Lecture 5
The Eye: III. Central Neurophysiology of Vision

Visual fields

Temporal and nasal fields

-unequal

-nasal field is restricted by nose.

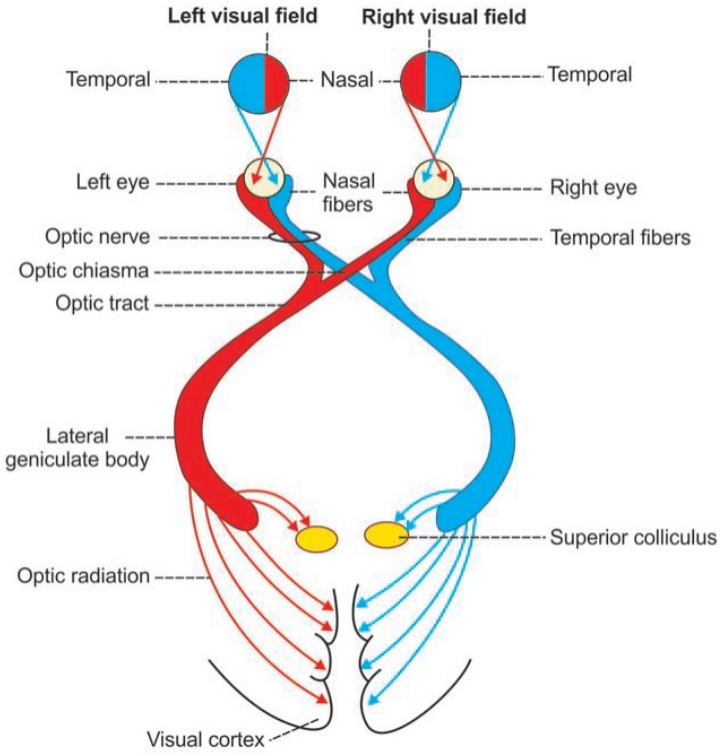
Light rays from temporal part of visual field→ipsilateral nasal half of retina

light rays from nasal part of visual field → ipsilateral temporal half of retina

Upper and lower fields

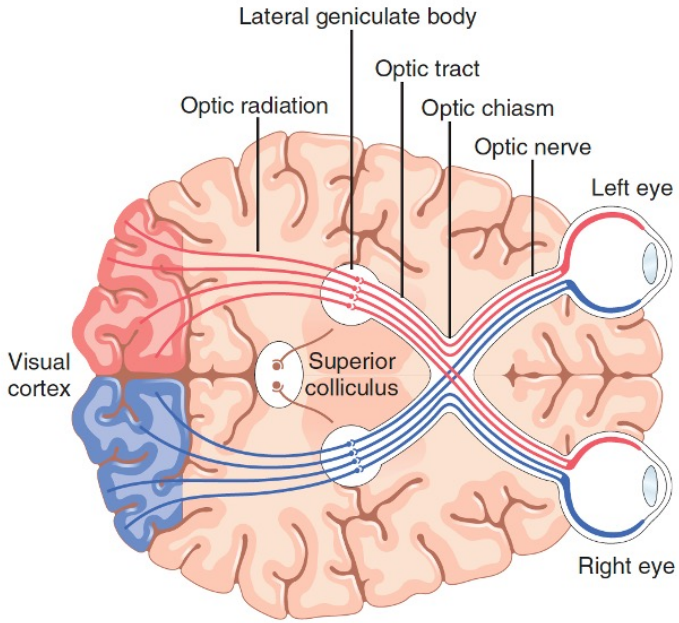
-upper→ restricted by eyelid & orbital margin.

-lower → restricted by cheek



Visual Pathways to the Brain

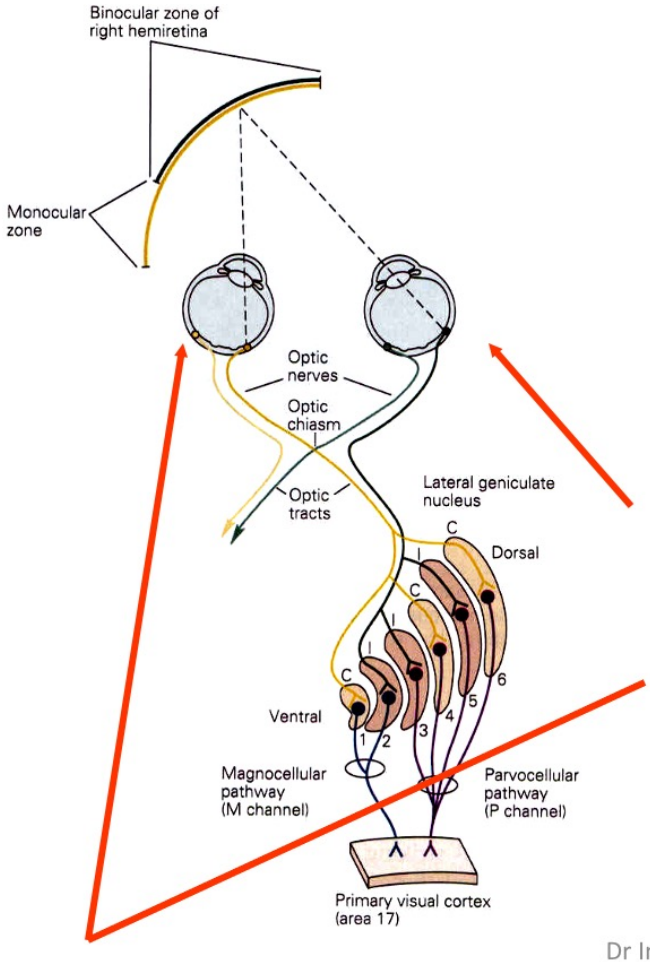
- optic nerve.
  - axons of ganglion cells of the retina.
- optic chiasm.
  - all fibers from the nasal halves of the retina cross to the opposite side and join fibers from the opposite temporal retina to form the optic tracks.
- synapse in the dorsal lateral geniculate nucleus (LGN).
- from LGN→ geniculocalcarine fibers to primary visual cortex by way of the optic radiation (geniculocalcarine tract).
- visual cortex in calcarine fissure in medial occipital lobe.



Optic tract Projections to Subcortical Regions

- suprachiasmatic nucleus of the hypothalamus.
  - control of circadian rhythms
- pretectal nuclei.
  - pupillary light reflex.
  - accommodation of the lens.
- superior colliculus
  - rapid directional movement of both eyes.
- ventral lateral geniculate
  - control of bodies behavioral functions

Lateral Geniculate Nucleus



Half of the fibers in each optic tract are derived from one eye, and half from the other eye.

Signals from the two eyes are kept apart in the LGN.

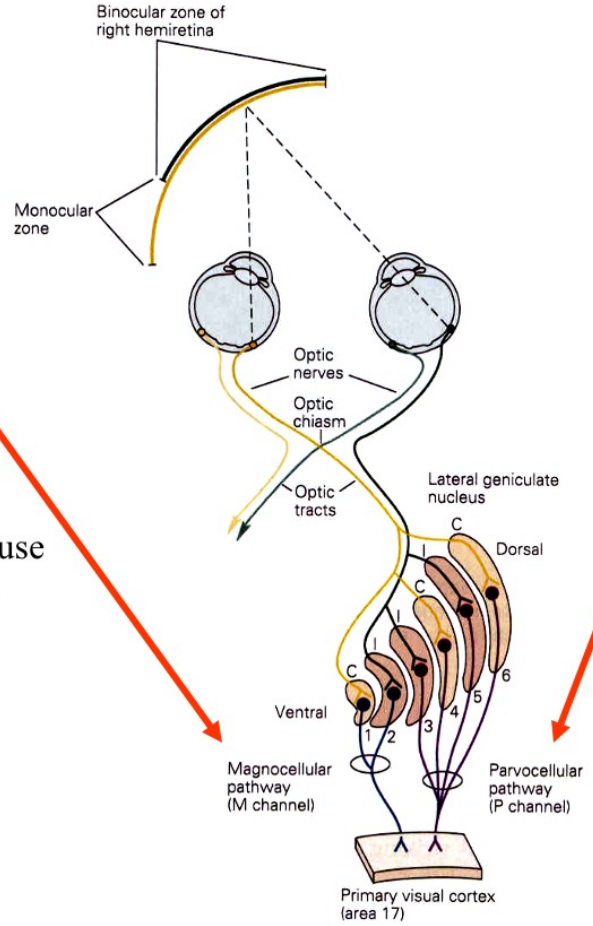
Layers 2, 3, and 5 receive input from lateral half of ipsilateral eye

Layers 1, 4, and 6 receive input from medial half of contralateral eye

Organization of the LGN

magnocellular layers

Layers 1-2
Large neurons
Input from M retinal ganglion cells
Rapid conduction
Blak & white vision
Magnocellular pathway
poor point-to-point transmission because of limited number of M cells & wide dendritic spread in retina.



parvocellular layers

Layers 3-6
Small-medium neurons
Input from P type ganglion cells
Moderate conduction
Color vision
Parvocellular pathway
Accurate point-to-point transmission

Function of the Dorsal Lateral Geniculate

- Two principle functions.
  - receives visual information from retina and sends it to primary visual cortex for processing.
  - “gate control” of information to primary visual cortex.

“Gate” Function of the LGN

- LGN receives **inhibitory** inputs from

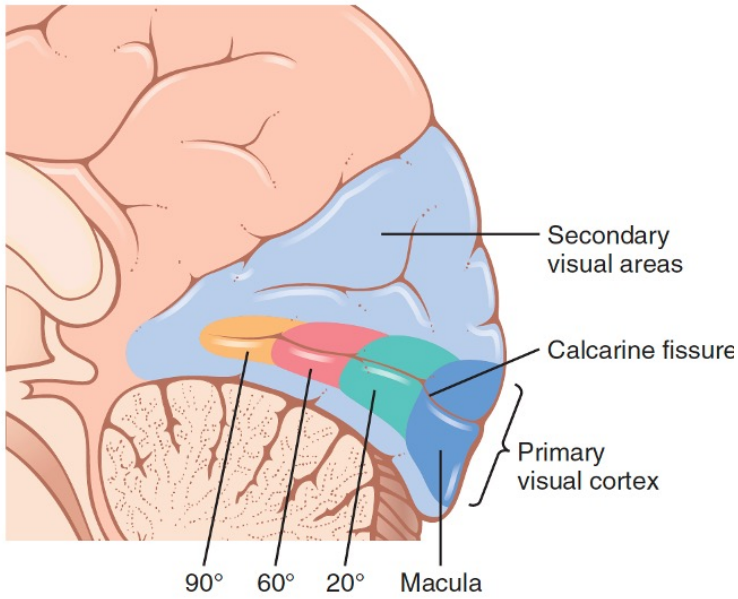
1. corticofugal fibers from primary visual cortex.
2. reticular areas of the midbrain.

- inhibitory inputs control the visual input that is allowed to pass to the cortex.

Primary Visual Cortex/visual area I/striate cortex

- Area 17
- large representation in visual cortex for the macula (region for highest visual acuity) near occipital pole.
- upper portion of retina is represented superiorly
- lower portion is represented inferiorly.

•receives the primary visual input→ perception of visual impulses.



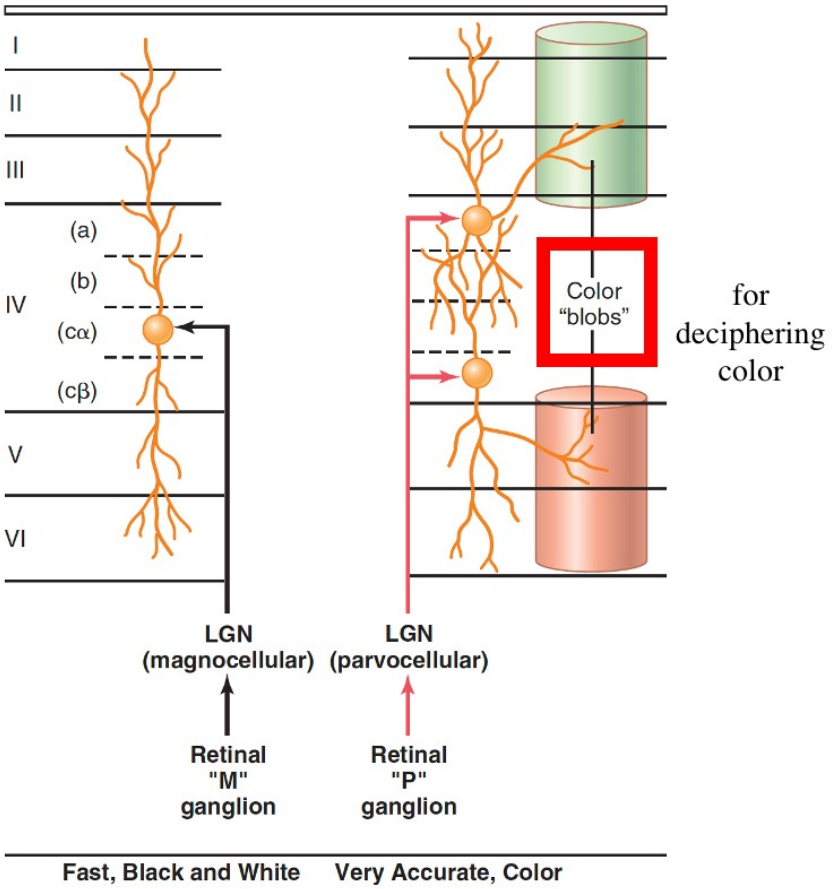
Layered/columnar structure of primary visual cortex

- 6 layers/several million vertical columns

- **geniculocalcarine** fibers terminate mainly in layer **IV-** subdivisions.
- signals from M ganglion cells →IVcα→ cortical & deeper levels.
- signals from P cells → layer IVa & IVcβ→ cortical & deeper levels.
- cortical surface & deeper levels→further processing

- signals to layers I, II, and III eventually transmit signals for short distances **laterally** in the cortex.

- signals to layers V and VI excite neurons that transmit signals much greater distances.



Interaction of Visual Signals from the Two Separate Eyes.

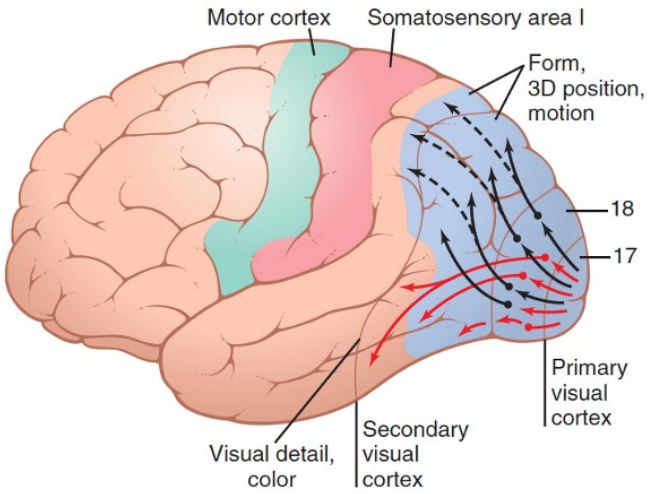
- images on the two retinas are not exactly the same
- the closer the object, the greater the disparity
- Signals from 2 eyes remain separated from each other when they arrive in layer IV

- layer IV deciphers whether the respective areas of 2 visual images from 2 eyes are matching each other ’in-register” → fused
- if not matching → directional gaze of separate eyes are adjusted to obtain matching images

- Strabismus/diplopia/Squint/cross-eye
- lack of fusion of eyes in one or more of the visual coordinates: horizontal, vertical, or rotational.
- types of strabismus
- (1) horizontal
- (2) vertical
- (3) torsional
- (4) Combinations

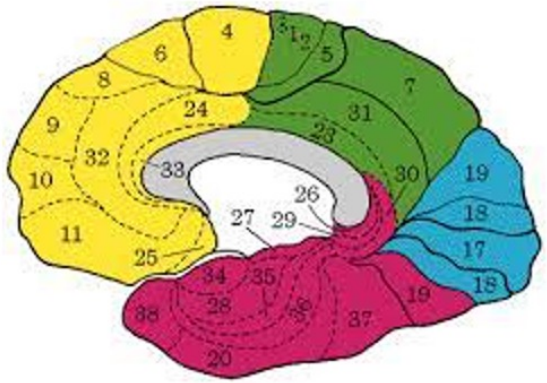
Secondary Visual Areas/visual association areas

- Brodmann's area 18
- Surrounds Primary Visual Cortex
- Analysis of secondary signals → interpretation of visual impulses
- signals representin form, 3D & motion →transmitted into superior portions of occipital and posterior portions of parietal lobe.
- signals for visual detail (recognizing letters, texture and & color=deciphering from all this information what the object is and what it means) →anteroventral portion of occipital & ventral portion of posterior temporal

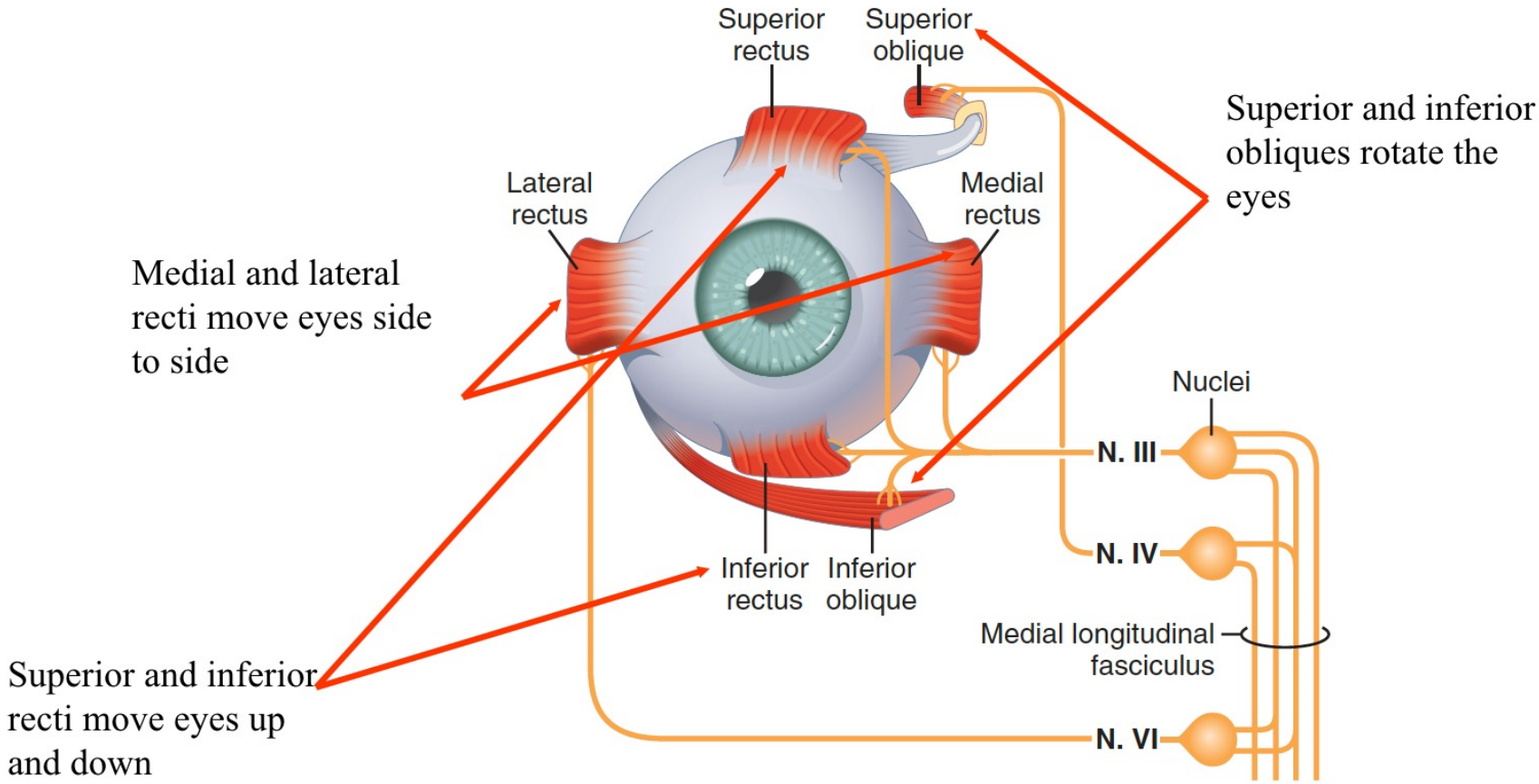


Occipital eye field (area 19)

Concerned with the movement of eyes



Eye movements are controlled by 3 separate pairs of muscles.



Movement	Primary muscle	Secondary muscle
1. Abduction	Lateral rectus	Superior oblique Inferior oblique
2. Adduction	Medial rectus	Superior rectus Inferior rectus
3. Elevation	Superior rectus	Inferior oblique
4. Depression	Inferior rectus	Superior oblique
5. Extorsion	Inferior oblique	Inferior rectus
6. Intorsion	Superior oblique	Superior rectus

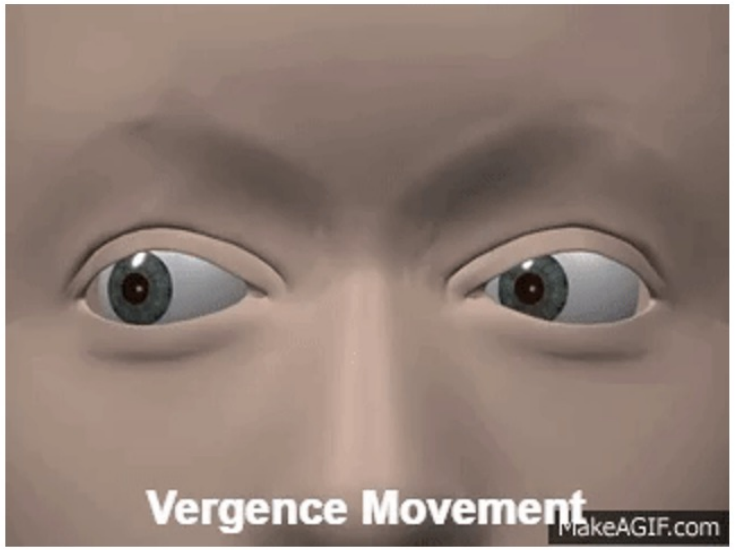
Eye movements

1. Conjugate movement →both eyeballs move in same direction-medial rectus of one eye and lateral rectus of the other eye.

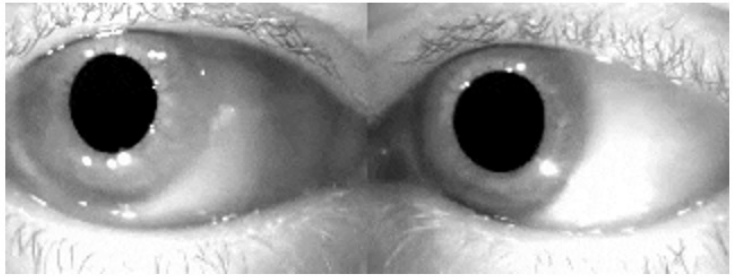
2. Disjugate Movement→both eyeballs move in opposite direction-convergence and divergence.

3. Convergence →movement of both eyeballs towards nose

- simultaneous **contraction** of medial rectus and simultaneous relaxation of lateral rectus of both eyes
- Accomodation

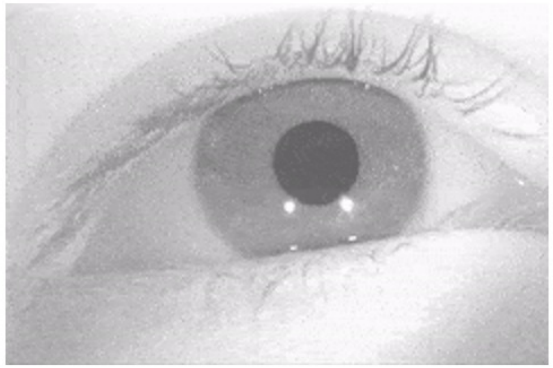


Eye movements



4. Pursuit Movement→ when eyeballs follow a moving object.

5. Saccadic/ optokinetic Movement
Saccadic movement is the quick jerky movement of both eyeballs when the fixation of eyes (gaze) is shifted from one object to another object.

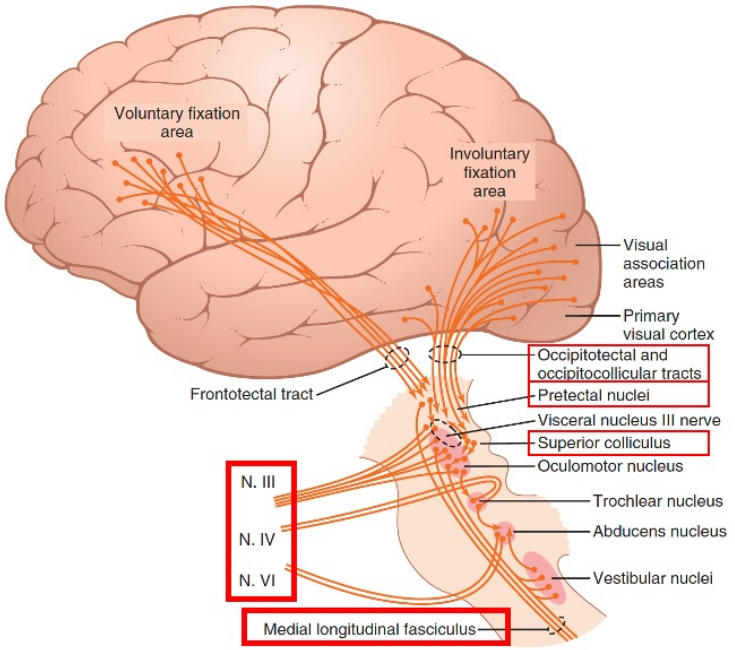


Neural Pathways Controlling Eye Movement

- **fixation movements** of the eyes controlled by two neuronal mechanisms, *voluntary* and *involuntary.*

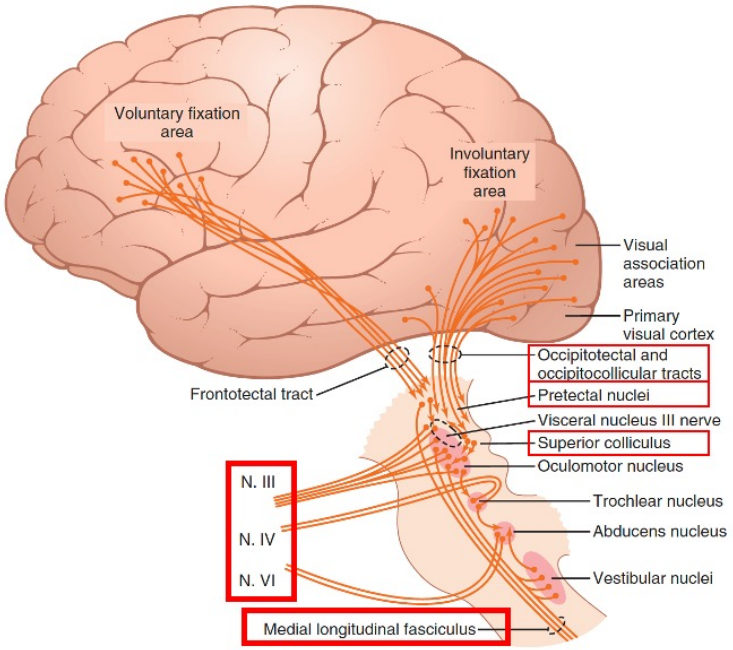
  - *voluntary fixation* movements "unlocking":

  allows person to move eyes voluntarily to find an object controlled by an area in the **premotor cortex (frontal lobes).**



Neural Pathways Controlling Eye Movement

- **fixation movements**
  - *involuntary fixation*
  - mechanism causes eyes to "lock" on object of attention found with the voluntary fixation mechanism.
  - three types of continuous but almost imperceptible movements:
    - ➢continuous tremor→30 -80 cycles/sec caused by successive contractions of the motor units in the ocular muscles;
    - ➢slow drift
    - ➢sudden flicking movements
  - controlled by **secondary visual areas** of the occipital cortex.
  - results from negative feedback mechanism controlled at the level of the *superior colliculus* that prevents objects of attention from leaving the foveal portion of the retina.



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