NS II
Spring 2024
Lecture 7
Classification and neuronal control of eyes movements

Zuheir A Hasan

Professor of physiology

College of Medicine HU

VOR reflex : eye movements initiated by head rotation
Neuronal pathways for VOR

- Vestibular Receptors & Vestibular 1° Afferent Neurons*

↓

- Horizontal Movements: Medial Vestibular Nucleus*

↓

- VI motor nucleus excites Lateral Rectus of One Eye

↓

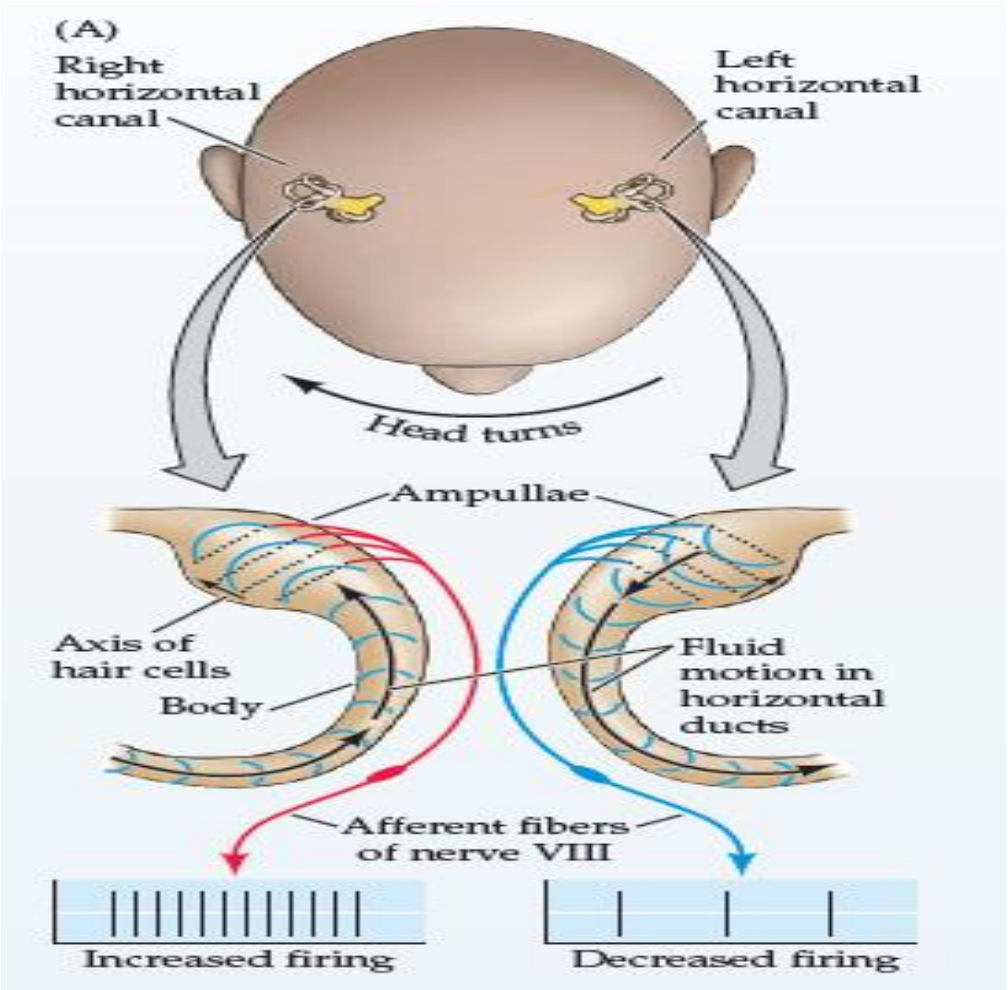
- VI motor nucleus interneuron via (MLF) to III motor nucleus excites Medial Rectus of Opposite Eye

↓

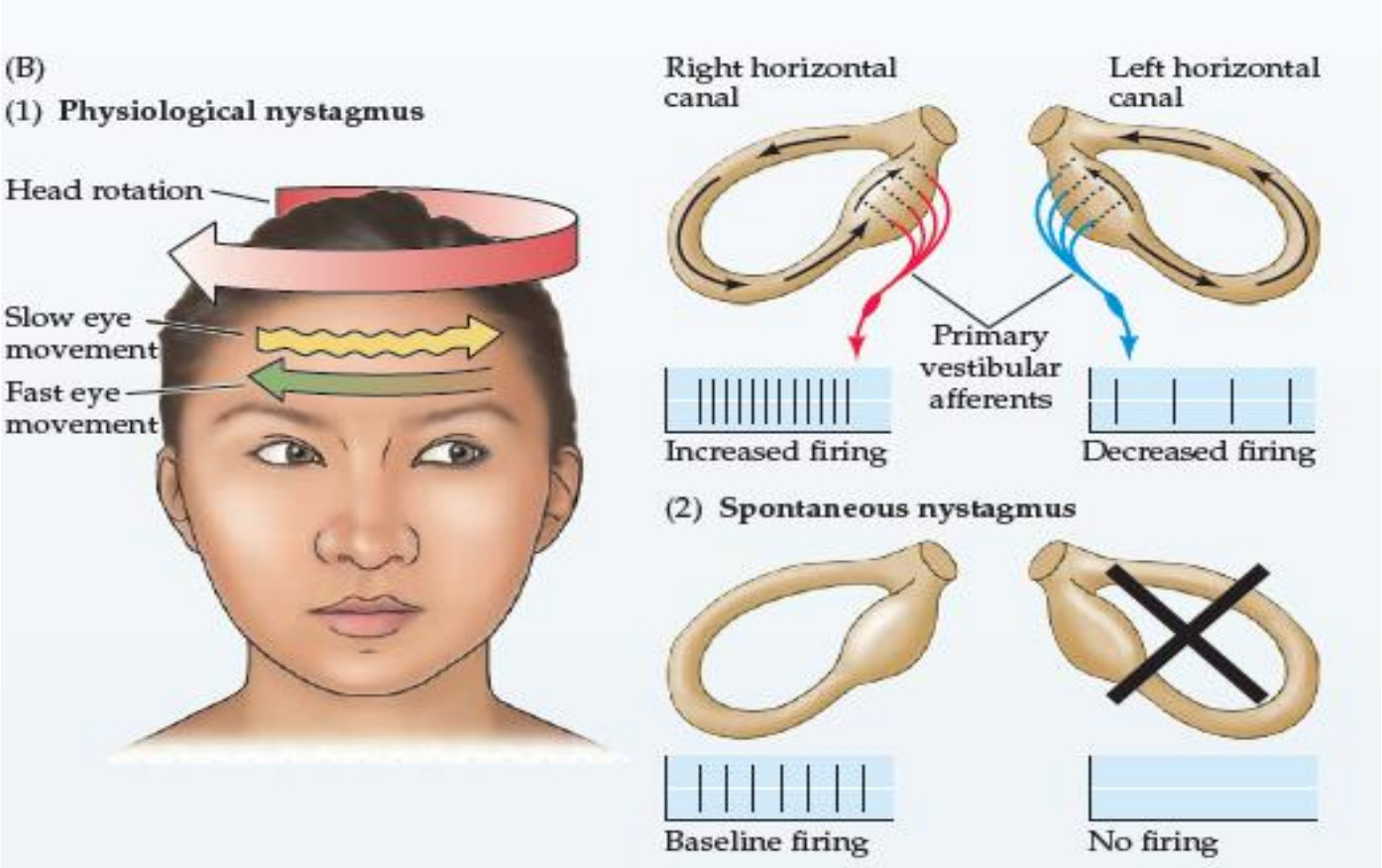
- Conjugate eye movements opposite to direction *of rotation*

Clinical Evaluation of the Vestibular System
Response of the vestibular system to angular acceleration

View looking down on the top of a person's head illustrates the fluid motion generated in the left and right horizontal canals and the changes in vestibular nerve firing rates when the head turns to the right.



Clinical evolution of vestibular system function



Clinical evolution of vestibular system function

Physiological nystagmus

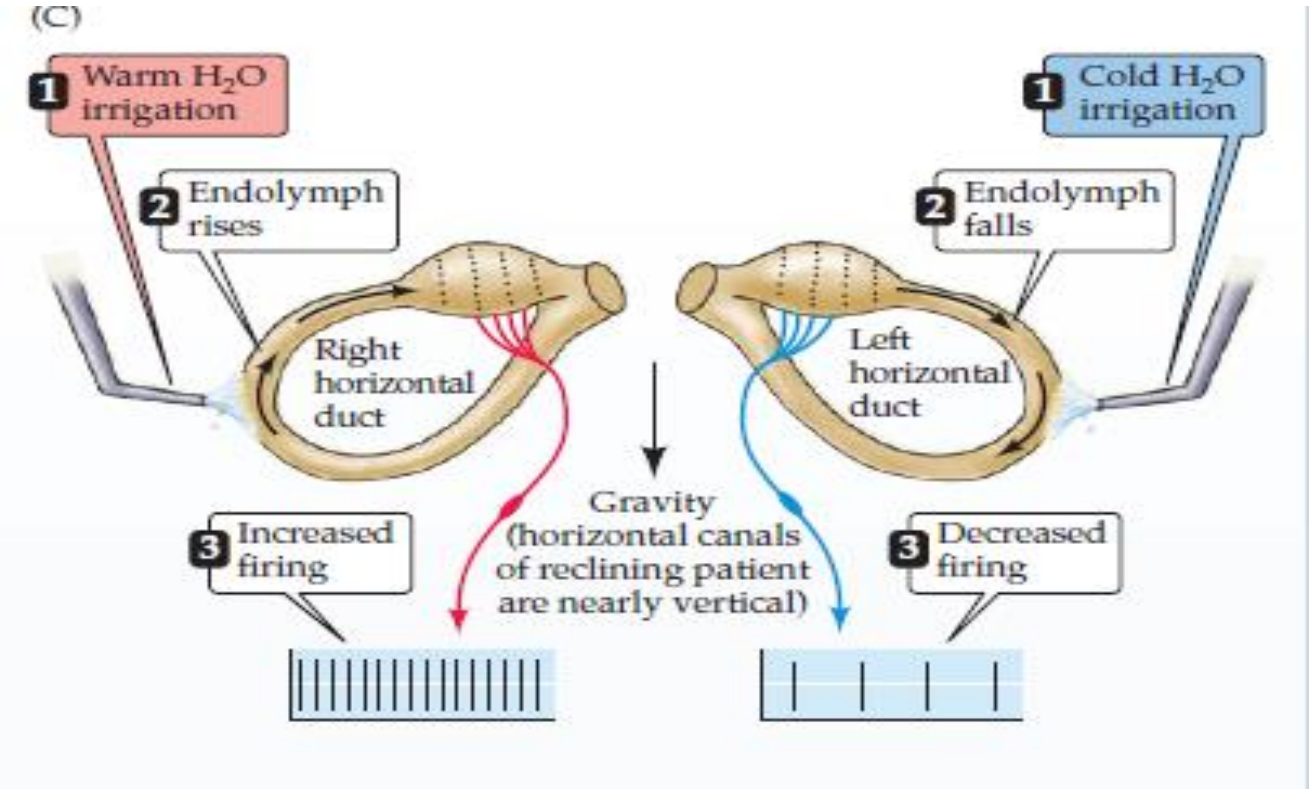
- In normal person . , rotating the head elicits physiological nystagmus, which consists of a slow eye movement counter to the direction of head turning.
- The slow component of the eye movements is due to the net differences in left and right vestibular nerve firing rates acting via the central neuronal circuit
- Spontaneous nystagmus
- where the eyes move rhythmically from side to side in the absence of any head movements, occurs when one of the canals or nerves is damaged.
- In this situation, net differences in vestibular nerve firing rates exist even when the head is stationary because the vestibular nerve innervating the intact canal fires steadily at rest, in contrast toa lack of activity on the damaged side.

Caloric test

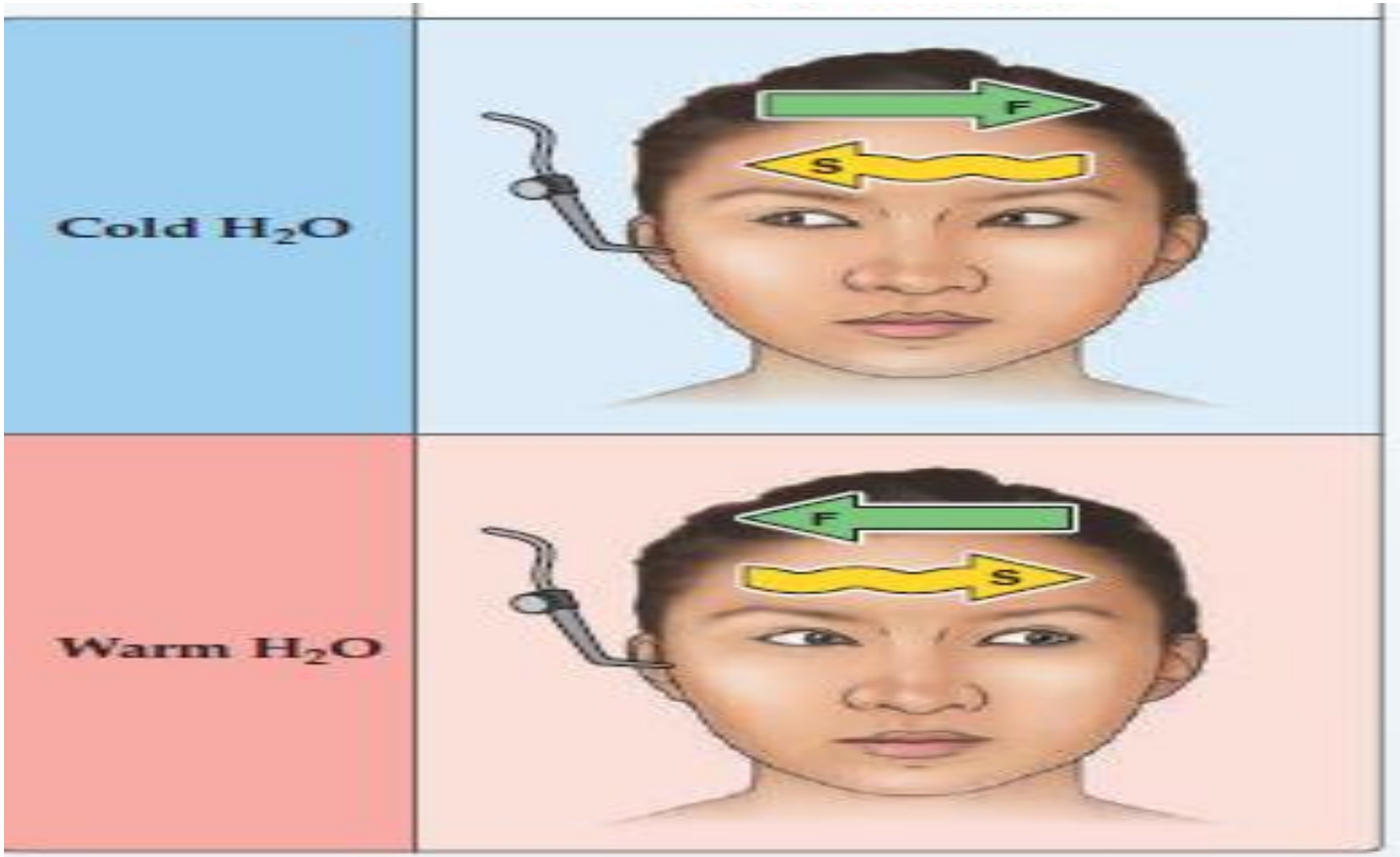
- The semicircular canals are stimulated by instilling warm (40°C) or cold (30°C) water into the external auditory meatus.
- The temperature difference sets up convection currents in the **endolymph of the canal** with consequent motion of the cupula.
- with water slightly warmer than body temperature generates convection currents in the canal (that mimic the endolymph movement induced by turning the head to the irrigated side.
- Irrigation with cold water induces the opposite effect.

- In healthy persons, warm water causes nystagmus that bears toward the stimulus, whereas cold water induces nystagmus that bears toward the opposite ear.
- This test is given the mnemonic **COWS** (**C**old water nystagmus is **O**pposite sides, **W**arm water nystagmus is **S**ame side.

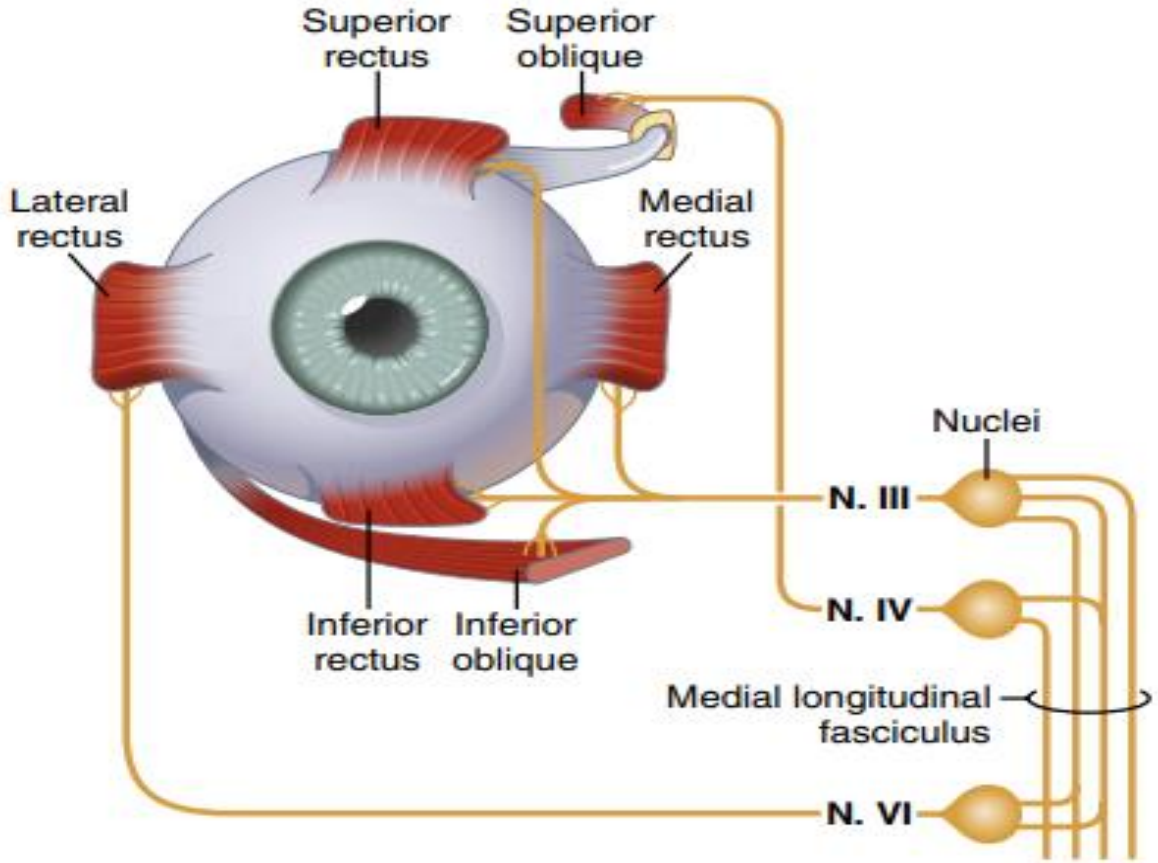
Response of vestibular nerve in caloric test



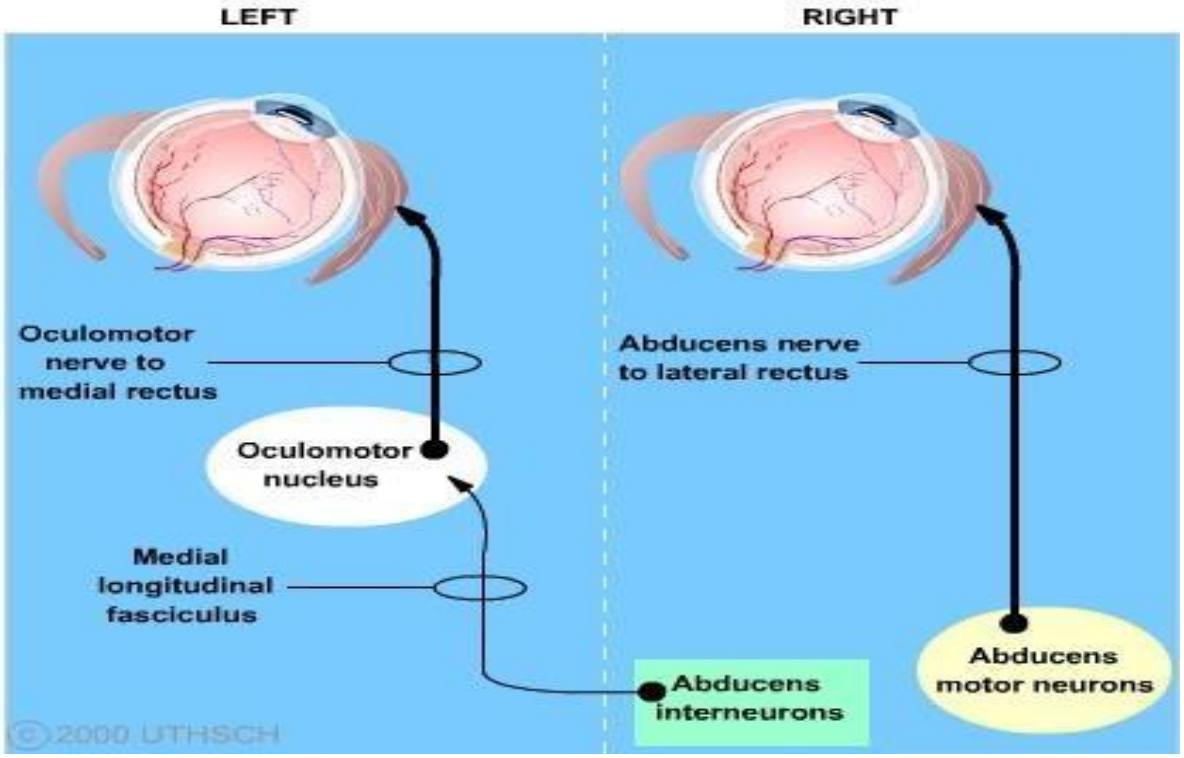
Nystagmus during caloric test



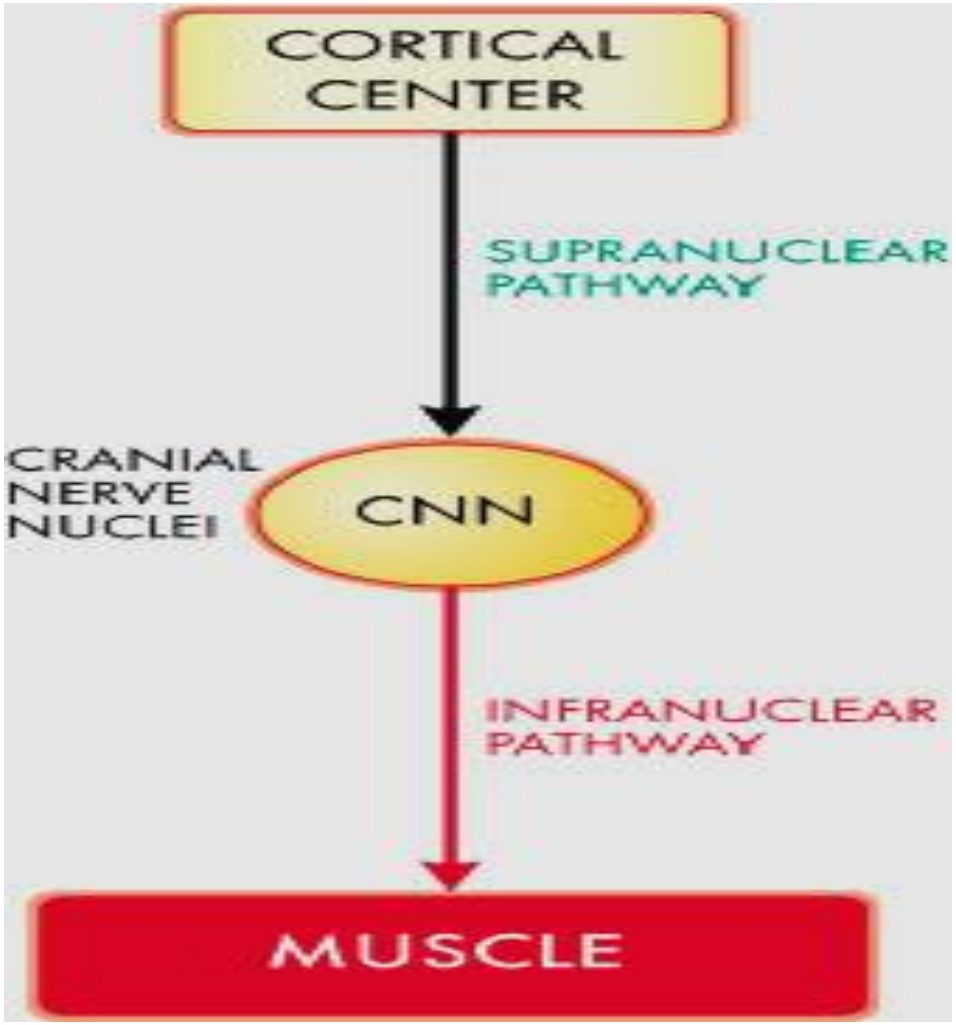
Cranial Nerves which control eyes movements



The axons of the abducens interneurons decussate and travel in the medial longitudinal fasciculus to the contralateral oculomotor nucleus to excite the motor neurons controlling the medial rectus of the eye contralateral to the abducens nucleus



Supranuclear and internuclear pathway ways



Gaze center in the brain

- **Vertical** is located in the midbrain reticular formation[2]
- has direct control over the lower motor neurons in the oculomotor and trochlear nuclei
- The **horizontal gaze center**
  - is called the paramedian pontine reticular formation (PPRF)
  - has direct control over the abducens lower motor neurons and interneurons
  - Recall that the abducens nucleus contains
    - lower motor neurons that send their axons in the ipsilateral abducens nerve to the lateral rectus muscle
    - interneurons that send their axons in the contralateral medial longitudinal fasciculus to the oculomotor neurons controlling the medial rectus

Fixation Movements of the Eyes
Voluntary fixation mechanism

- Allows a person to move the eyes voluntarily to find the object on which he or she wants to fix the vision.
- The voluntary fixation movements are controlled by a cortical field located bilaterally in the premotor cortical regions of the frontal lobes
- Bilateral dysfunction or destruction of these areas makes it difficult for a person to “unlock” the eyes from one point of fixation and move them to another point

Fixation Movements of the Eyes involuntary fixation mechanism

- Causes the eyes to “lock” on the object of attention once it is found
- It is controlled by secondary visual areas in the occipital cortex, located mainly anterior to the primary visual cortex
- To summarize, posterior “involuntary” occipital cortical eye fields automatically “lock” the eyes on a given spot of the visual field and thereby prevent movement of the image across the retinas.
- To unlock this visual fixation, voluntary signals must be transmitted from cortical “voluntary” eye fields located in the frontal cortex.

Neuronal control of eyes movement

Frontal eye field
Visual association area
Superior colliculus
Oculomotor apparatus
MLF
Gaze centers

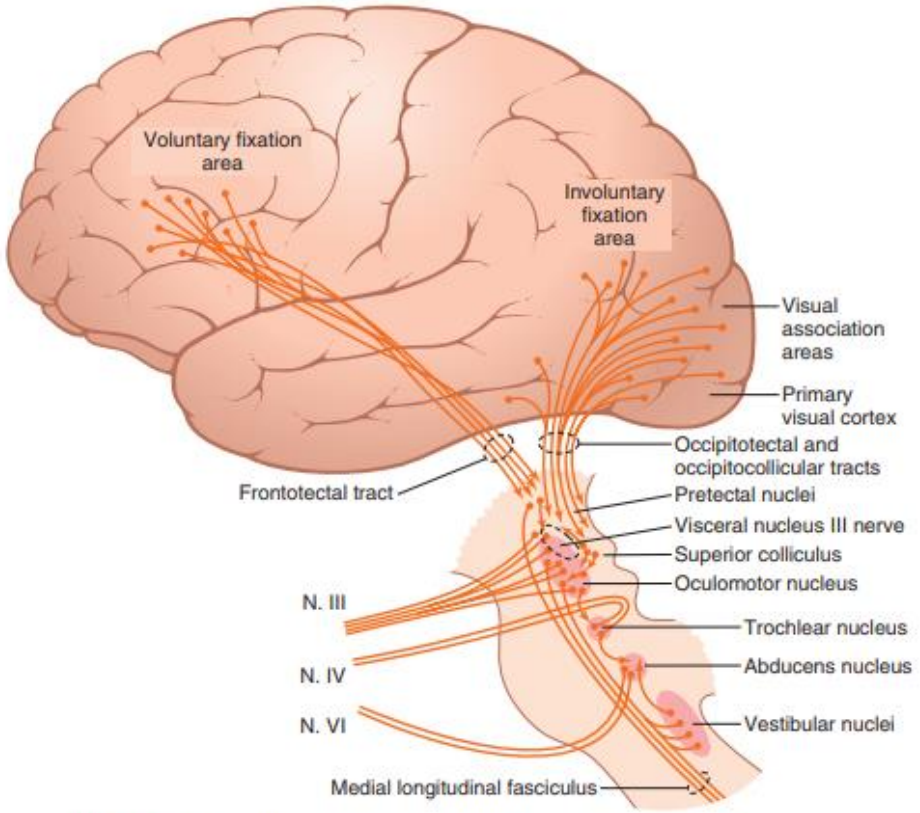


Figure 52-8. Neural pathways for control of conjugate movement of the eyes. N., nerve.

Classification of eye movements

Eye Movement Type	Function
	Gaze Stabilization
Vestibulo-ocular	Initiated by vestibular mechanisms during brief rapid head movement
	Gaze Shifting
Vergence	Adjusts for different viewing distance Near or far vision
Smooth Pursuit	Follows moving visual target
Saccade	Directs eyes toward visual target

Saccades : definition and characteristics

- Saccades are rapid, sudden jerky ballistic movements of the eyes that abruptly change the point of fixation.
- A saccade is a rapid, conjugate, eye movement that shifts the center of gaze from one part of the visual field to another. Saccades are mainly used for orienting gaze towards an object of interest.
- Saccadic eye movements are said to be ballistic because the saccade-generating system cannot respond to subsequent changes in the position of the target during the course of the eye movement. Meaning that Vision is suppressed during saccadic movements
- They bring new objects of interest onto the fovea and reduce adaptation in the visual pathway that would occur if gaze were fixed on a single object for long periods.

Saccades : definition and characteristics

- They range in amplitude from the small movements made while reading to the much larger movements made while gazing around a room.
- The rapid eye movements that occur during REM sleep are also saccades
- Saccades occur very rapidly and occurs a rate of 2-to-3 jumps/sec,.
- For example if we say, look to the right, the eyes turn to the right. This occurs rapidly and is a rapid eye movement. The system, which controls this command pathway, is the saccadic system

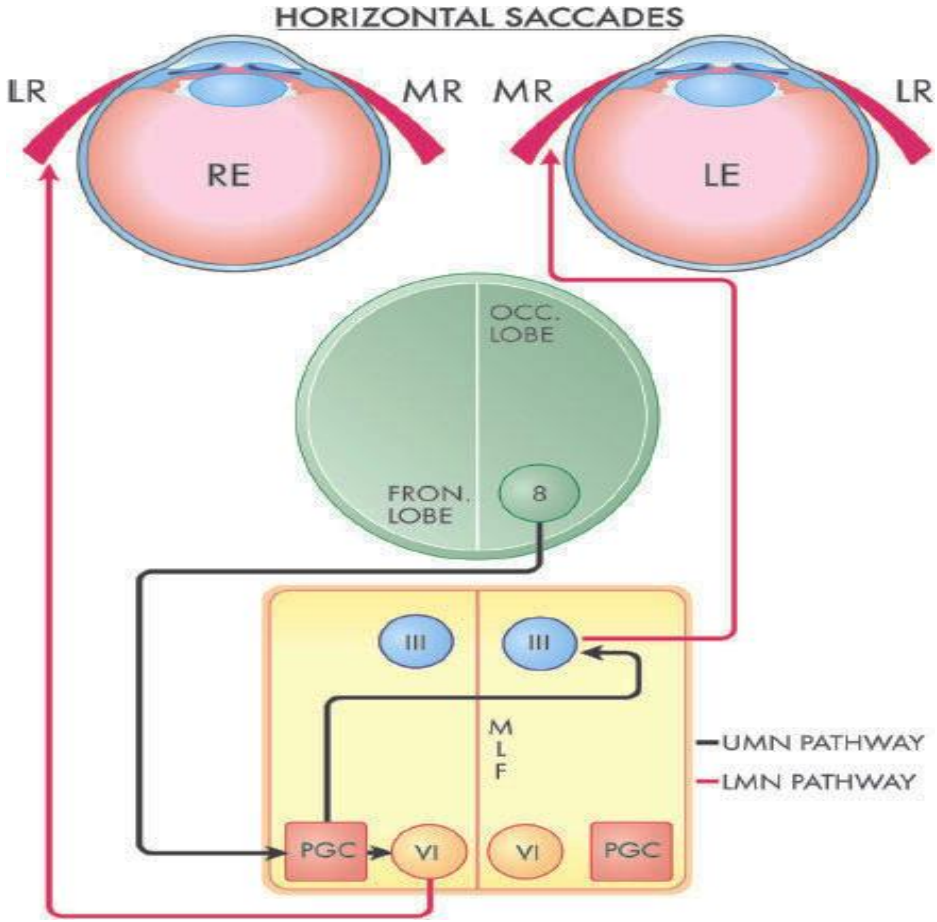
Horizontal and Vertical saccades

In horizontal saccades, the eyes move horizontally and in vertical saccades, the eyes move up and down.

In vertical saccades, the eyes move up and down. Let us now understand the pathway of the horizontal saccades

Horizontal saccades are unilaterally controlled whereas the vertical saccades are bilaterally controlled.

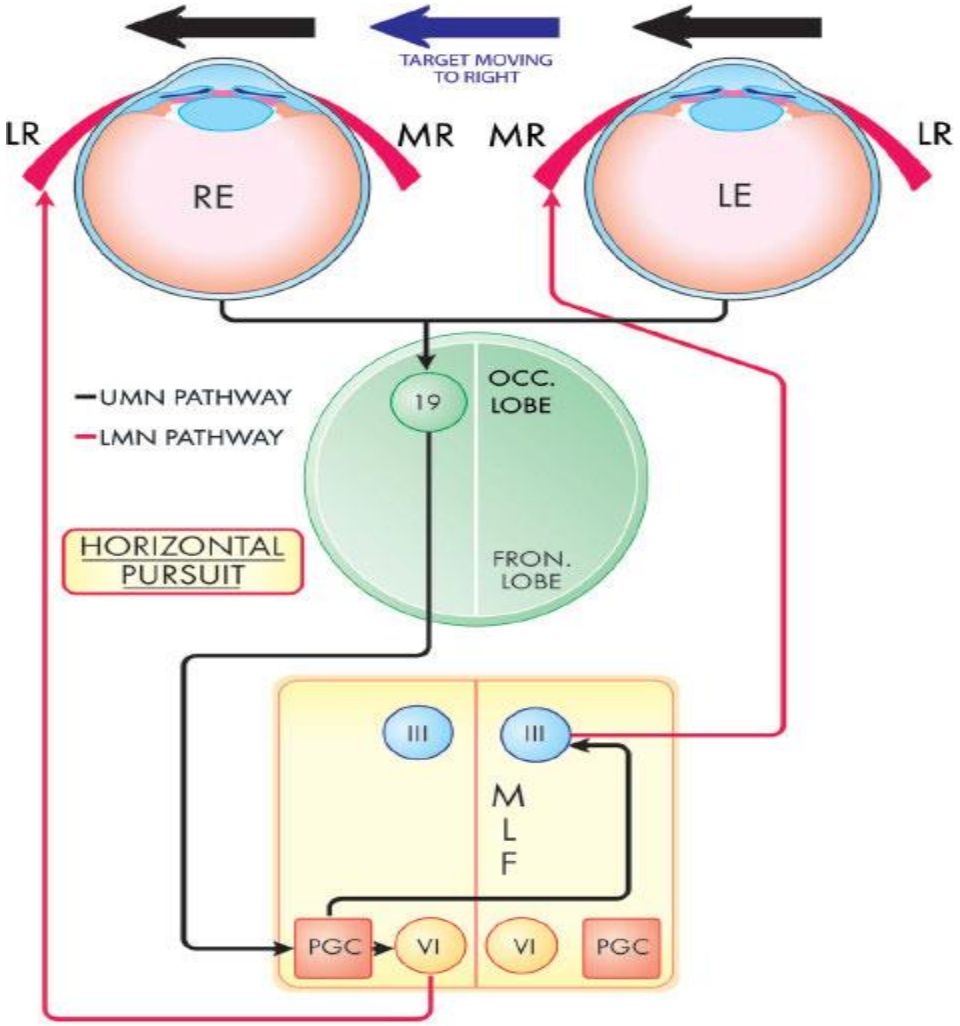
The voluntary saccades neuronal circuit



Smooth pursuit movements
also termed as *following or tracking movements*

- Slower tracking movements of the eyes designed to keep a **moving** stimulus on the fovea.
- Pursuit movements are smooth, continuous, conjugate eye movements with velocity and trajectory determined by the moving visual target.
- By tracking the movement of the visual target, the eyes maintain a focused image of the target on the fovea.
- A visual stimulus (the moving visual target) is required to initiate this eye movement
- horizontal pursuits and for vertical pursuits.
- Under voluntary control in the sense that the observer can choose whether or not to track a moving stimulus

Smooth pursuit movements



Vergence movements

Vergence movements are either convergence movements or divergence movement

- Adjusts for different viewing distance near or far vision
- **Convergence movements : is reflexive visual response associated with near reflex triad .**
- **It** brings the visual axes toward each other as attention is focused on objects near the observer.

Neural Control of Vergence Movements

- Command to diverge or converge the eyes is largely based on information from the two eyes about the amount of binocular disparity reaching the visual cortex

- The information from the occipital cortex is sent to “vergence centers” in the brainstem located in the midbrain near the oculomotor nucleus.
- Some neurons command convergence movements while others command divergence movements.
- These neurons also coordinate vergence movements of the eyes with accommodation of the lens and pupillary constriction to maximize the clarity of images formed on the retina

Function of superior colliculus neurons

- Receive afferent input from
  - retina,
  - inferior colliculus (auditory)
  - parietal (visual association) area
- based on afferent information, correct and send control signals for the amplitude and direction of the saccades to the vertical and horizontal gaze centers located in brain stem
- Superior colliculus also initiates reflex orienting saccades.
- Also important for integration of auditory and visual reflexes