

# **ELECTROOCULOGRAPHY**

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- Method for assessment of the eye movements employing the measurement of potential difference between cornea and retina
- This potential generates an electric dipole oriented in parallel with the optical axis of the eye
- The main goal of eye movements: to maintain and stabilize the object of interest at the point of the sharpest vision (yellow spot)

# Types of eye movements

- **Sustaining (miniature)** – such as **fixation** - Looking into our eyes do not stray far away in space, but they are automatically fixed on a point in space (its visual field)
- **Smooth pursuit movements** - assist the macular stabilization of the observed object
- **Saccadic movements** – assist the transferring the view to a new object
- **Nystagmus** – rhythmic eye-bulb movements, with 2 components: slow deviation to one side and fast twitch to the opposite side (slow is vestibular, fast from brainstem structures)
- **Vestibulo-ocular reflex** – stabilization of the retinal image during sudden, non-uniform movements of the head
- **Optokinetic nystagmus** – regular eye movement stabilizing the view during slight movement of the head or when the object changes its position with respect to motionless head

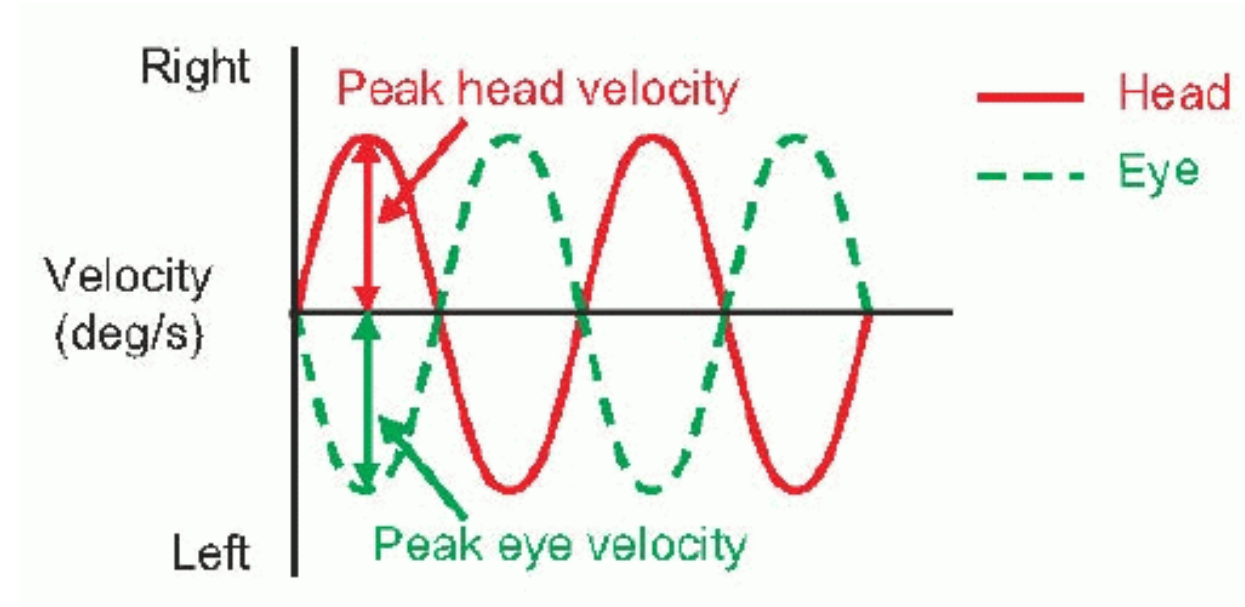
# Eye Movement

Function of Eye Movement	Type of Eye Movement	
"Holding" (slow)	<ul style="list-style-type: none"> <li>•Smooth Pursuit</li> <li>•Optokinetic Nystagmus (slow phase)</li> <li>•Vestibular Nystagmus</li> </ul>	<ul style="list-style-type: none"> <li>•Convergence</li> <li>•Divergence</li> <li>•Accommodative Vergence</li> </ul>
"Catching" (fast)	<ul style="list-style-type: none"> <li>•Saccades</li> <li>•Optokinetic Nystagmus (quick phase)</li> </ul>	
"Sustaining" (miniature)	<ul style="list-style-type: none"> <li>•Microsaccades</li> </ul>	<ul style="list-style-type: none"> <li>•Tremor</li> <li>•Drift</li> </ul>
voluntary eye movement; involuntary eye movement		

# ***The Vestibular Apparatus***

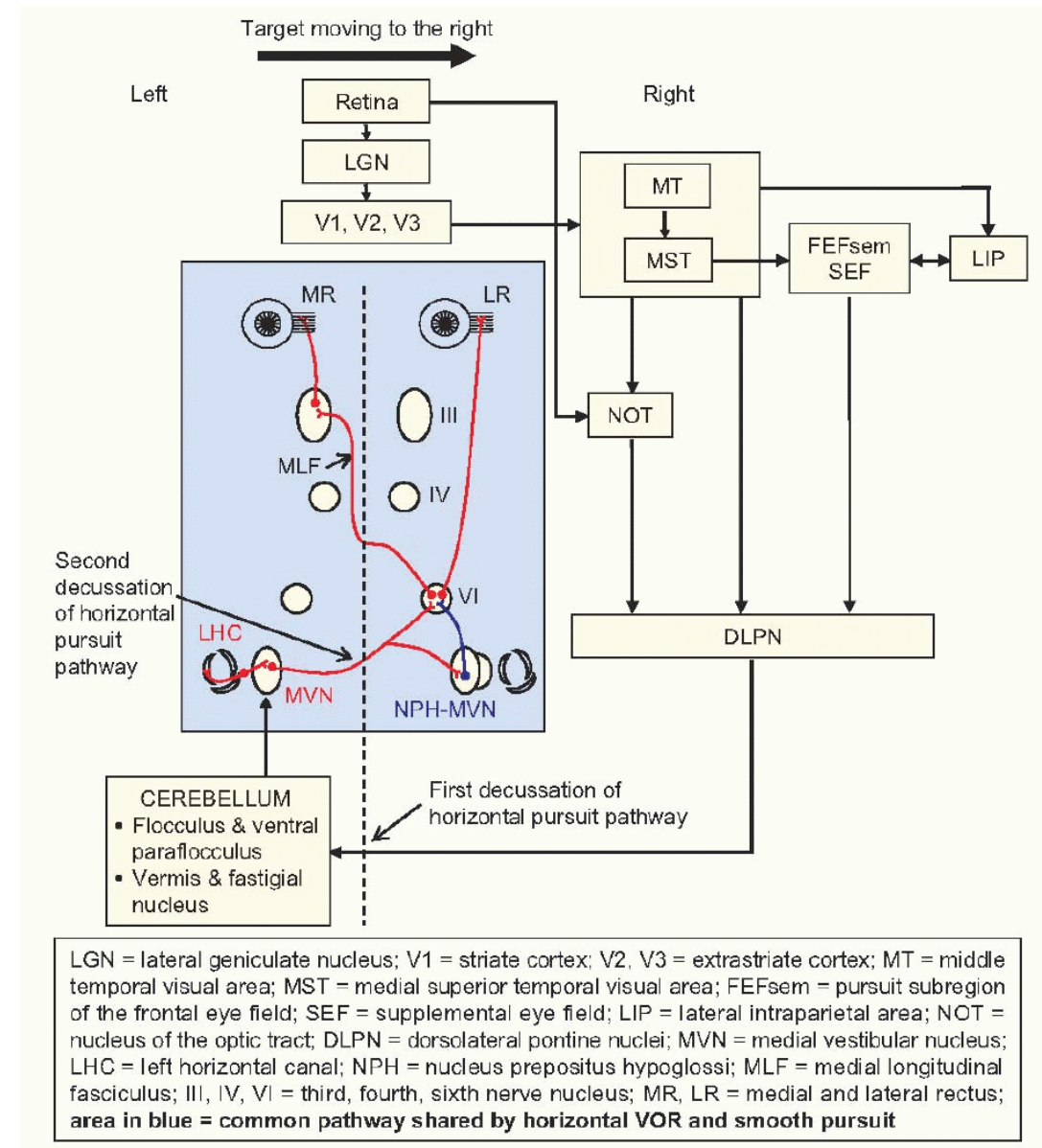
- The vestibulo-ocular and optokinetic reflexes are the earliest eye movements to appear phylogenetically
- The **vestibulo-ocular reflex (VOR)** stabilizes retinal images during head motion by counter-rotating the eyes at the same speed as the head but in the opposite direction

# Characteristics of the VOR



The VOR stabilizes retinal images during brief head movements by counter-rotating the eyes at the same speed as the head but in the opposite direction

# Summary of Central Control of Pursuit Eye Movement



# **Vertigo**

# **Nystagmus**



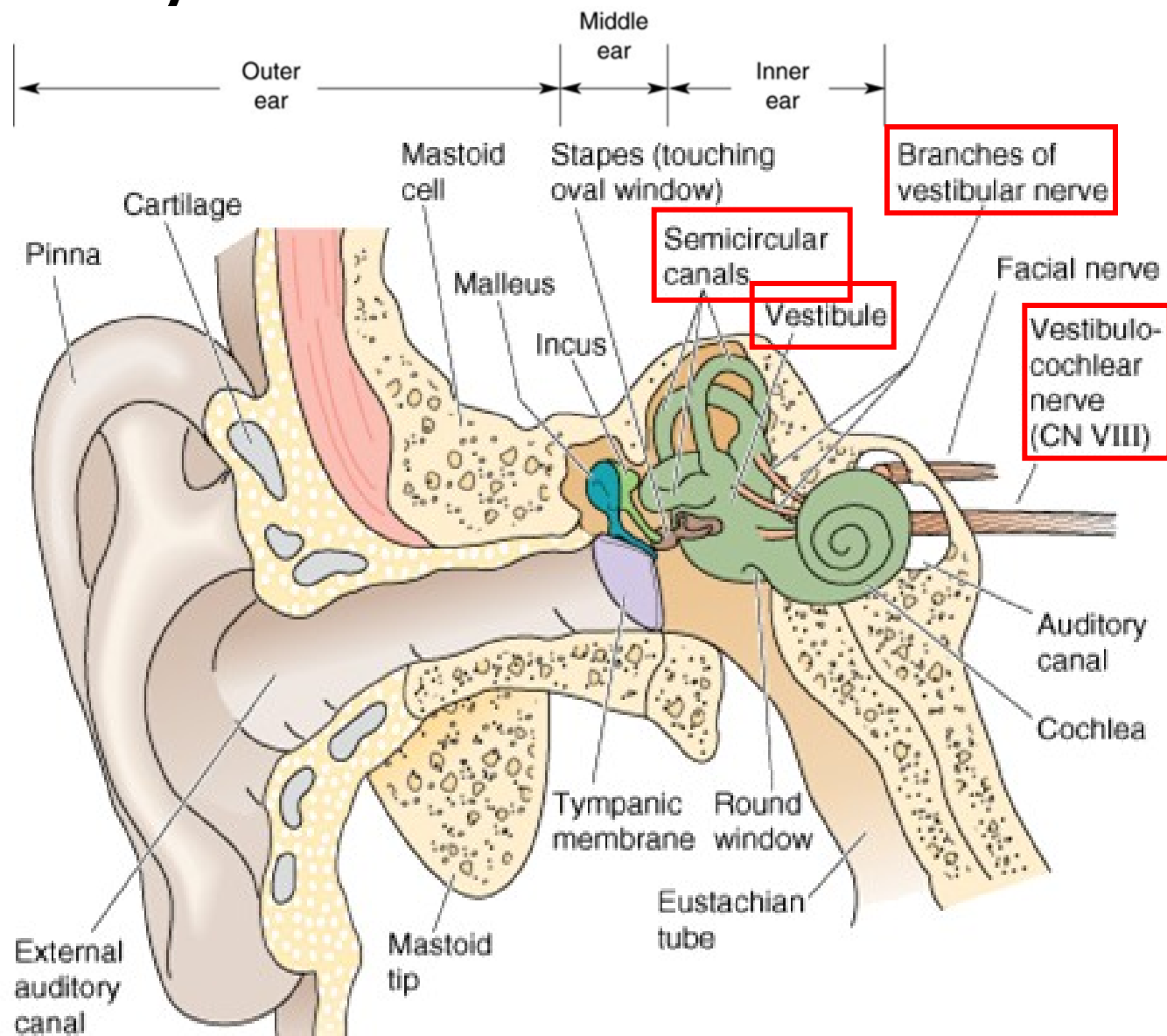
# Vertigo

- Vertigo (dizziness)– subjective loss of stability in space, rotation of surrounding space or rotation of body in space
- connected with objective symptoms – disturbances of equilibrium and nystagmus – by stimulation of the labyrinths
- semicircular canals are stimulated by:
  - rotation - post-rotational vertigo
  - Caloric (application of external auditorial tube either with cold=27°C or warm=47°C water)
  - electric current - galvanic vertigo

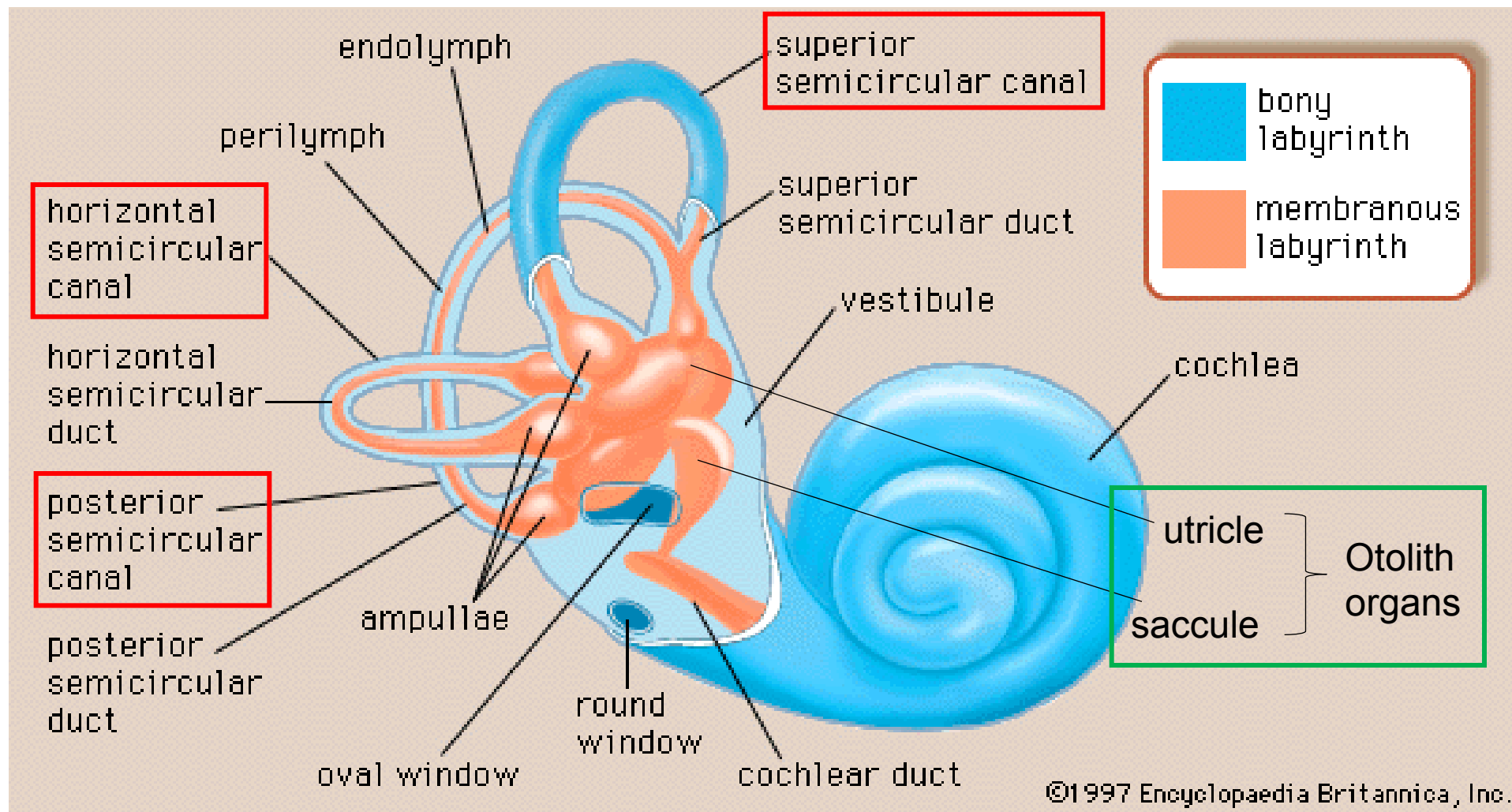
# Nystagmus

- rhythmic eye-bulb movements, 2 components: slow deviation to one side and fast twitch to the opposite side
- slow is vestibular, fast from brainstem structures
- Nystagmus at rest – vestibular system is affected by some pathological process or cerebellum

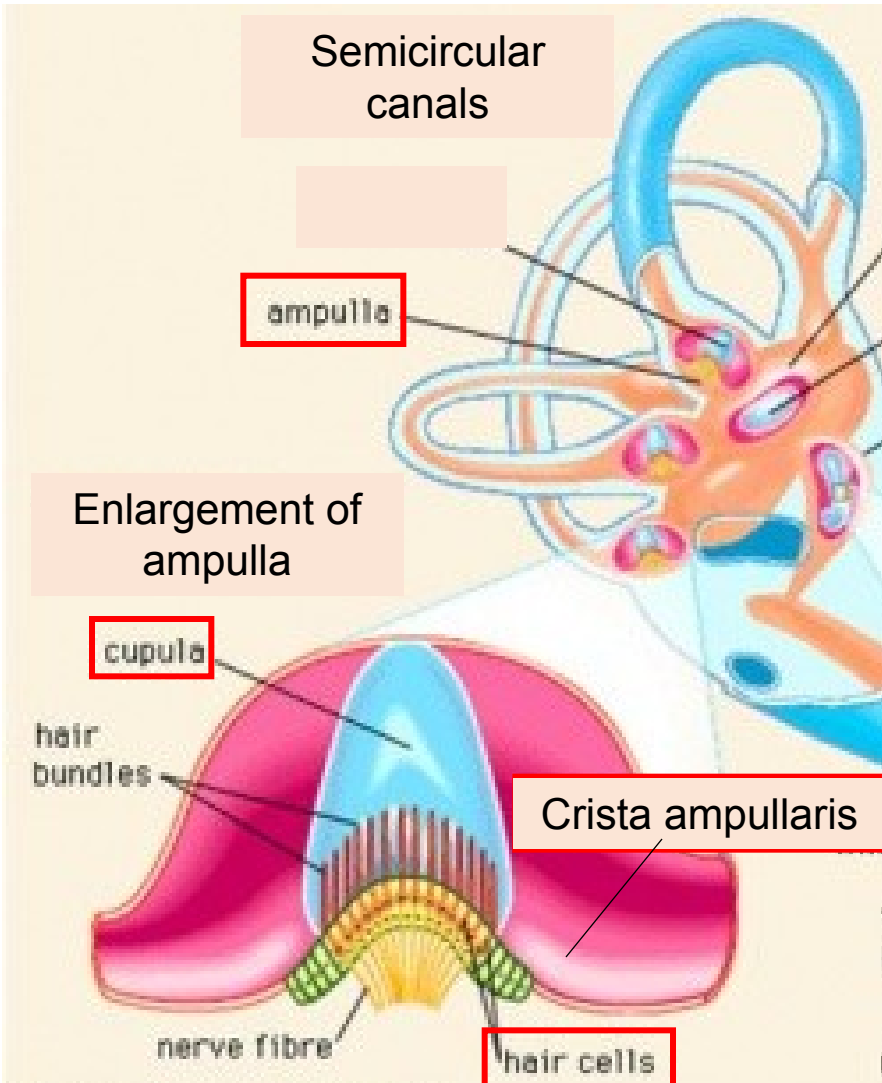
# Vestibular System: Structure



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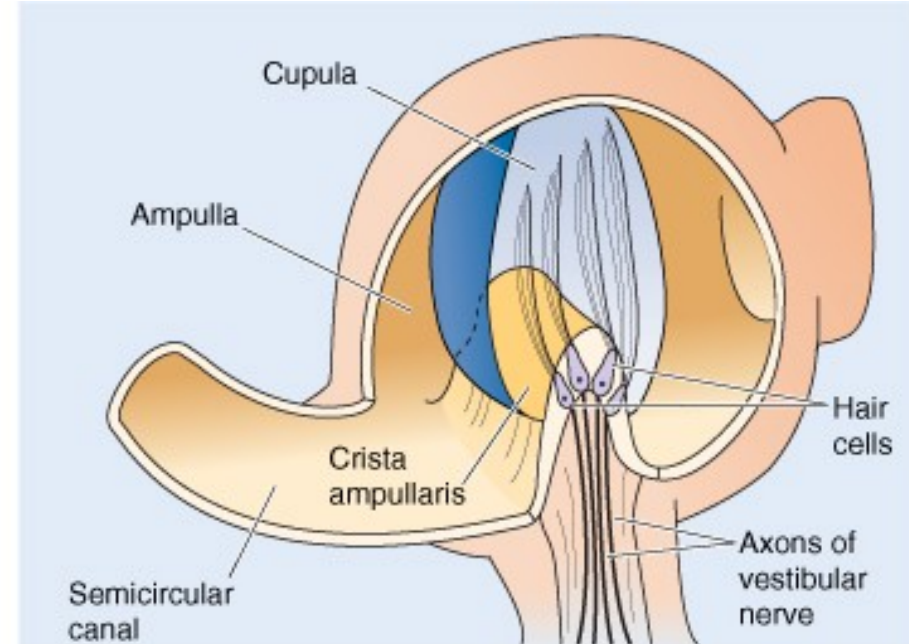
# Semicircular canals: structure



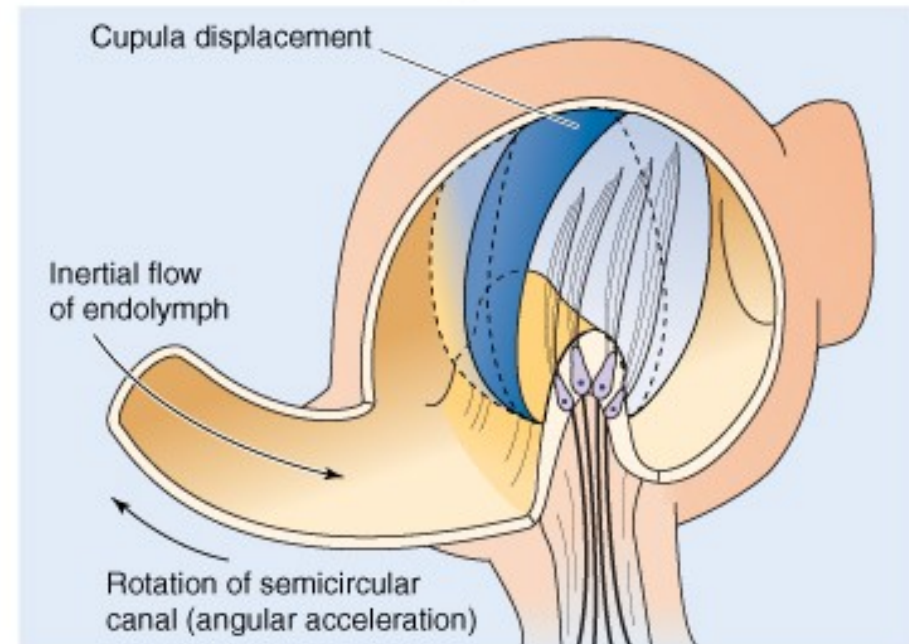
- each semicircular canal contains an ampulla
  - Contains hair cells embedded in sensory epithelium called crista ampullaris
  - Cilia of hair cells project into gelatinous cap called cupula

# Semicircular canals: function

- Specialized for responding to **rotational acceleration** of the head
- Head rotation results in the movement of endolymph in opposite direction
- Bends cupula which bends hair cells
  - Same mechanical/electrical coupling as in auditory hair cells

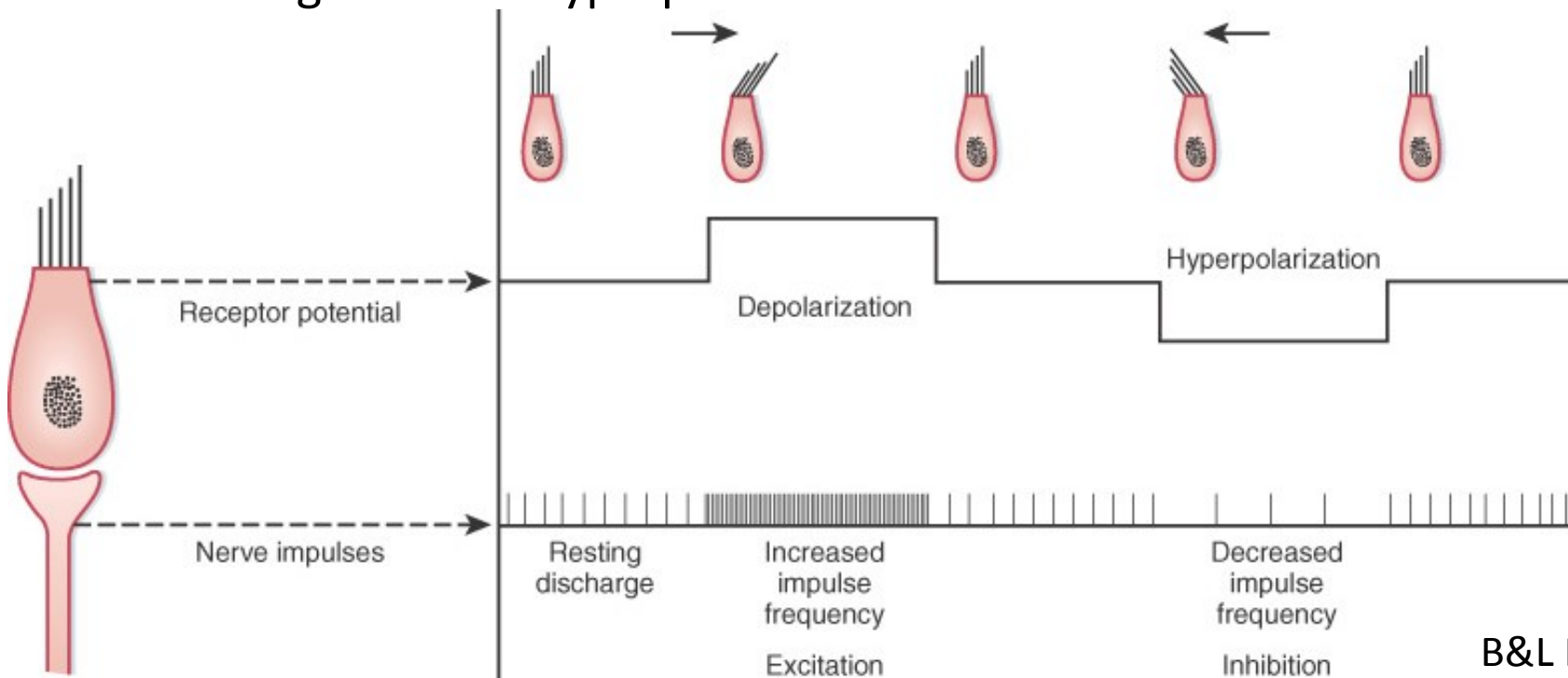


Rotation of canal



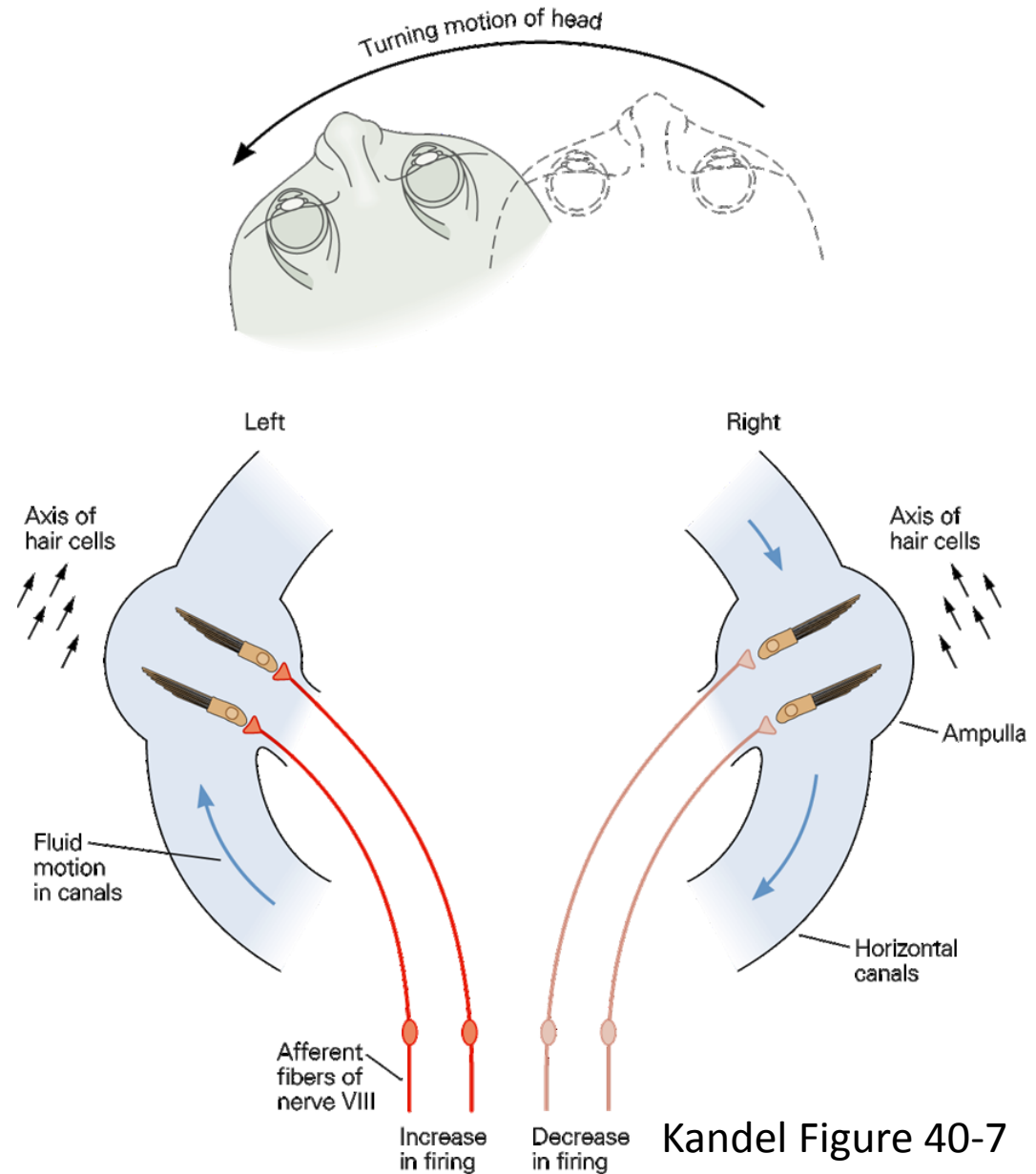
# Semicircular canals: sensory transduction

- Steriocilia maintain directionality on both sides of the head
  - Bending towards kinocilium → opens mechanically gated cation channels →  $K^+$  influx → depolarization
  - Bending away from kinocilium → closes channels that are open during resting state → hyperpolarization



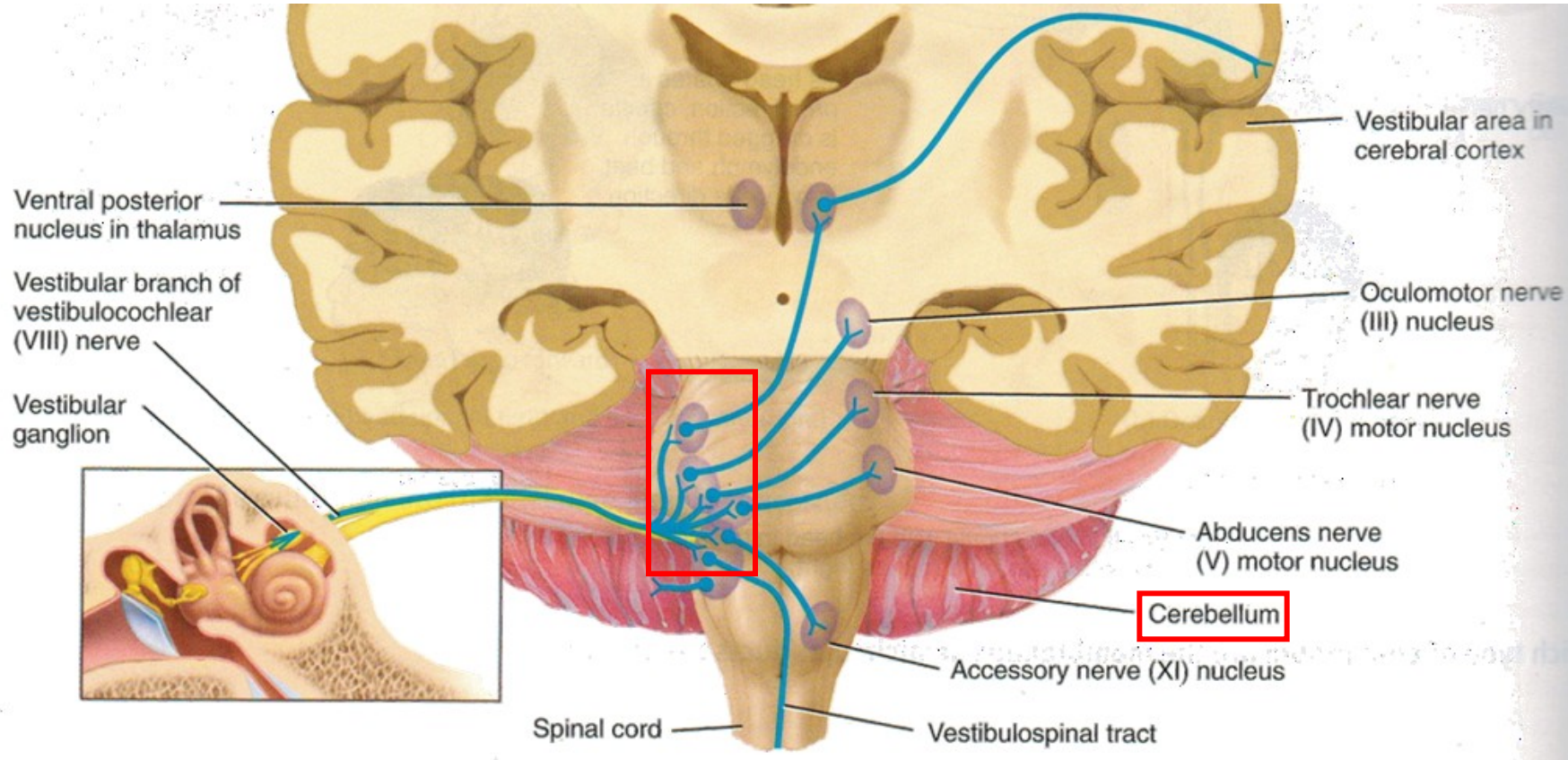
# Semicircular canals: sensory transduction

- Paired canals work together to signal head movement
- With turning of the head, hair cells on one side of the body send excitatory signals to the brain while hair cells on the opposite side are inhibited



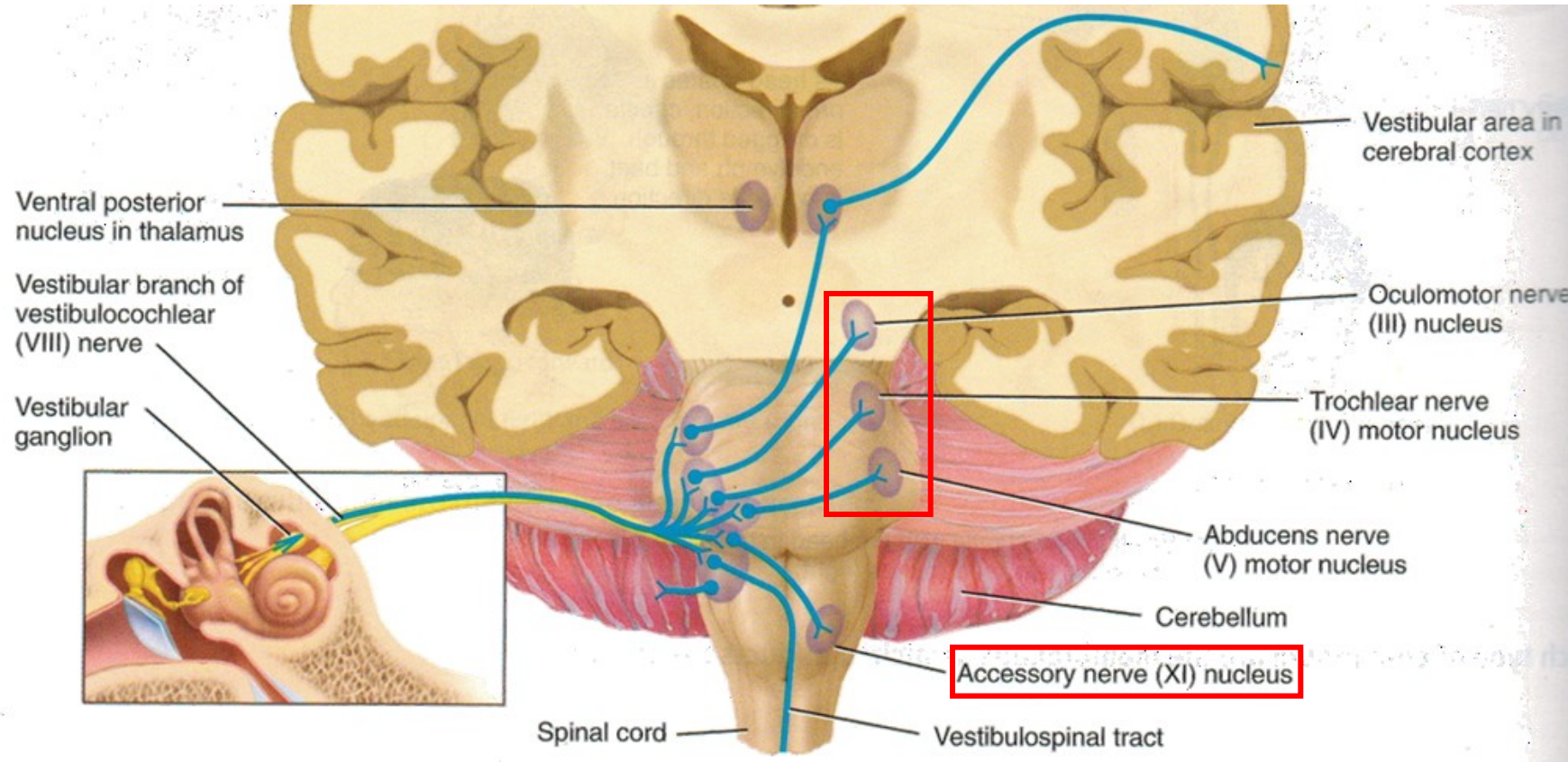


# Vestibular Pathways



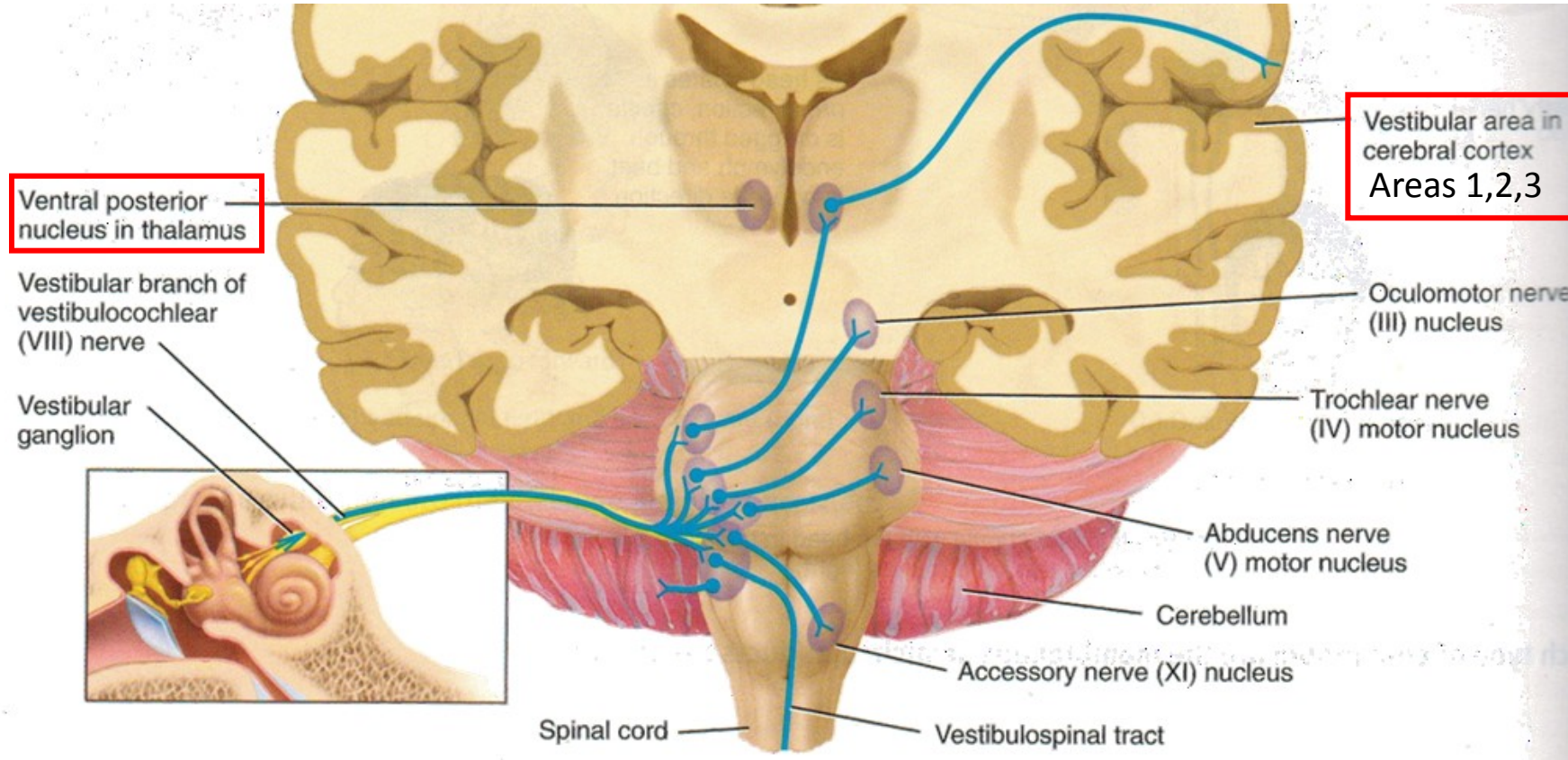
- vestibular afferents synapse on vestibular nuclei located in medulla & pons
  - Nuclei integrate information from vestibular, visual, and somatic receptors and send collaterals to
    - 1.cerebellum
      - Sends corrective adjustments to motor cortex: maintenance of balance and posture

# Vestibular Pathways



- 2. nuclei of cranial nerves
  - Control coupled movements of the eyes, maintain focus and visual field
- 3. nuclei of accessory nerves
  - Control head movement and assist with equilibrium

# Vestibular Pathways



- 4.ventral posterior nucleus of thalamus and vestibular area in cerebral cortex (part of primary somatosensory cortex)
  - Conscious awareness of the position and movement of head

# Vestibular Reflexes

## Vestibulospinal Reflexes

- Senses falling/tipping
  - contracts limb muscles for postural support

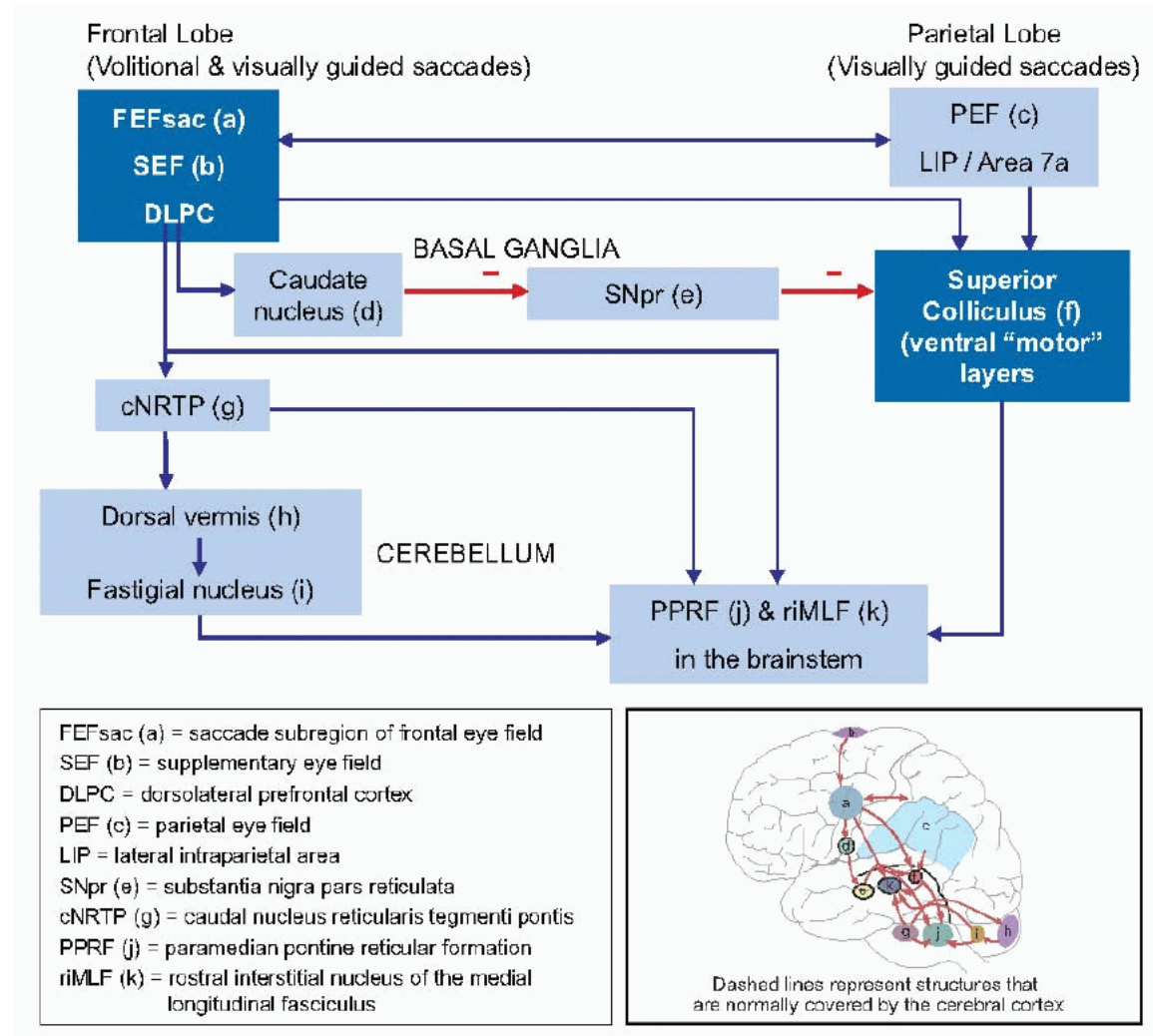
## Vestibulocollic Reflexes

- acts on the neck musculature to stabilize the head if body moves

## Vestibulo-ocular Reflexes

- stabilizes visual image during head movement
  - causes eyes to move simultaneously in the opposite direction and in equal magnitude to head movement

# Summary of Central Control of Saccades



Redrawn from Leigh RJ, Zee DS. The Neurology of Eye Movements. 3rd ed. New York: Oxford University Press; 1999. With permission of Oxford University Press.

- Activation of the frontal eye field (FEFsac) and superior colliculus (SC) on one side generates contralateral horizontal saccades.
- Simultaneous activation of FEFsac on both sides or SC on both sides generates vertical and torsional saccades.