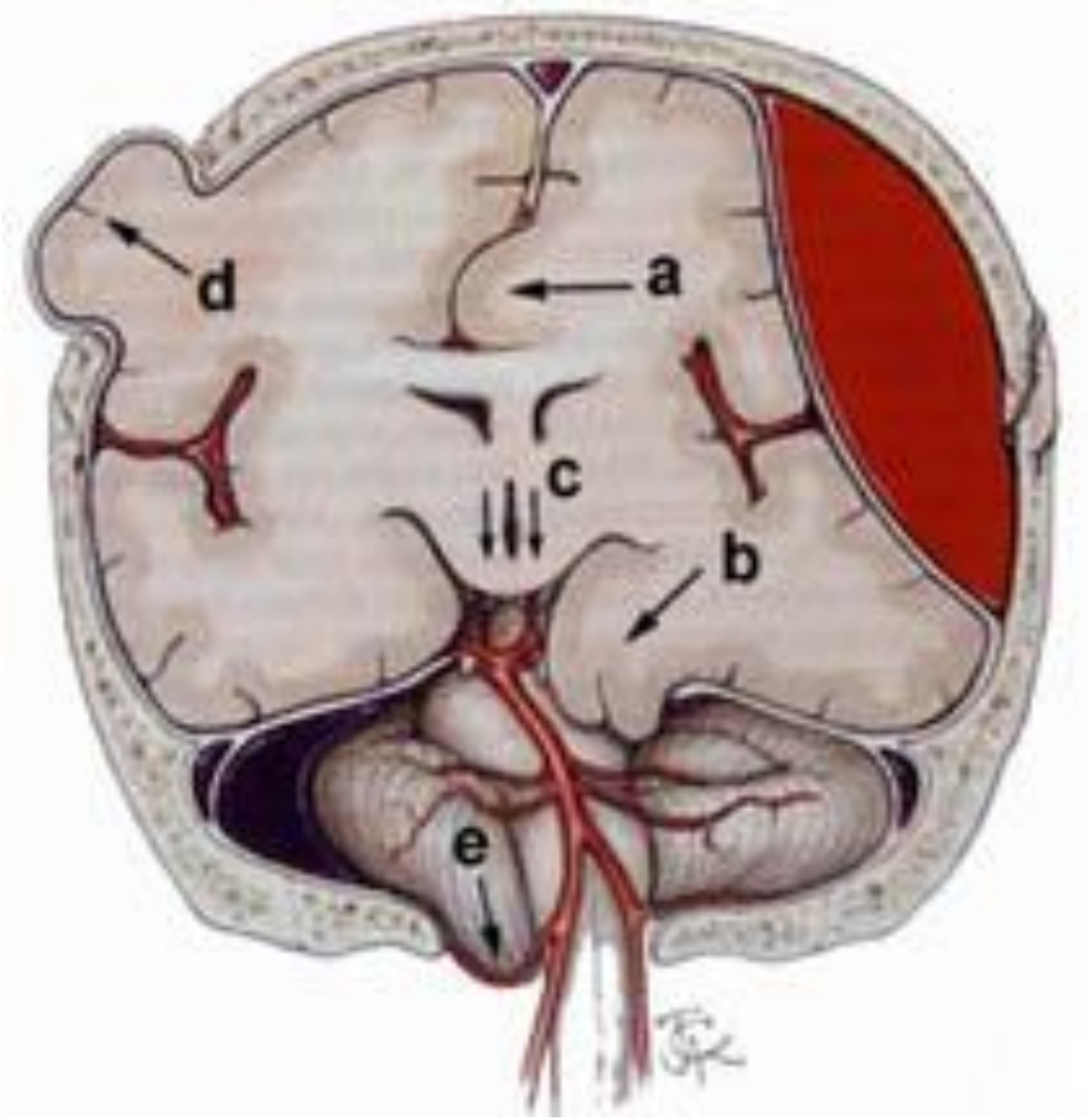
R VI nerve palsy

Left OCM nerve (III) palsy

Pupilary (iris) innervation





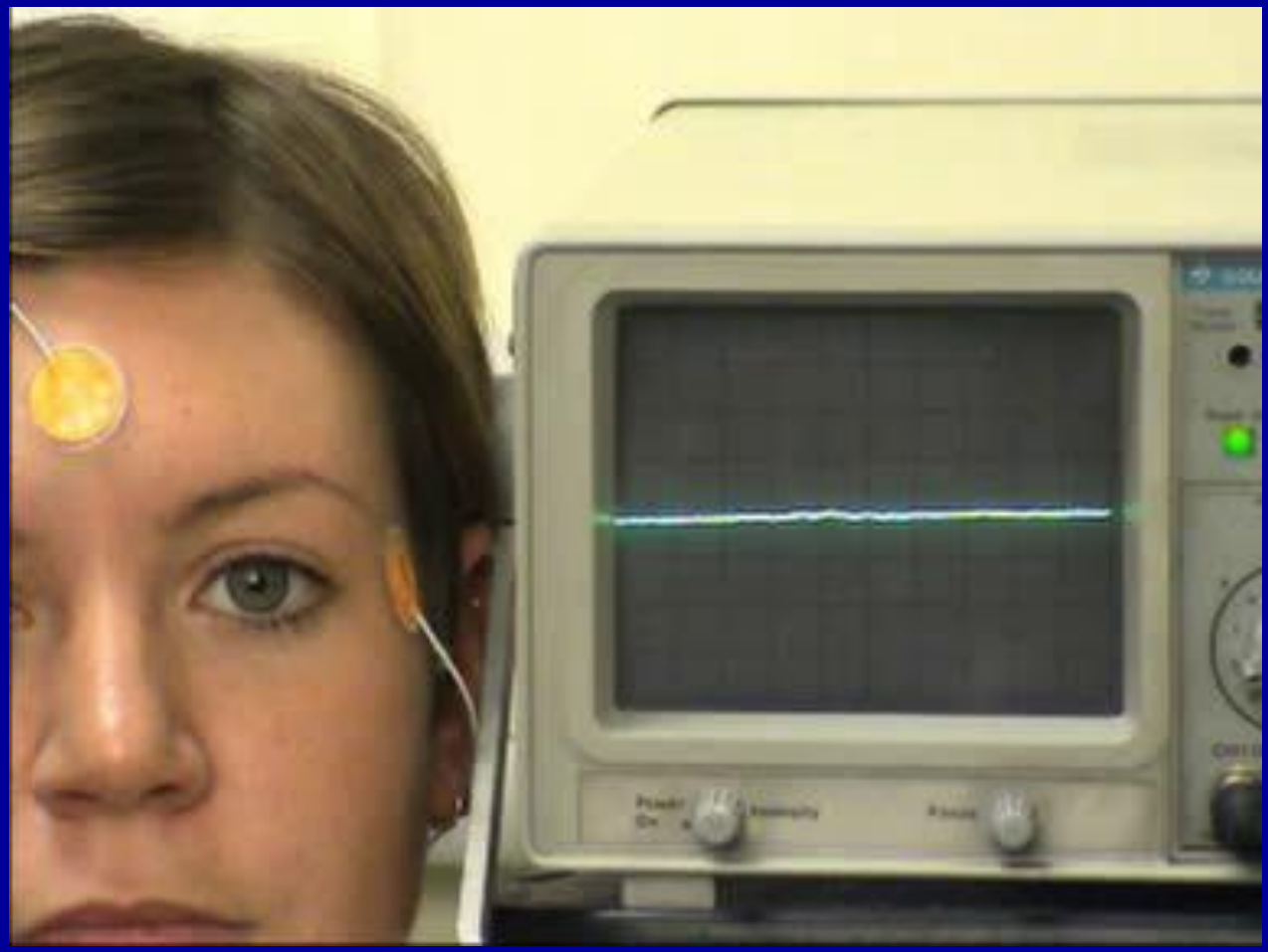

d
a
c
b
e

Conjugate Movements

- Vestibulo-ocular reflexes
- Smooth pursuit
- Sacades
- Nistagmus (vestibular and optokinetic)

SACCADES

transfer
gaze



- conjugate; fast up to 600°/s; spontaneous, reflex or voluntary; 90% accurate;
- saccades are the ‘beats’ component of nystagmus;
- horizontal saccades generated by the PPRF, vertical saccades by the riMLF
- gaze should be stable at the end of a saccade with eyes held on target

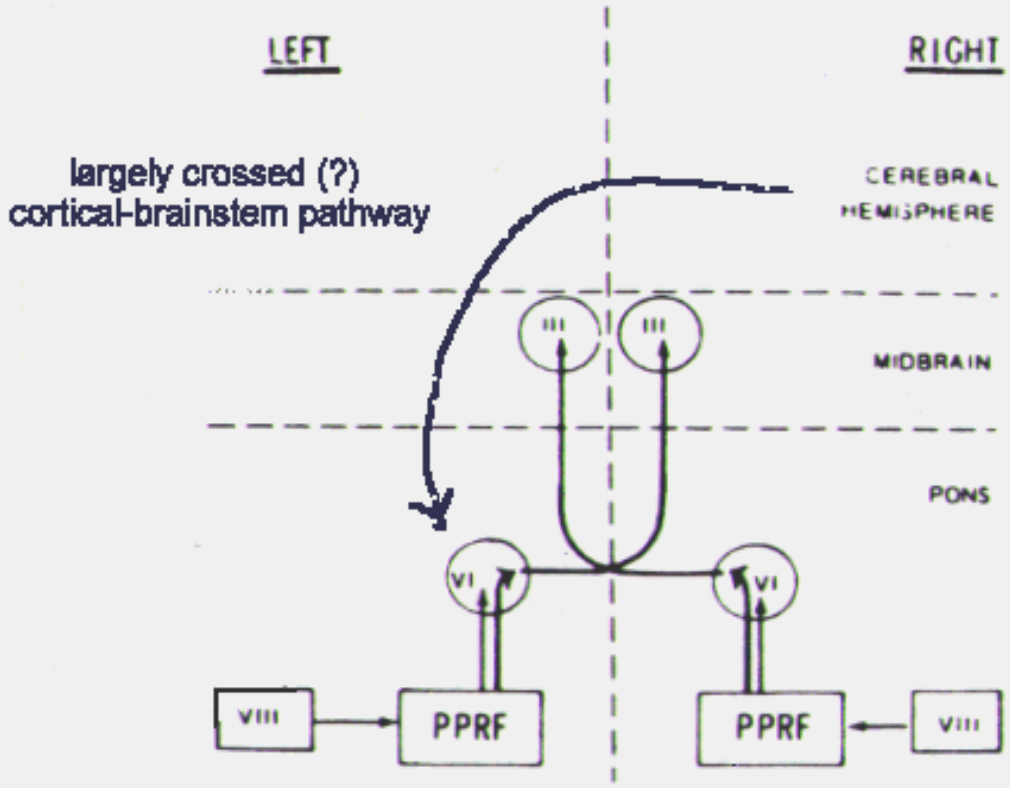
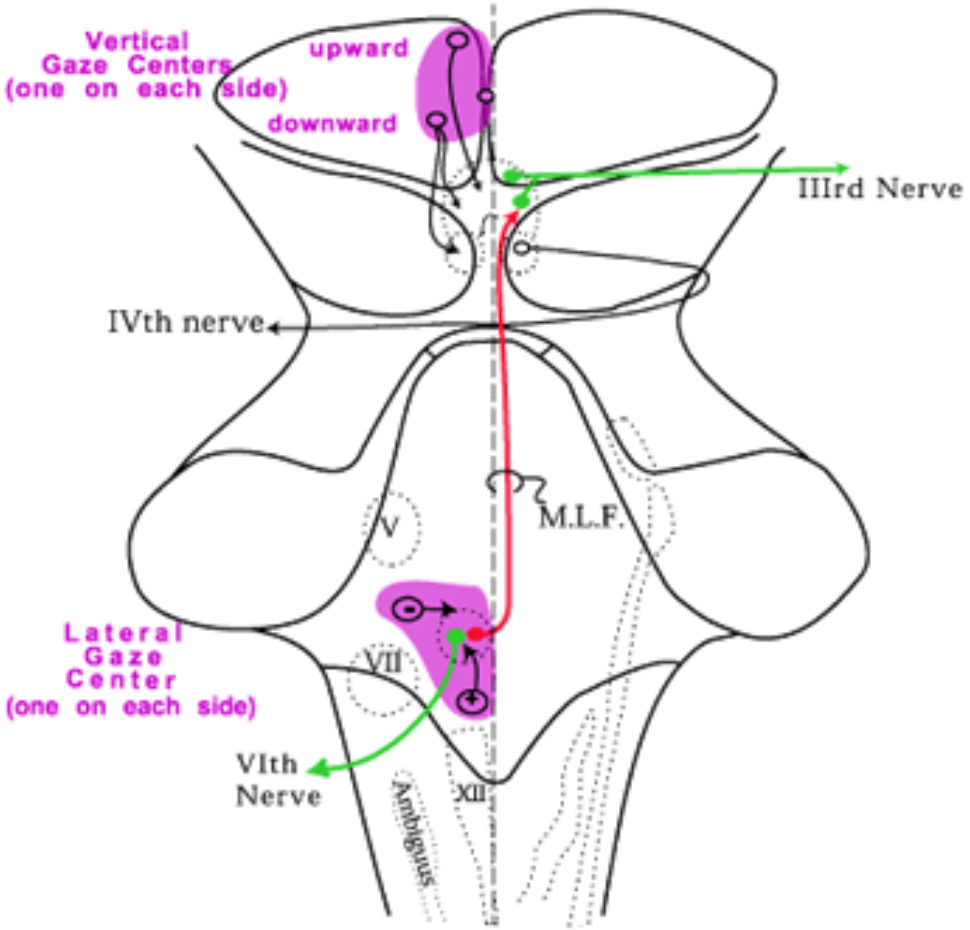


Fig. 2. Operational schematic showing output of paramedian pontine reticular formation (PPRF) to ipsilateral VI and opposite III nuclei. Crossing pathway ascends to midbrain in medial longitudinal fasciculi (MLF).

Brainstem wiring for Voluntary Eye Movements



Schematic diagram of the brainstem centers for lateral and vertical gaze, shown on the outline already used for brainstem and cranial nerve nuclei. For clarity's sake, each gaze center and each extraocular muscle nerve is shown on one side only.

Discharge pattern in an abducens motoneuron

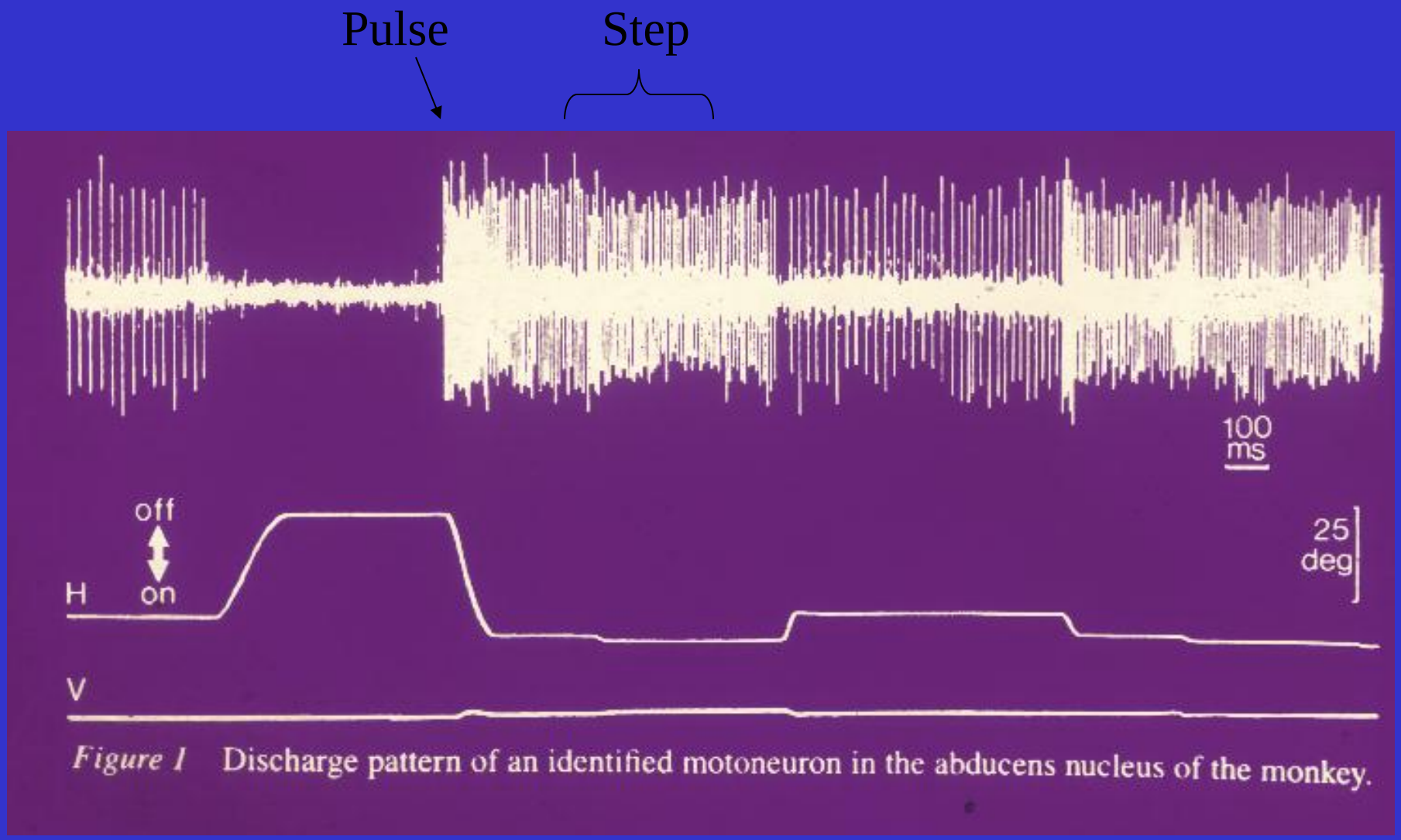
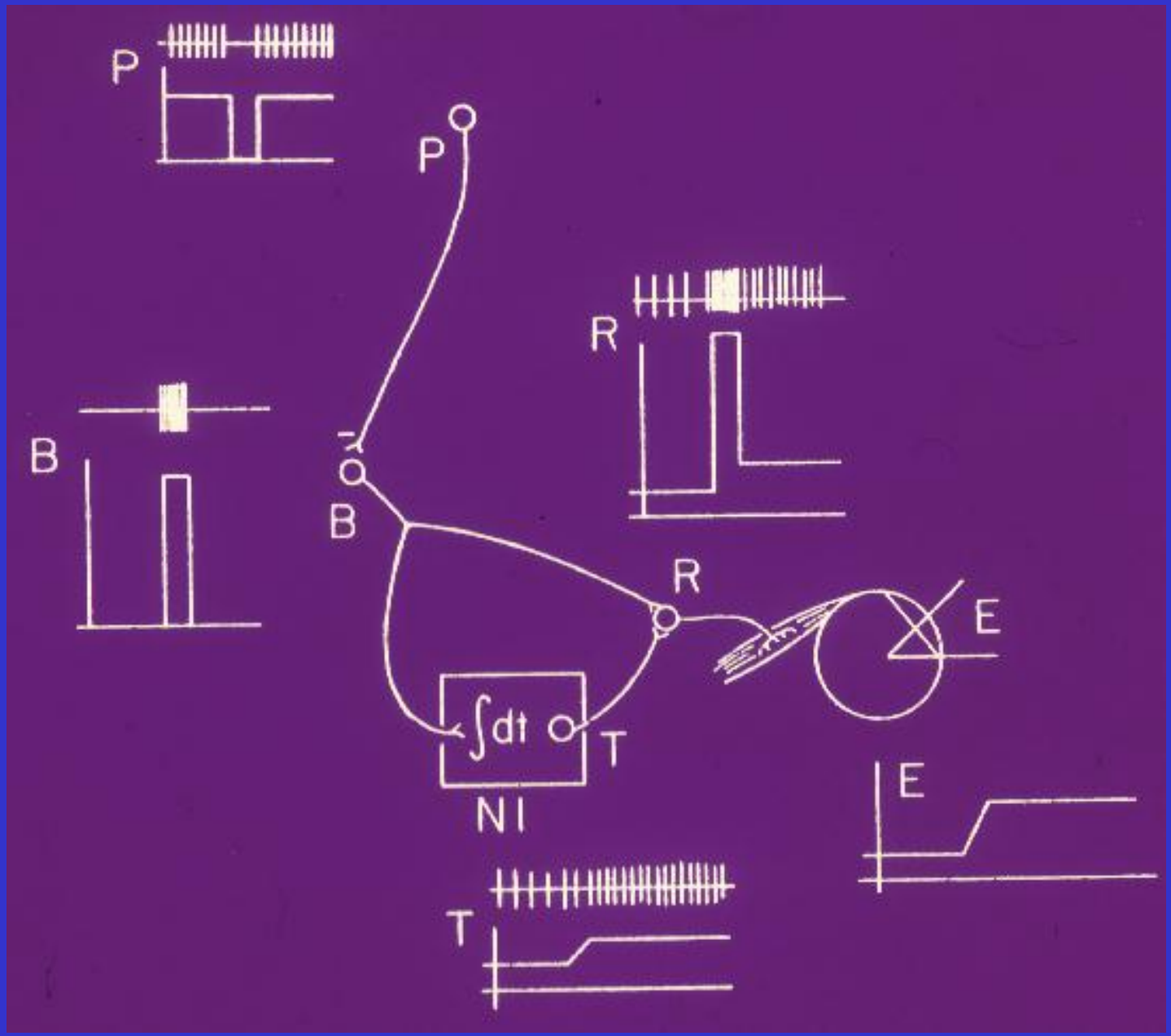
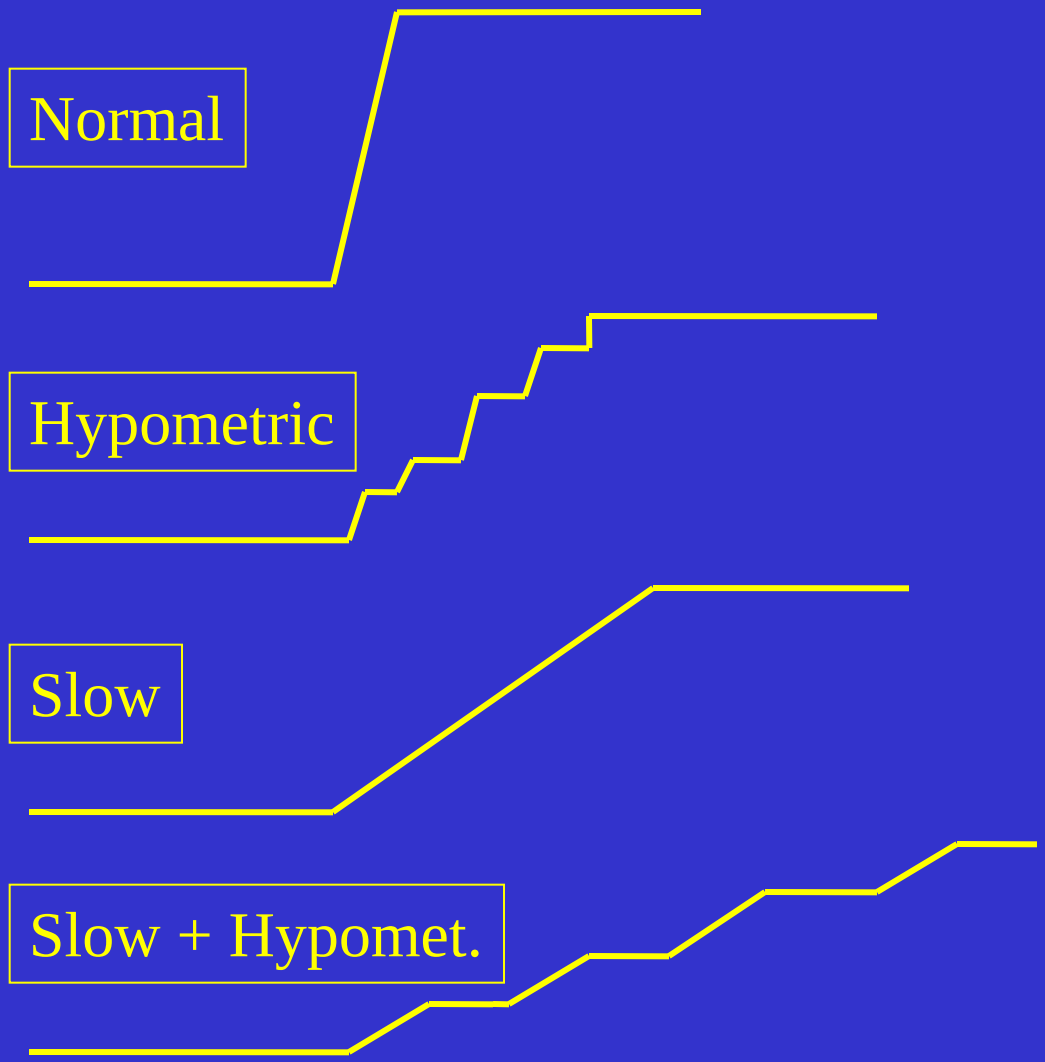


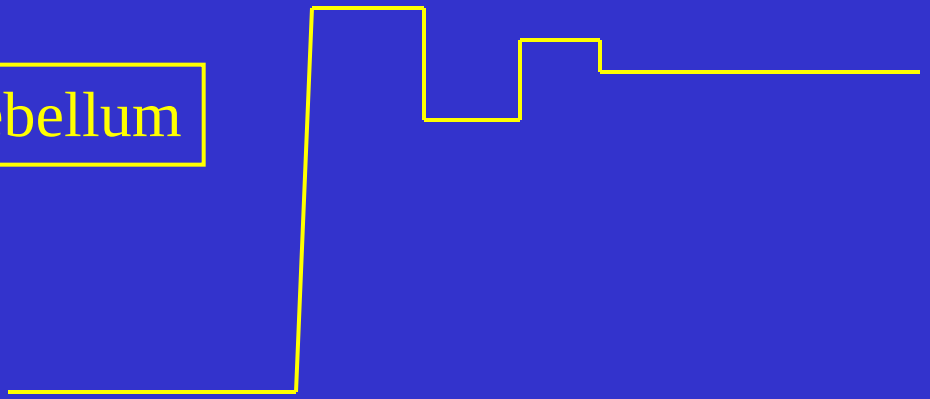
Figure 1 Discharge pattern of an identified motoneuron in the abducens nucleus of the monkey.


P
P
B
B
R
R
E
∫dt
T
NI
E
T

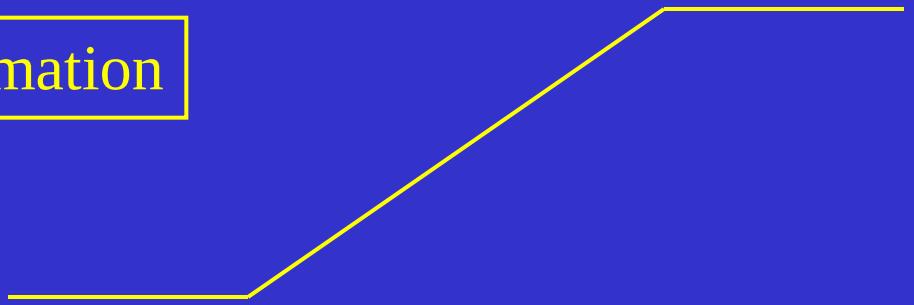

Normal
Hypometric
Slow
Slow + Hypomet.
1 sec.

Only two OCM abnormalities have great localising value:

Hypermetric saccades: Cerebellum

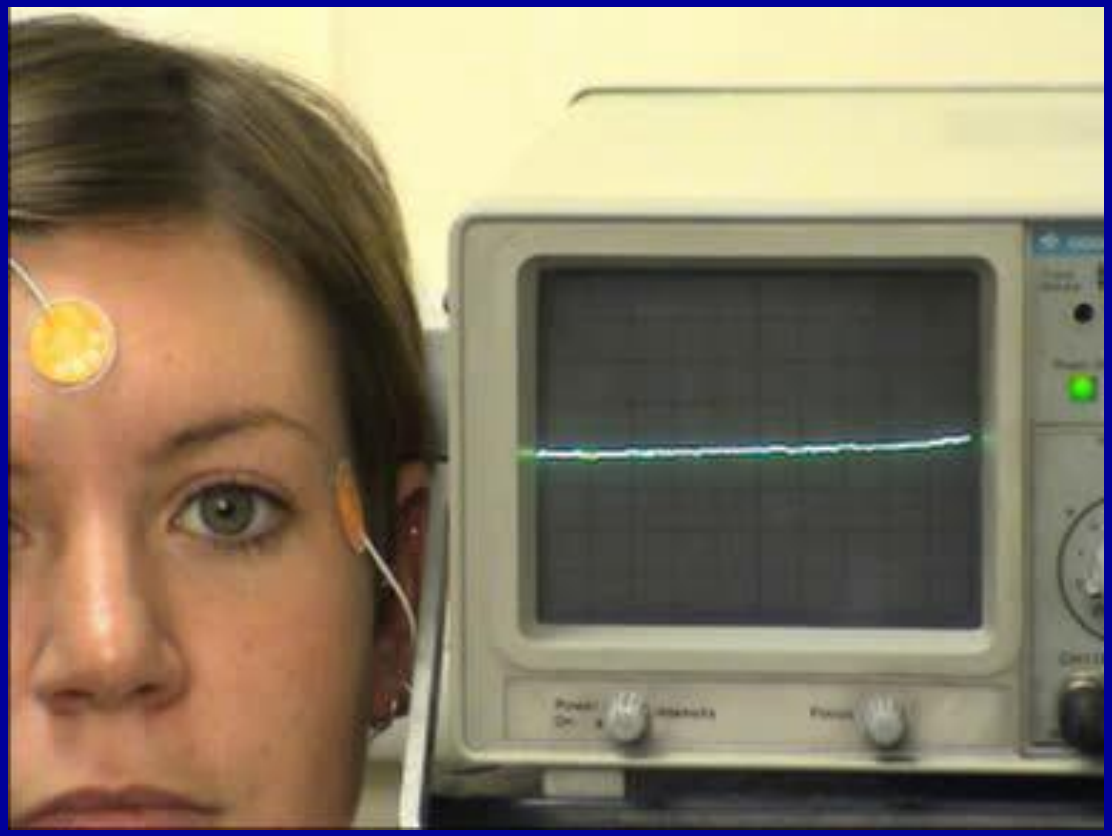


Slow saccades: Reticular formation



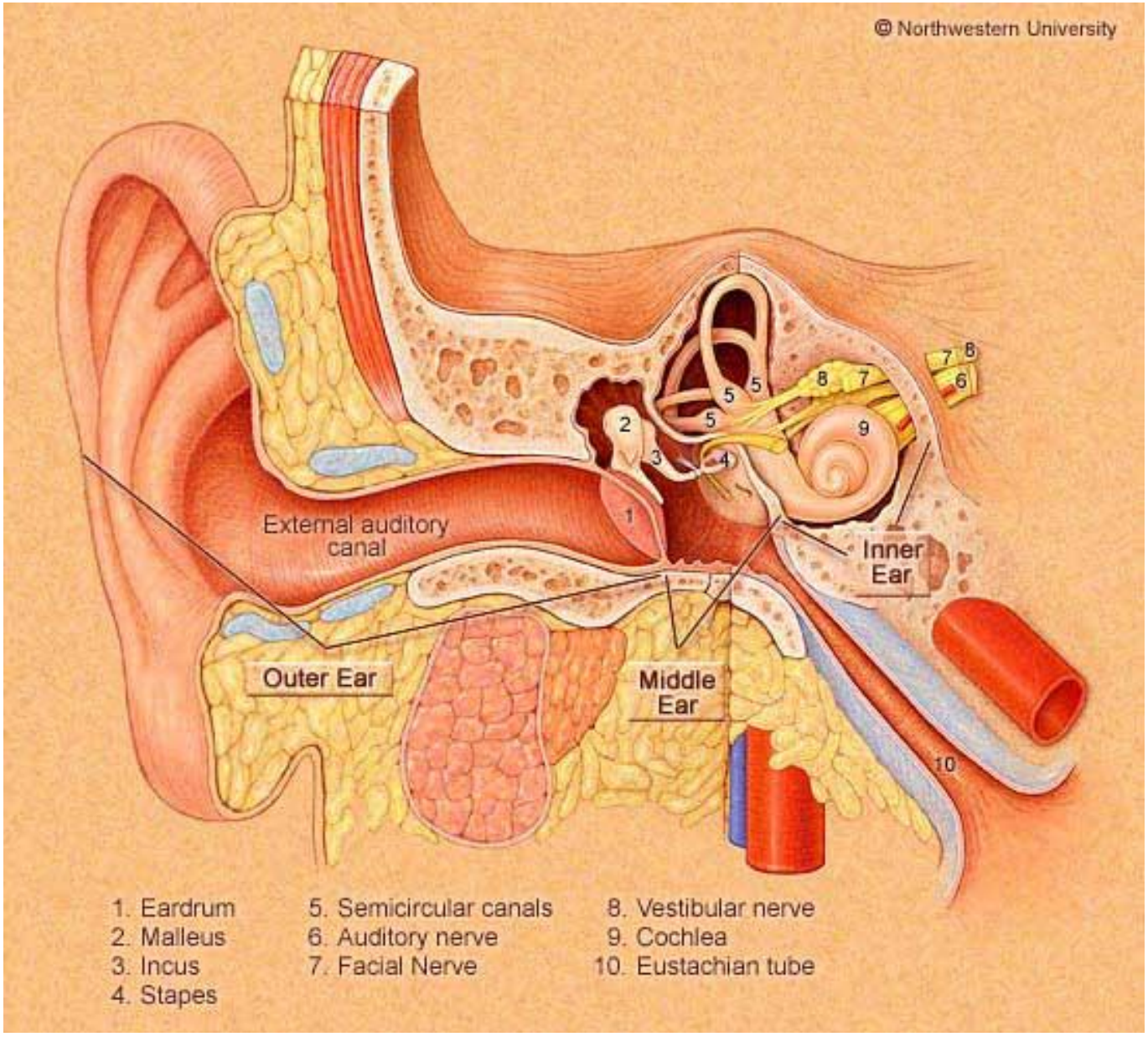
VESTIBULAR-OCULAR REFLEX

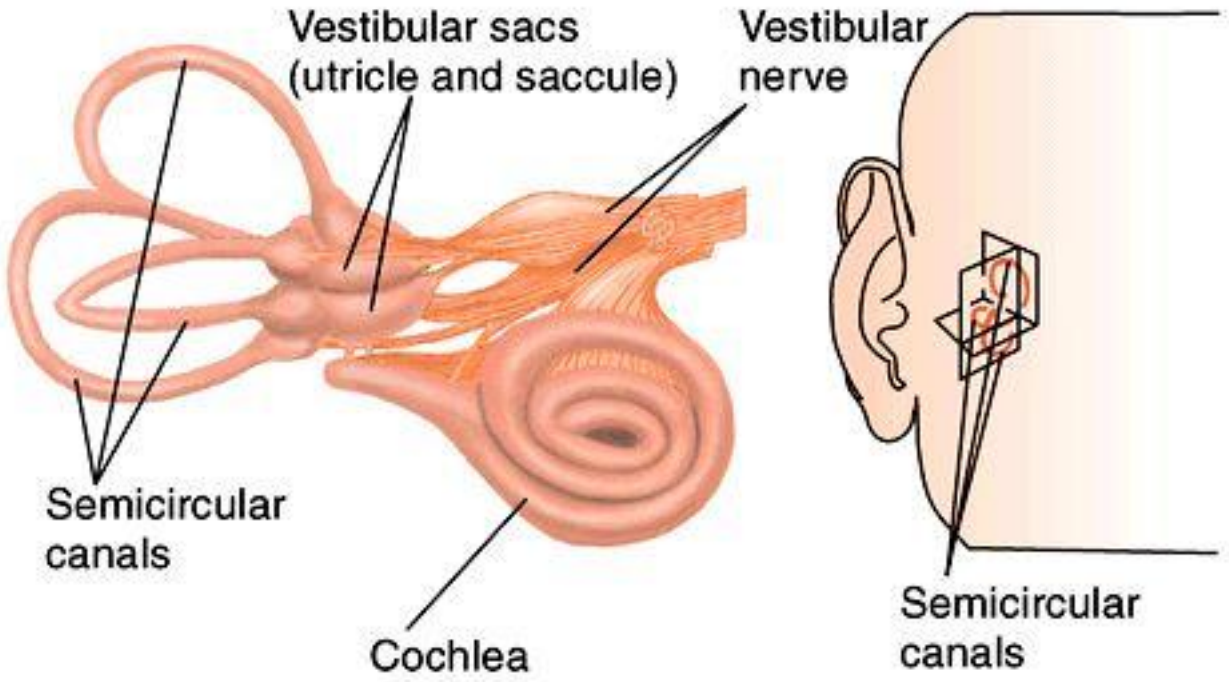
Primitive, powerful brainstem reflex which keeps the eyes fixated during self motion (eg walking, running)



- Mechanism: the eyes are driven in the opposite direction to the rotation of the head so that the movements cancel out and the eyes remain on target.
- The drive comes primarily from activation of the vestibular canal on the side of the head to which the head is turning. ***cannot signal continuing rotation.***

The ear and peripheral vestibular system




Vestibular sacs
(utricle and saccule)
Vestibular
nerve
Semicircular
canals
Cochlea
Semicircular
canals

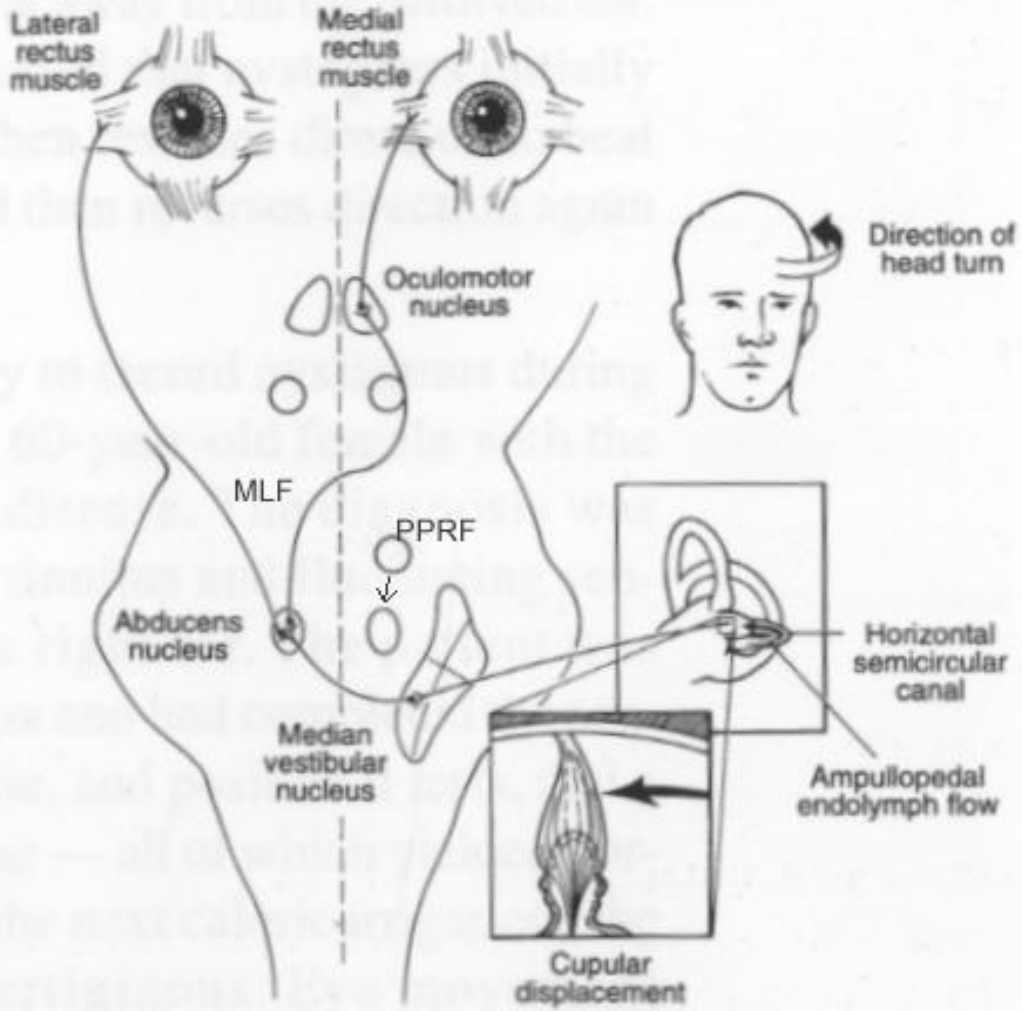


Figure 2.* *Afferent excitatory pathway from the horizontal semicircular canal for ocular motor control. Cupular displacement toward the ampulla evokes an excitatory stimulus in the horizontal canal whereas cupular displacement away from the ampulla is excitatory in the posterior and anterior canals.*

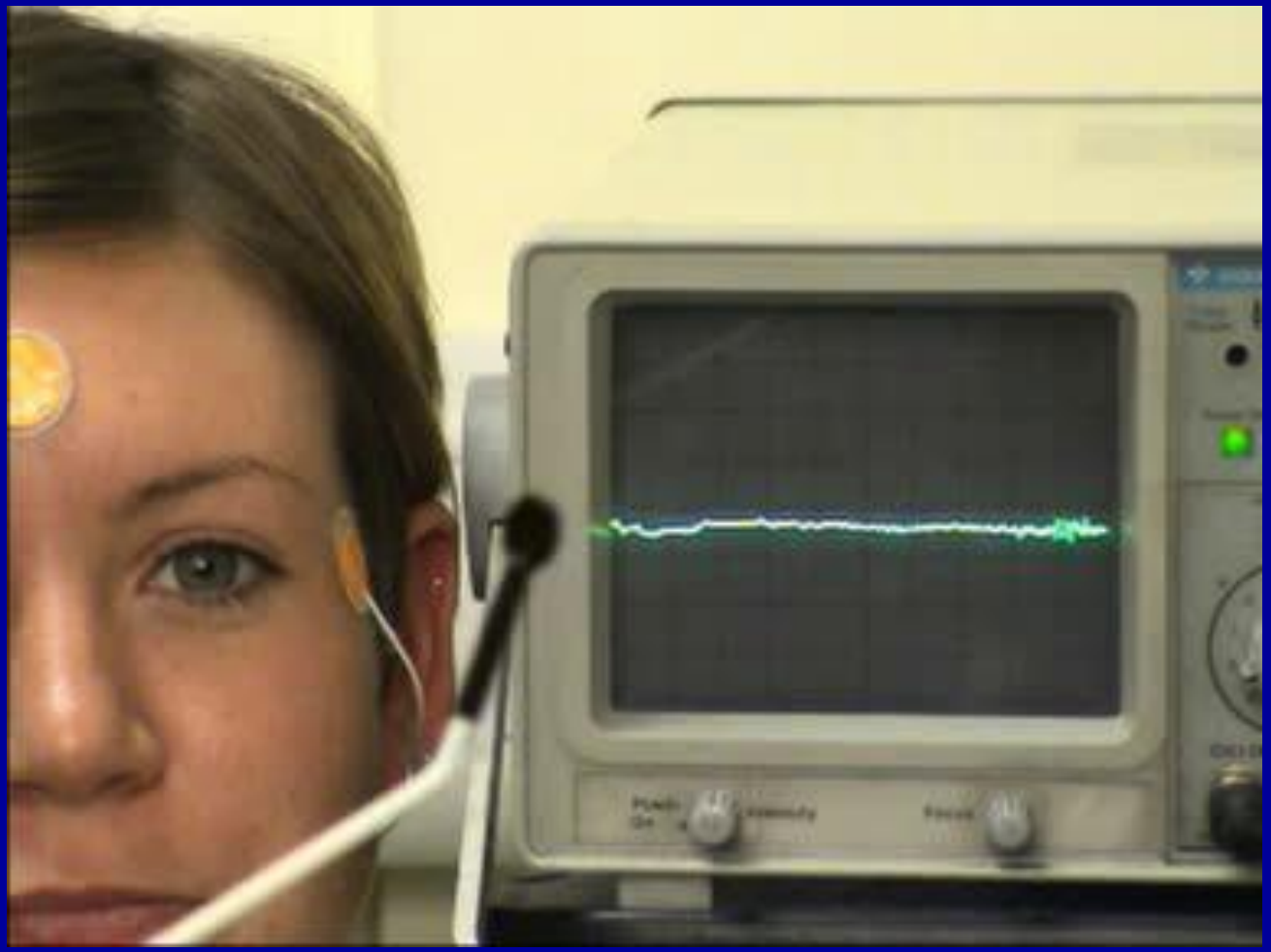
The VOR … and it’s voluntary visual suppression (VORS)

Normal Head Impulse Test or ‘head thrust test’

Bilaterally abnormal HIT

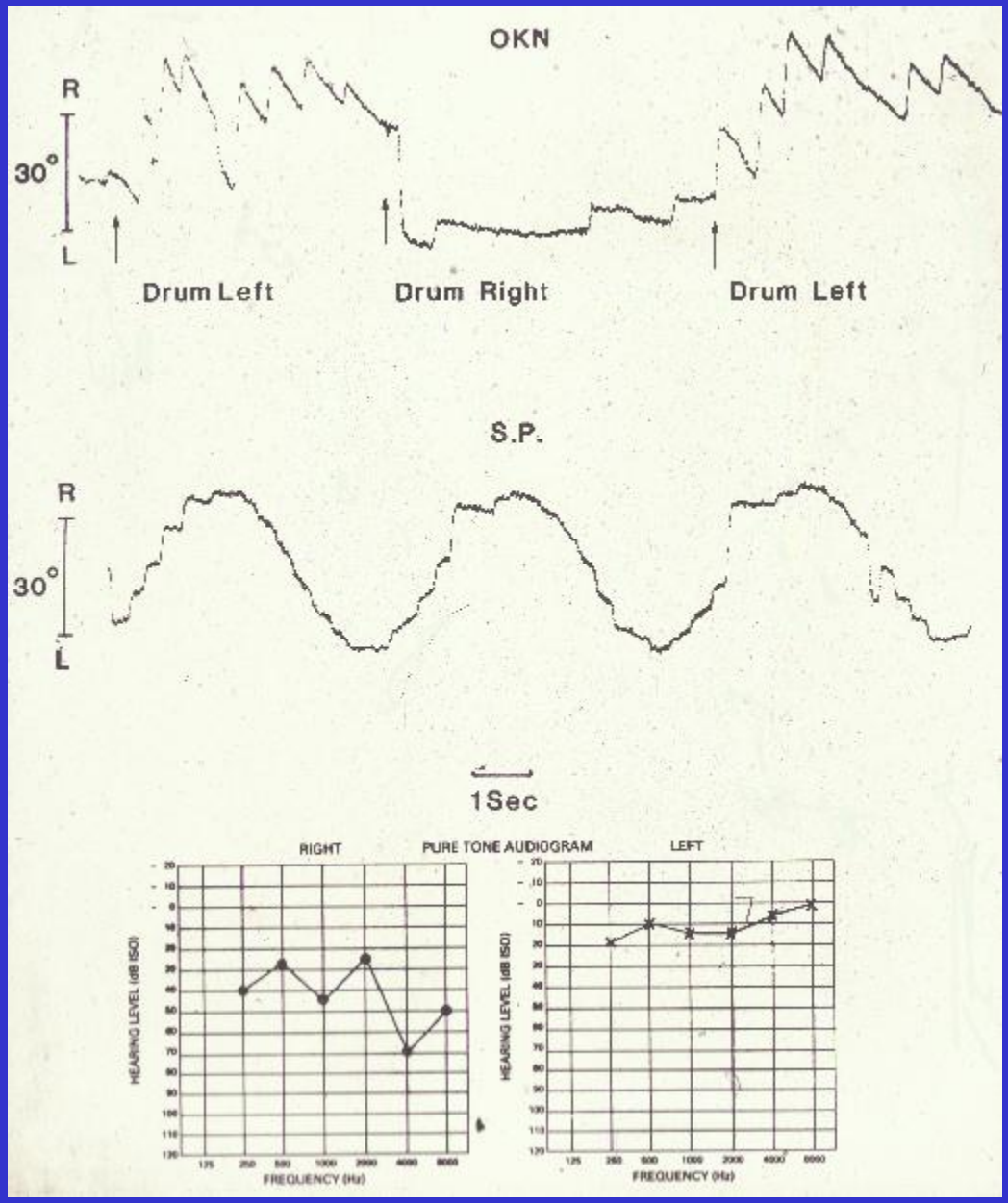
PURSUIT Phylogenetically modern function not present in most animals.

essential pathways
- visual cortex
- cerebellum



- Weak performance up to 60°/s at 0.5 to 1Hz max frequency.
- Driven by motion of a moving target across the retina.
- NB* Disorders are sensitive indicators of CNS dysfunction

Right
Ponto-Cerebellar
Tumour

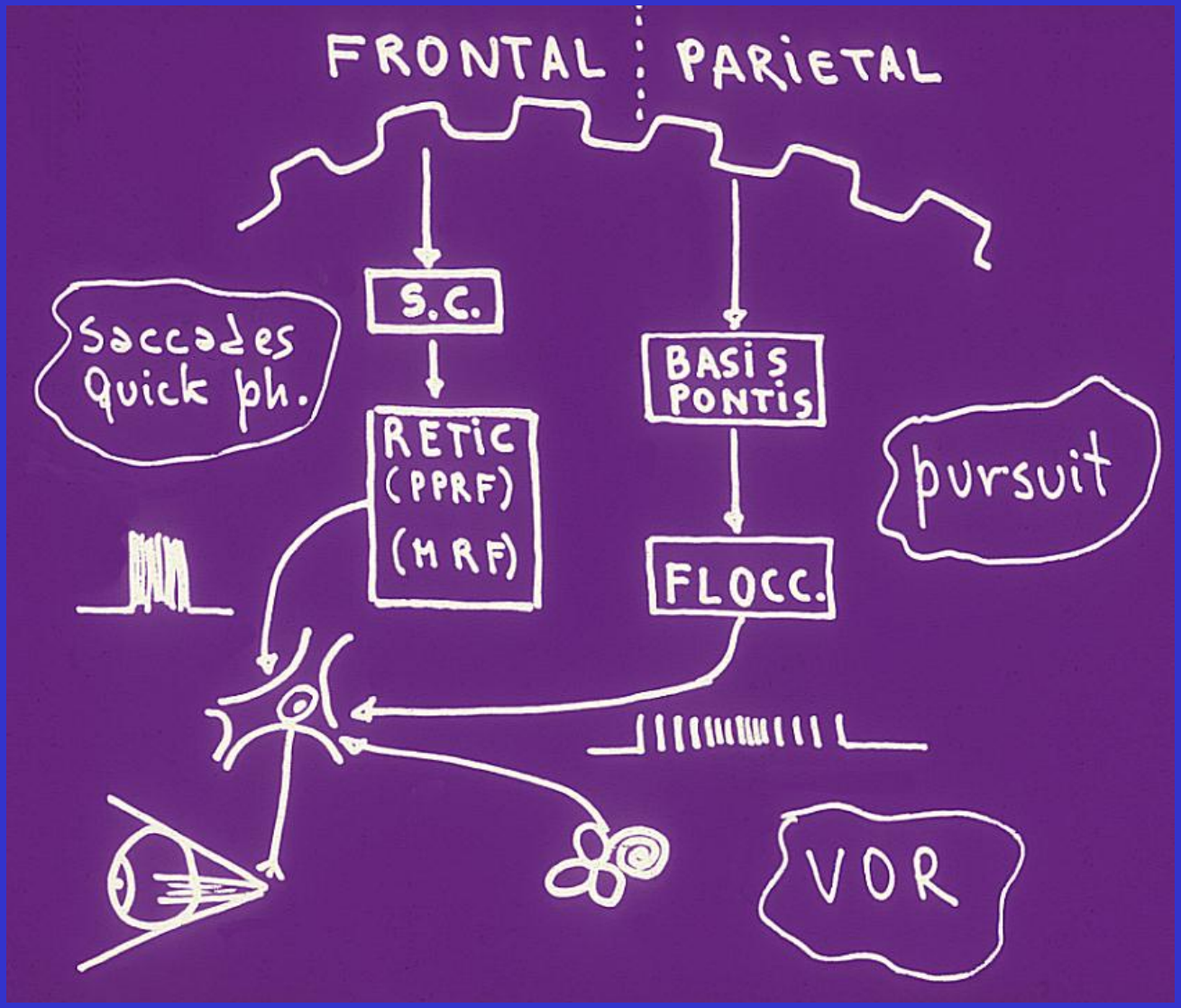


OPTOKINETIC REFLEX Phylogenetically old present in most animals.

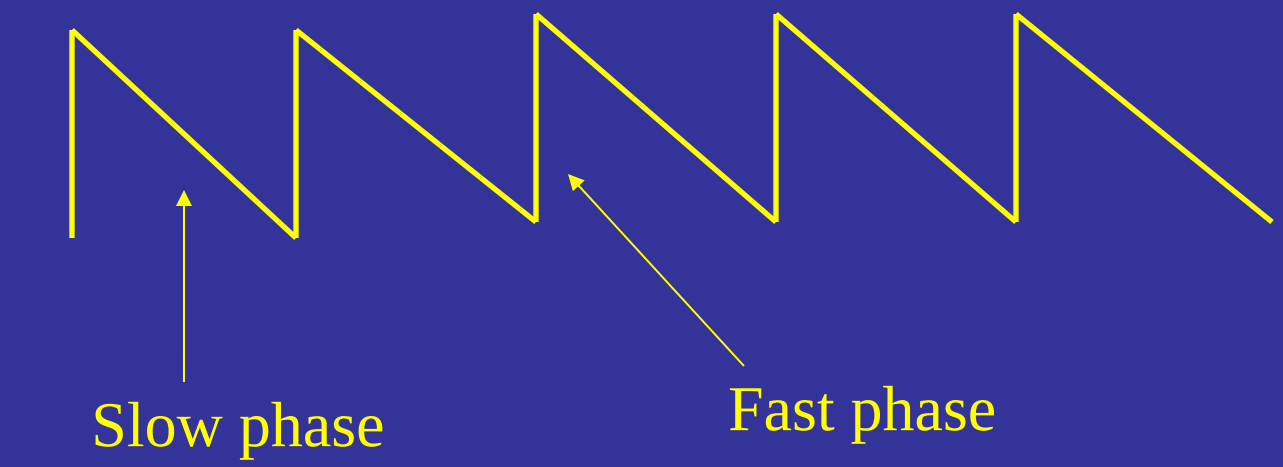
essential pathways
- visual cortex
- cerebellum

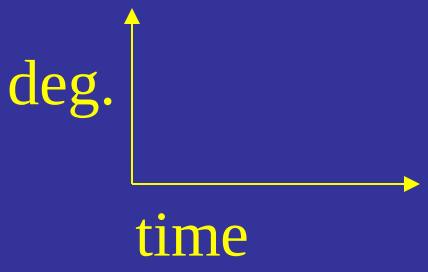
- Slow phase following driven by motion of an area of the visual field.
- The cumulative eye deviation is‘rest’ by fast phases: ‘optokinetic nystagmus’.
- Function of OKN is to complement the vestibular-ocular reflex by signalling ***sustained motion***

Eye movement pathways made really simple

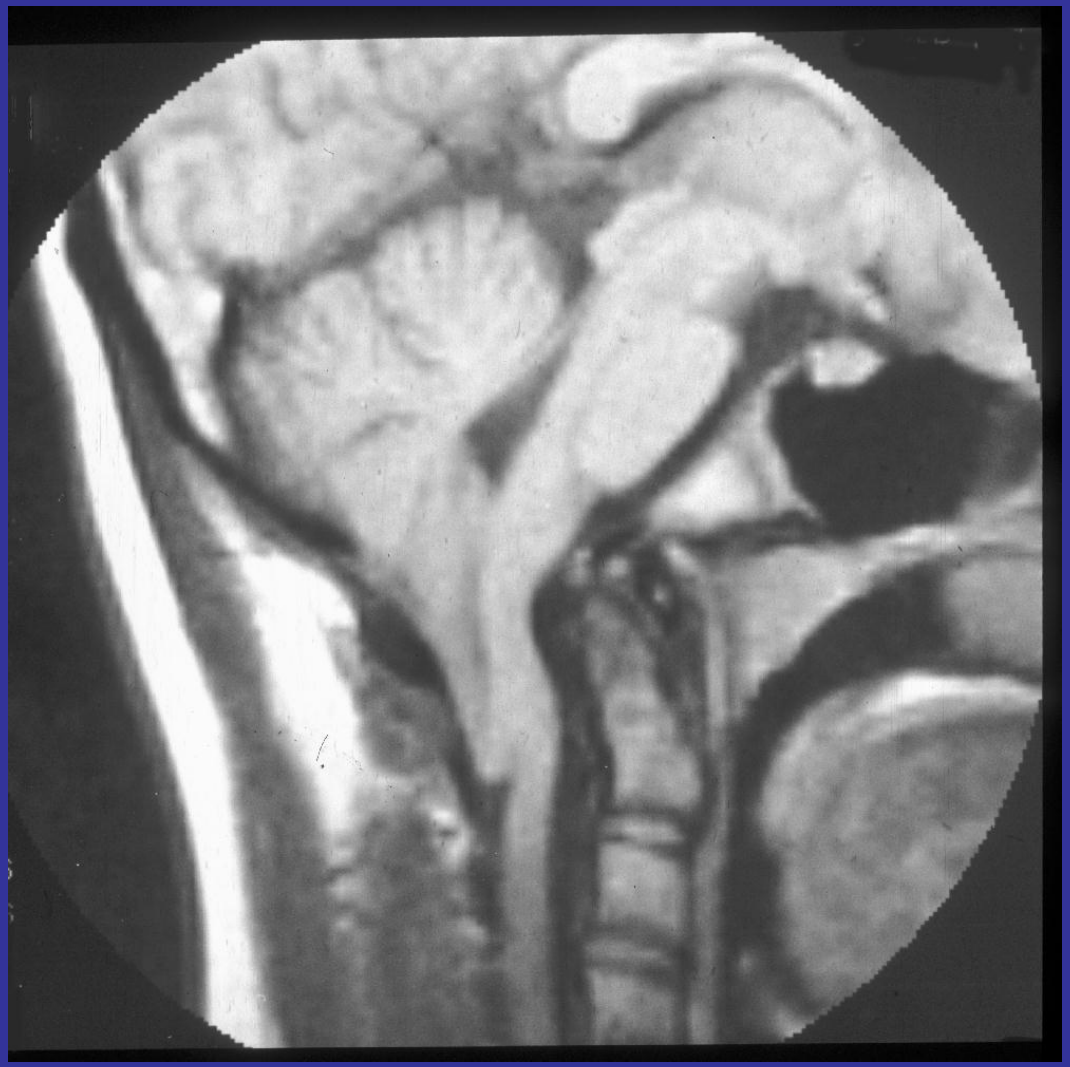


Saw-tooth or ‘jerk’ nystagmus

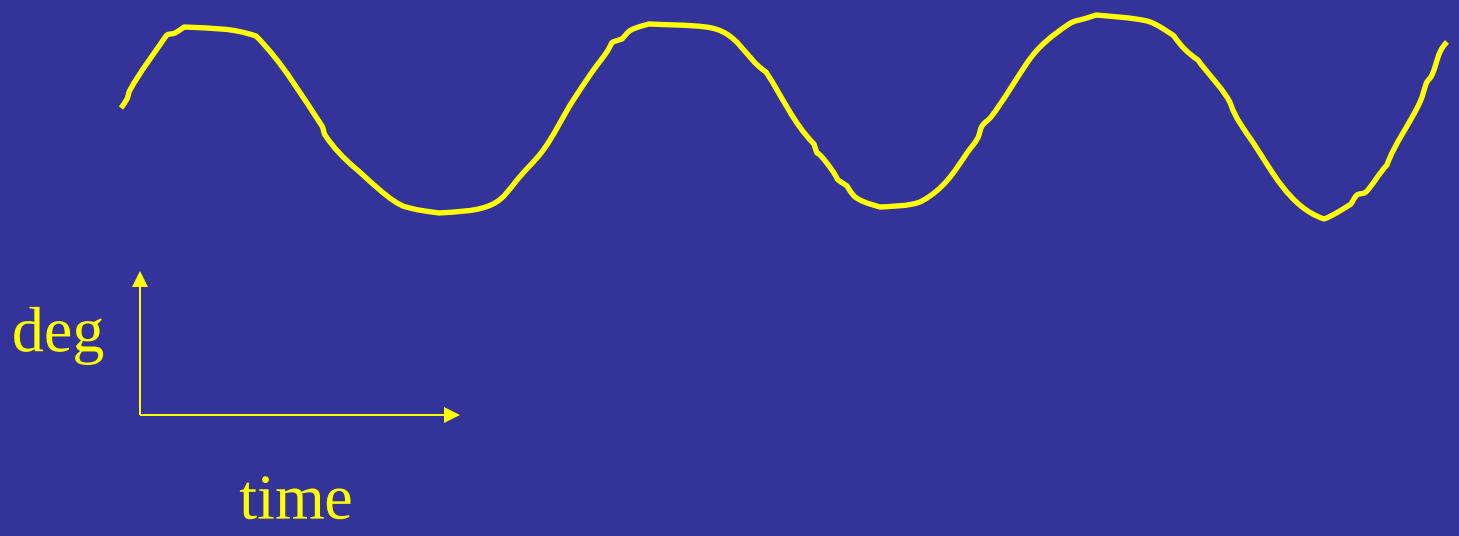




Arnold-Chiari Malformation with Down Beat Nystagmus



Pendular nystagmus



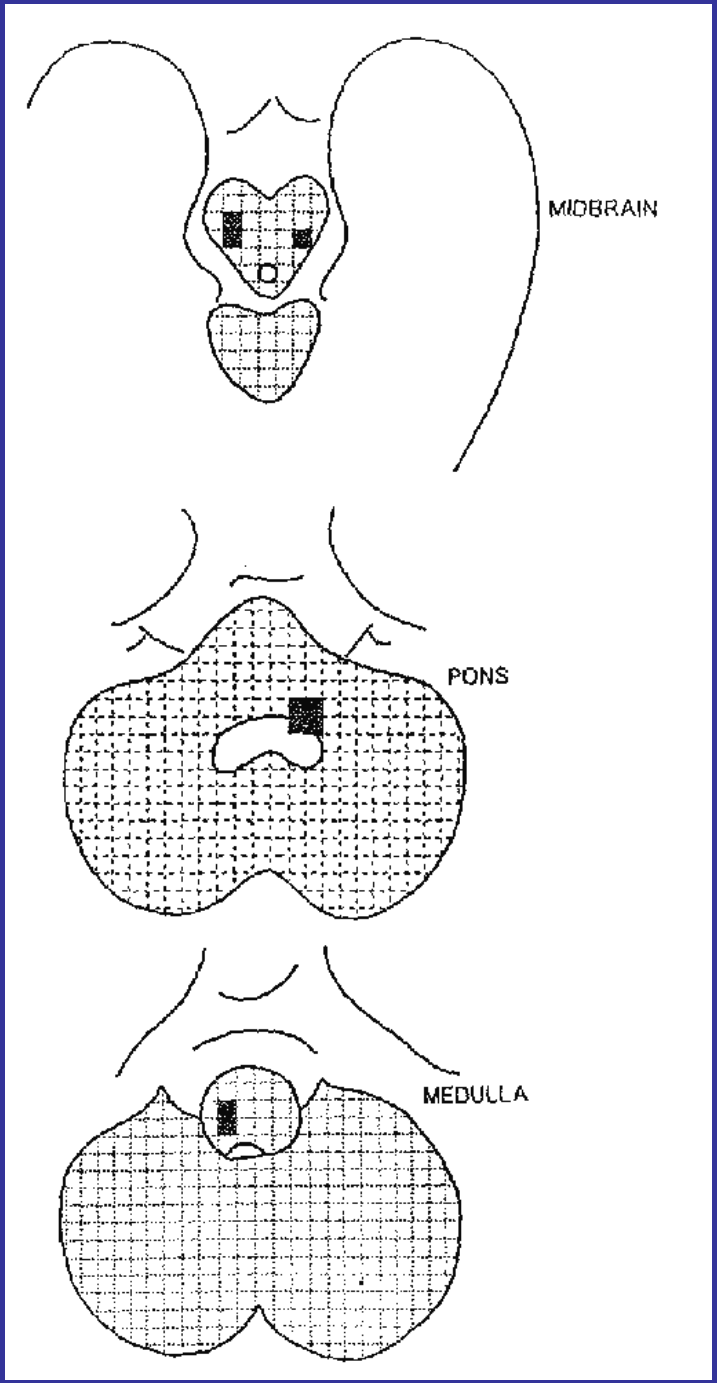
PENDULAR NYSTAGMUS:

Large or multiple lesions (CTT)

⇩

Inferior olive deafferentation

Lopez et al; Brain (1996)



Summary

- Anatomy:
  - Nuclei & nerve: III, IV and VI

    (III: all muscles but lateral rectus (VI) and superior oblique (IV)
  - Pre or supranuclear: e.g. pursuit (cerebellum), saccades (reticular nuclei PPRF)
- Physiology, Examination, Pathology:
  - Disconjugate:
    - normal (convergence),
    - Abnormal: diplopia, individual muscle actions -> individual nerves, INO
  - Conjugate: VOR, Smooth Pursuit, Saccades, Physiological nystagmus

    (abnormal: uni/bilateral vestibular lesion, slow saccades, broken SP)
  - Pathological nystagmus:
    - plane and direction, eg horizontal right beating
    - waveform: jerk (saw toothed) or pendular
    - spontaneous or evoked (by gaze, positioning, etc)