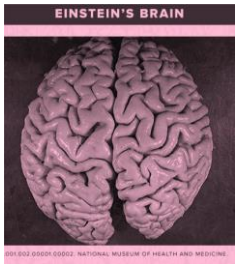
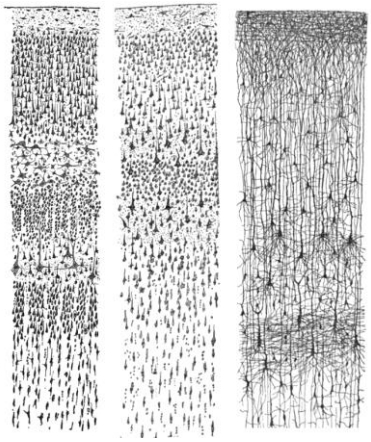
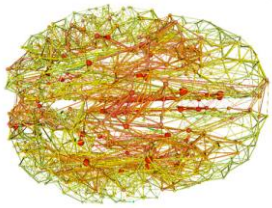
Welcome to Clinical anatomy of the head, neck and neuronal pathways

Lecture #10







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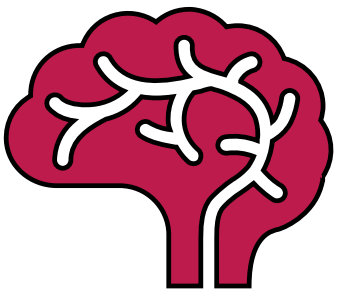
Today's lecture will cover:

1- Pathways of Somatomotor System

2- Connections of the Cerebellum and Basal Ganglia

3- Spinal Reflex Motor

4- Eye Movement



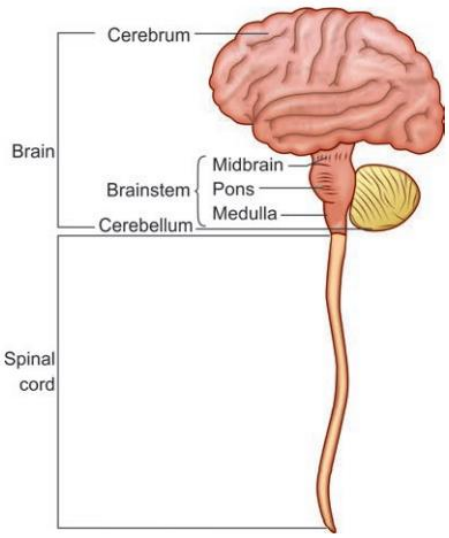
Pathways of Somatomotor System

Necessary components of proper motor control

- Volition
- Coordination of signals to many muscle groups
- Proprioception
- Postural adjustments
- Sensory feedback
- Compensation for the physical characteristics of the body and muscles
- Unconscious processing
- Adaptability

Levels of Movement Regulation

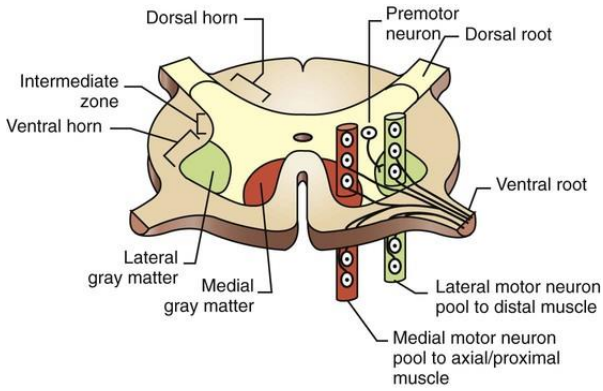
- Spinal cord
- Brain stem
- Cortex



- Cerebellum
- Basal ganglia

Lower Motor Neurons – Spinal Cord

- α motoneurons: innervate the extrafusal muscle fiber
- γ motoneurons: innervate intrafusal muscle fibers



- Somatotopic organization
  - medial column – axial muscles
  - lateral column – limb muscles
  - anteriorly – extensors
  - posteriorly - flexors

Lower Motor Neurons – Brain Stem

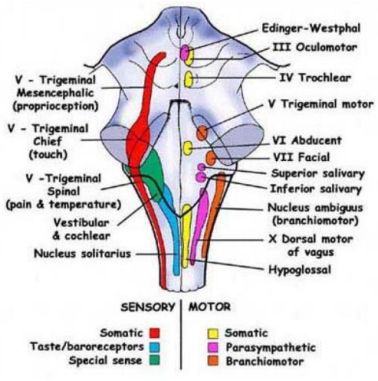


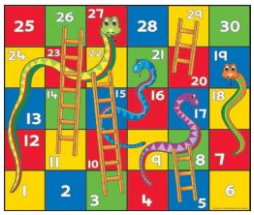
Table 3.1. Voluntary (somatic and branchiomotor) motor components of cranial nerves.

Nucleus	Type	Nerve	Muscles
Oculomotor *Midbrain*	Somatic *Preotic somites*	III Oculomotor	Levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, inferior oblique
Trochlear *Midbrain*	Somatic *Preotic somites*	IV Trochlear	Superior oblique
Trigeminal motor *Pons* for chewing	Branchiomotor *first arch*	Vc Mandibular	Temporalis, masseter, digastric (anterior belly), mylohyoid, medial and lateral pterygoids, tensor palati, tensor tympani
Abducens *Pons*	Somatic *Preotic somites*	VI Abducens	Lateral rectus
Facial motor *Pons*	Branchiomotor *second arch*	VII Facial	Muscles of facial expression, buccinator, stapedius, occipitofrontalis, stylohyoid, digastric (posterior belly), platysma
Nucleus ambiguus *Medulla* for swallowing, phonation	Branchiomotor (see Section 16.3) *third arch* *fourth arch* *sixth arch*	IX Glossopharyngeal X Vagus, pharyngeal branches X Vagus, recurrent laryngeal XI Spinal accessory	Stylopharyngeus Muscles of pharynx Muscles of larynx Sternocleidomastoid, trapezius
Hypoglossal *Medulla*	Somatic *Occipital somites*	XII Hypoglossal	Intrinsic tongue muscles, hyoglossus, genioglossus, styloglossus

Monkhouse, *Cambridge: Cambridge University Press* 2005

Supraspinal System of Movement Control

- Medial system
  - bilateral
  - terminates on the interneurons or the medial column of lower motor neurons
  - controls maintenance of balance and postural movements
- Lateral system
  - mostly cross the midline and descend contralaterally
  - terminates on the interneurons or the lateral column of lower motor neurons
  - controls fine manipulative movements of the hand and fingers



Medial System

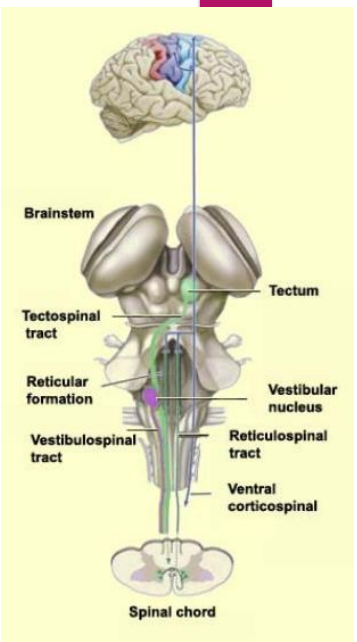
- Cortical pathways
  - **Anterior corticospinal tract**

  medial column of lower motor neurons
- Subcortical pathways
  - **Medial** and **lateral vestibulospinal tracts**

  control of balance and postural movements, head movements
  - **Tectospinal tract** (sup. colliculus)

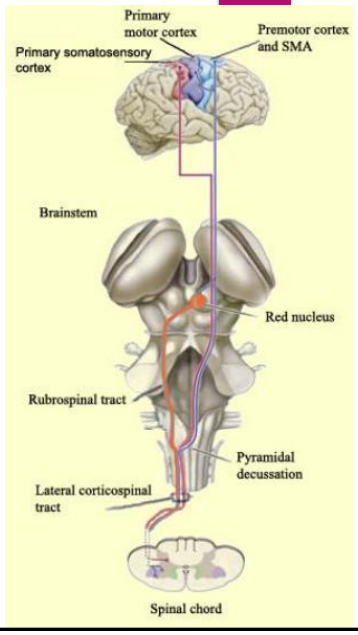
  coordination of movements of the head and eyes during watching
  - **Medial** (pontine) and **lateral** (medullary) **reticulospinal tracts**

  control of postural movements



Lateral System

- Cortical pathways
  - **Lateral corticospinal tract**
- Subcortical pathways
  - **Rubrospinal tract** (Red nucleus of mid brain) contralaterally descends to the lateral column facilitatory to flexors of upper limb



Corticospinal tract and Corticonuclear Tracts voluntary movements of the body

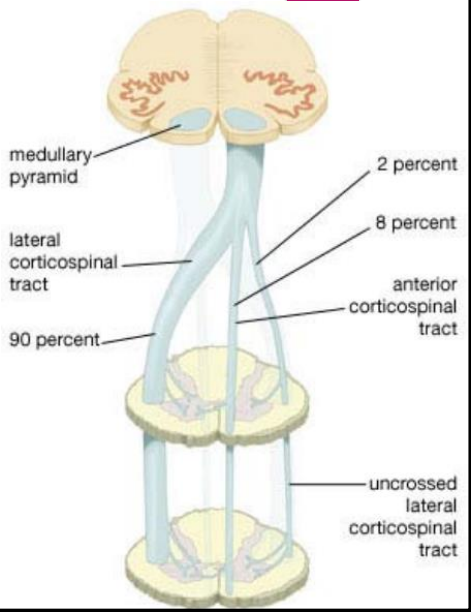
Corticospinal Tract (or Pyramidal Tract)

originates in the motor cortex

form the **medullary pyramids** at the level of the medulla

90% of the axons cross over to the contralateral side at the pyramidal decussation, forming the **lateral corticospinal tract** (lateral funiculus of the spinal cord)- *responsible for the control of the distal musculature*

10% of the axons (**anterior corticospinal tract-**anterior funiculus) cross over to the contralateral side through the anterior white commissure- *responsible for the control of the proximal musculature*



Corticospinal tract and Corticonuclear Tracts
voluntary movements of the body

Corticonuclear tract

terminate in the contralateral (and to some ipsilateral and some bilateral) motor nuclei of the cranial nerve

- somatomotore - ncl. CN. III., IV., VI., XII
- branchiomotore - ncl. CN. V., VII., IX., X

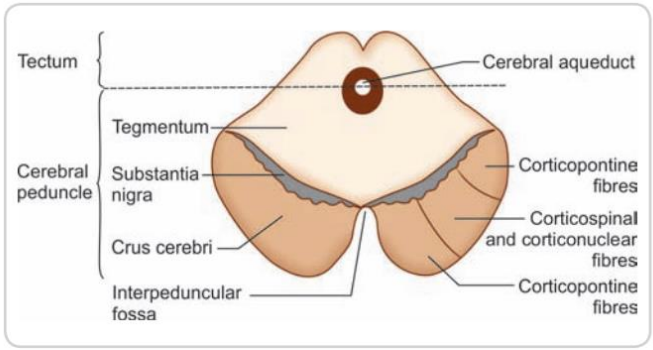
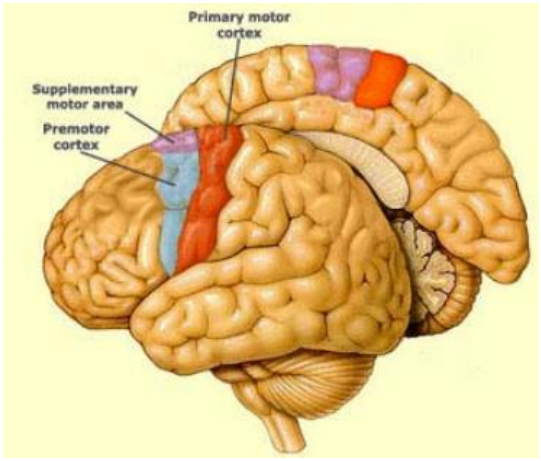
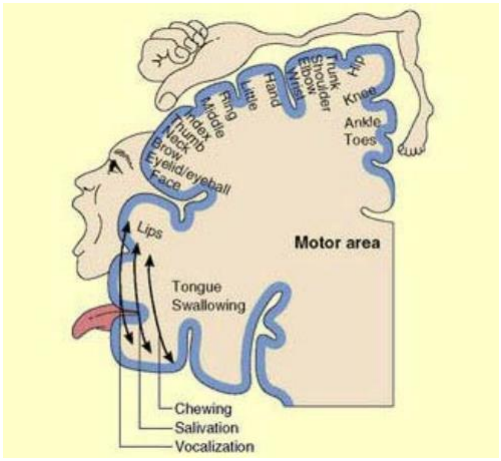


Figure 5.14: Transverse section of the midbrain showing its main subdivisions

Motor Cortex





Connections of the Cerebellum and Basal Ganglia

Motor Systems

- Cerebellum
- Basal Ganglia

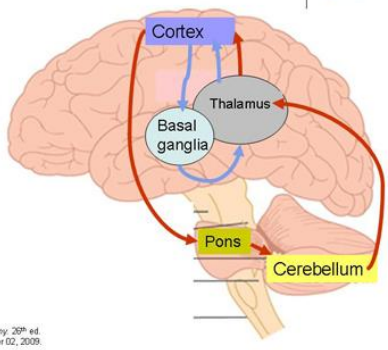
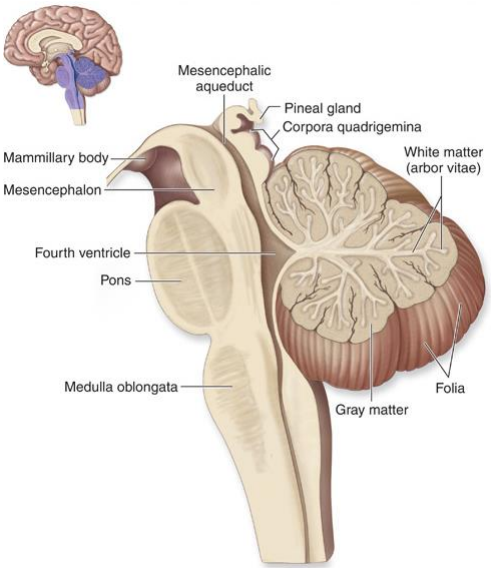


Figure 16-12. In: Waxman SG. *Clinical Neuroanatomy*. 26th ed. http://www.accessmedicine.com. Accessed November 02, 2009.

Cerebellum

Functions:

- Maintenance of balance and equilibrium
- Muscle tone
- Coordination of voluntary movements
- Motor learning



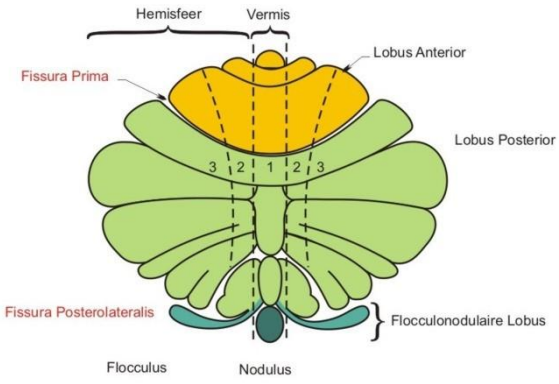
Damage to cerebellum:

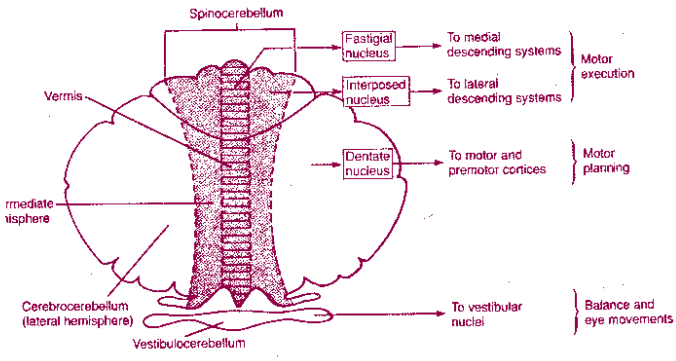
Inability to maintain the equilibrium of the body

Difficulty to touch his nose with a finger

Unable to fix the gaze on an object

Cerebellum
Anatomical Division





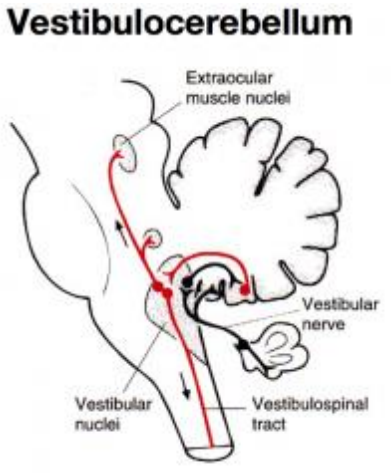
Connections of the Vestibulocerebellum

Flocculonodular lobe (vestibulocerebellum) → Vestibular ncll.

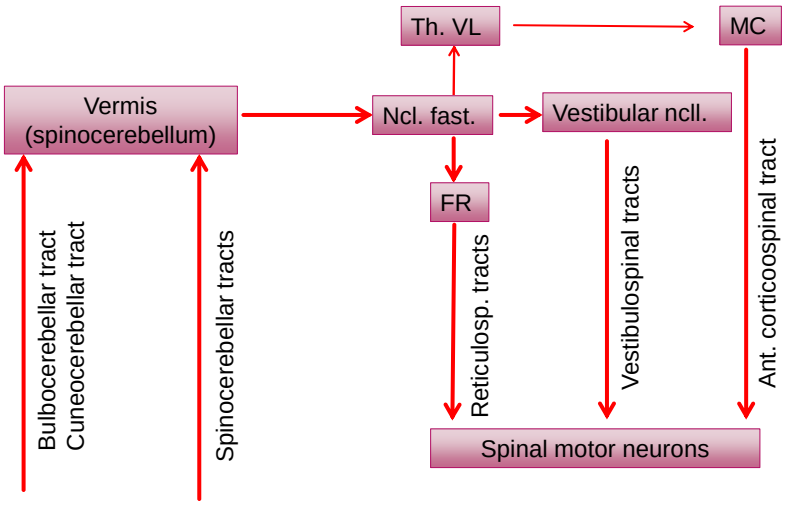
Vestibular ncll. → Spinal motor neurons (Vestibulospinal tracts)

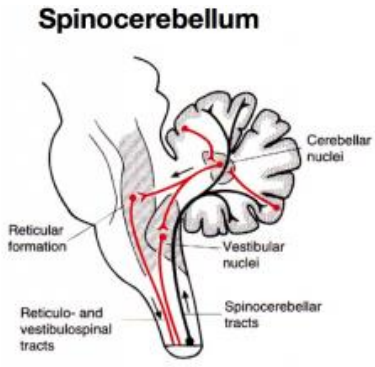
Vestibular system → Flocculonodular lobe (Vestibulocerebellar tract)

- **vestibular reflexes**
- **postural maintenance**



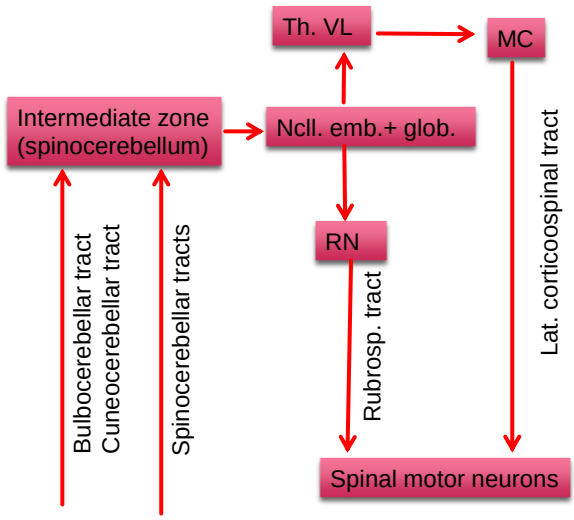
Connections of the Spinocerebellum – Median Zone

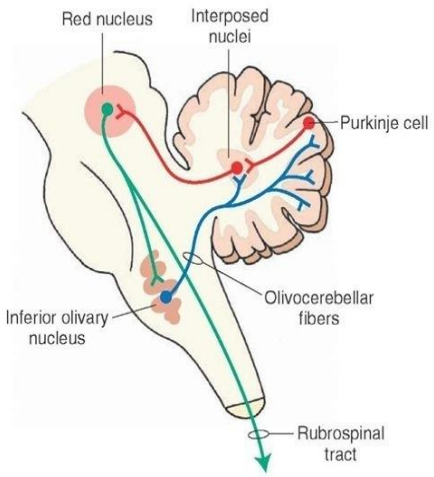




➢ **control of medial descending (motor) system**

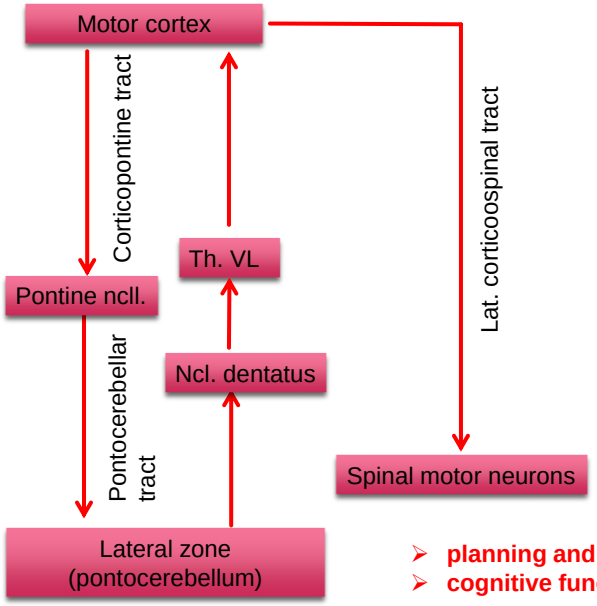
Connections of the Spinocerebellum – Paramedian Zone

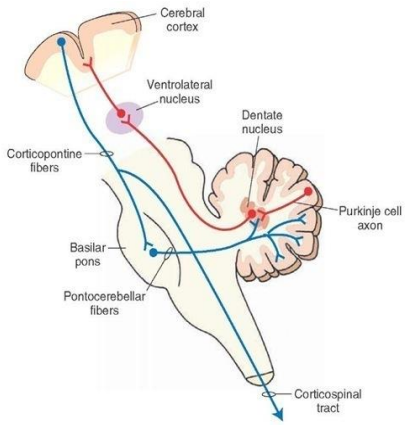




➢ **control of lateral descending (motor) system**

Connections of the Cerebro (ponto)-Cerebellum – Lateral Zone





- **planning and timing of movements**
- **cognitive functions**

Cerebellar Disorders

Ataxia - **errors in the force, direction, speed and amplitude of movements, loss of coordination**

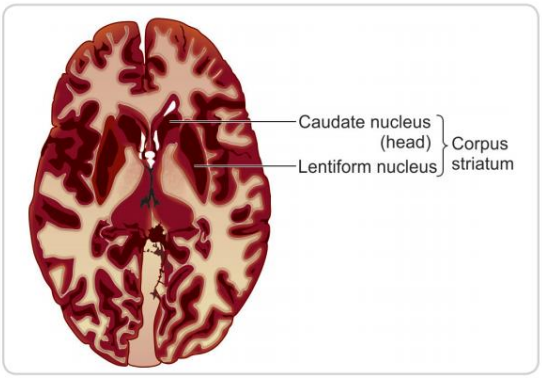
Dysmetria - „overshooting or undershooting“ - the hand may travel past the target

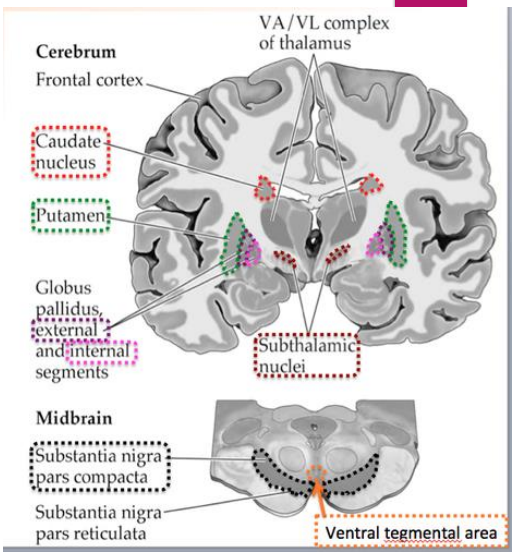
Hypotonia - **decreased muscle tone**

Adiadochokinesia - **inability to perform rapid alternating movements**

Intention tremor - involuntary movement caused by alternating contractions of opposing muscle groups

Basal Ganglia



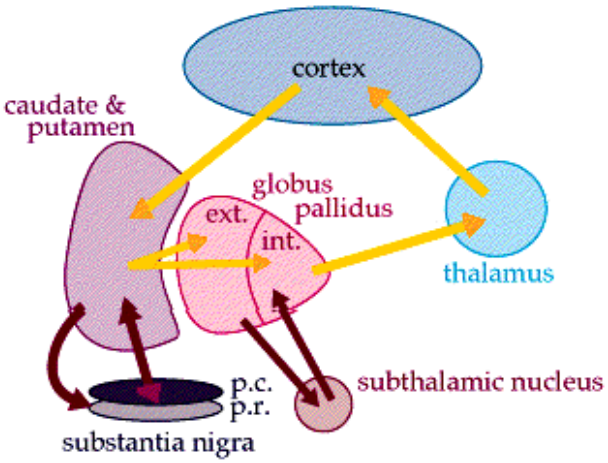


- Caudate nucleus
- Lentiform nucleus (putamen and the globus pallidus)
- Substantia nigra
- Ncl. subthalamicus

Basal Ganglia Connections

Connections

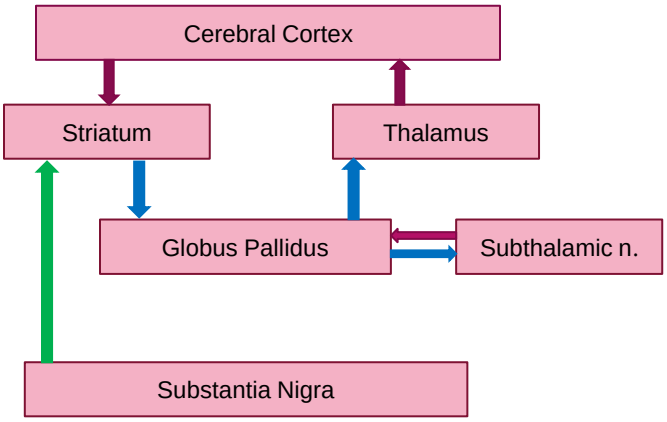
- Direct pathway
- Indirect pathway
- Nigrostrital pathway



Basal Ganglia Connections

Transmitters

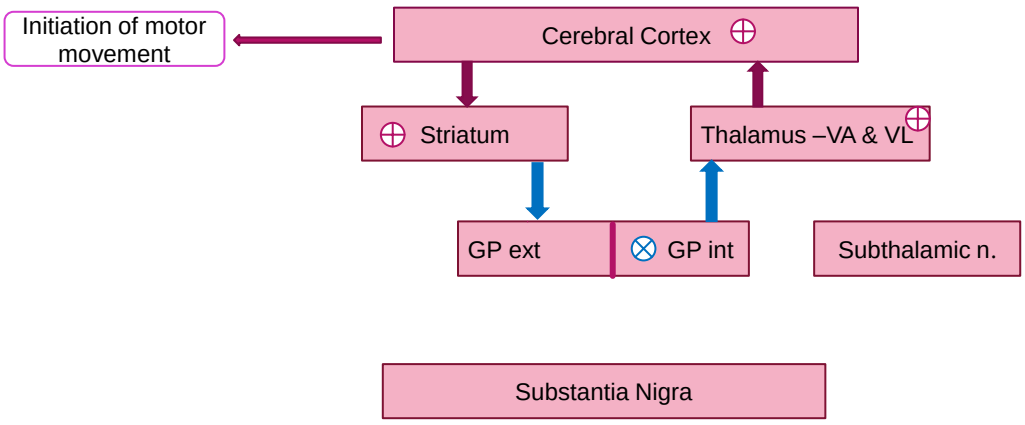
- **Glutamate**: corticostraital & thalamostrital
- **GABA**: striatopallidal & pallidothalamic
- **Dopmanie**: nigrostrital pathway



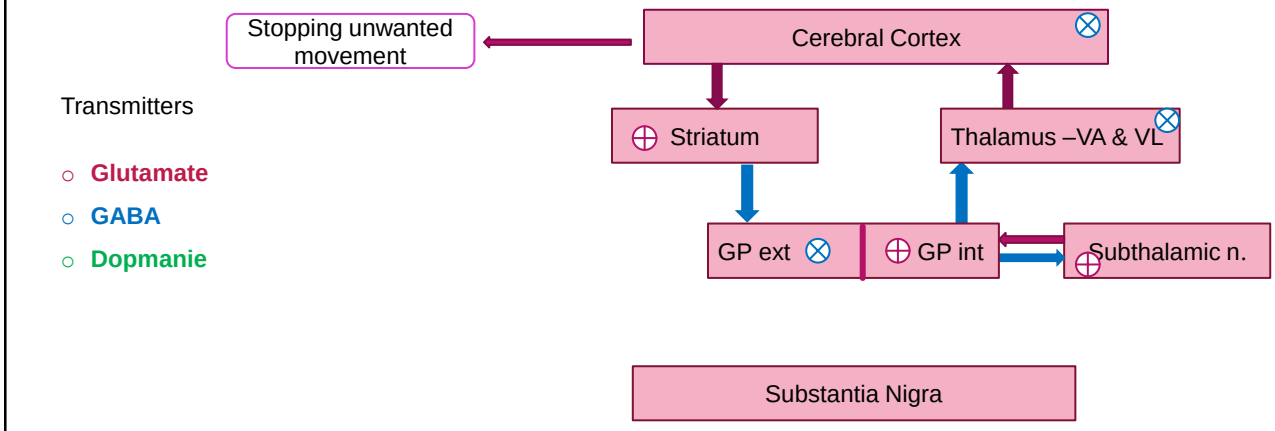
Basal Ganglia Connections- Direct Pathway

Transmitters

- **Glutamate**
- **GABA**
- **Dopmanie**



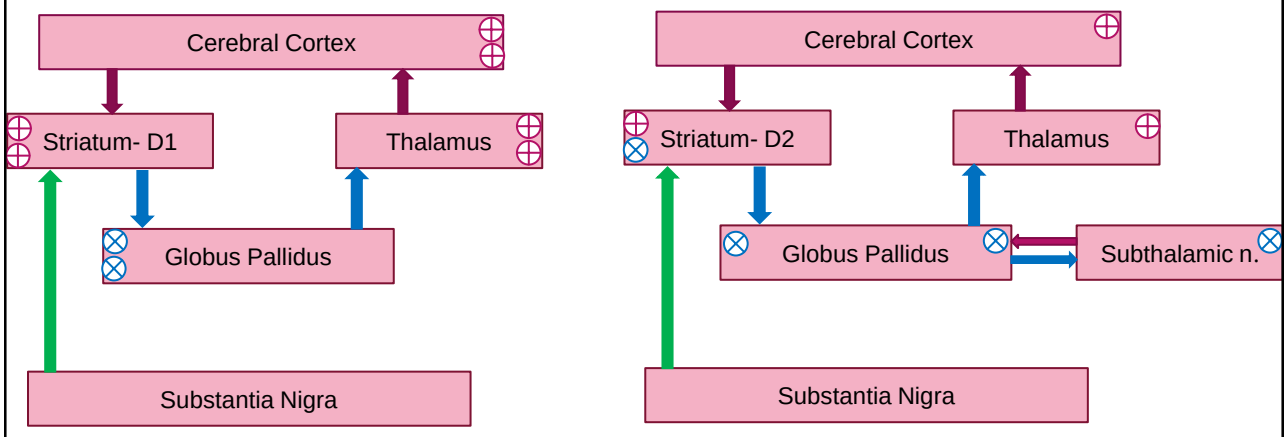
Basal Ganglia Connections- Indirect Pathway



Transmitters

- **Glutamate**
- **GABA**
- **Dopmanie**

Basal Ganglia Connections- Nigrostrital Pathway



Spinal Reflex Motor

- **Type of afferents**
  - somatic spinal reflexes
  - visceral spinal reflexes
- **Type of somatosensor**
  - proprioceptive reflexes
  - exteroceptive reflexes
- **Number of involved spinal segments**
  - monosegmental spinal reflexes
  - polysegmental spinal reflexes
- **Number of synapses**
  - monosynaptic reflexes
  - disynaptic reflexes
  - polysynaptic reflexes

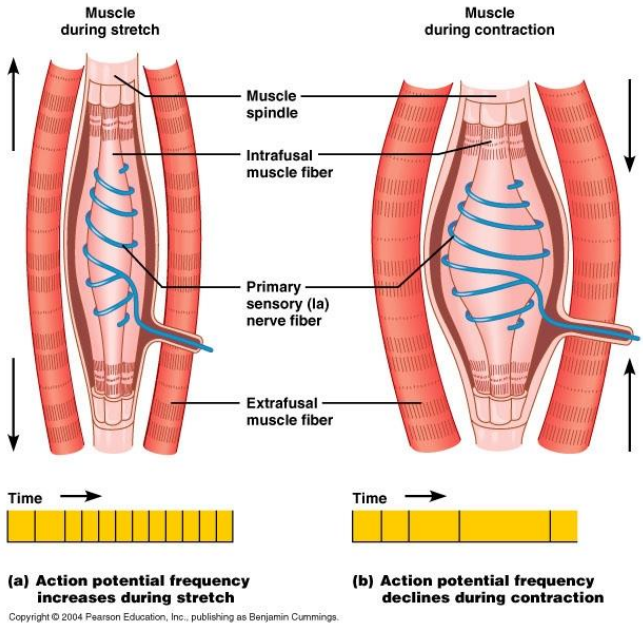
Skeletal Muscle Structure

Intrafusal muscle fibers are proprioceptors

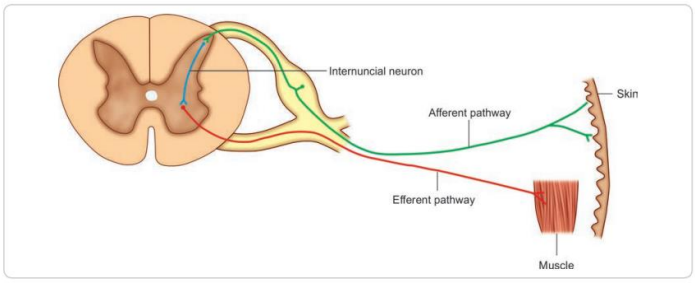
Innervated by gamma motorneurons

Extrafusal muscle fibers generate movement

Innervated by alpha motorneurons



Spinal Reflex



Structural components:

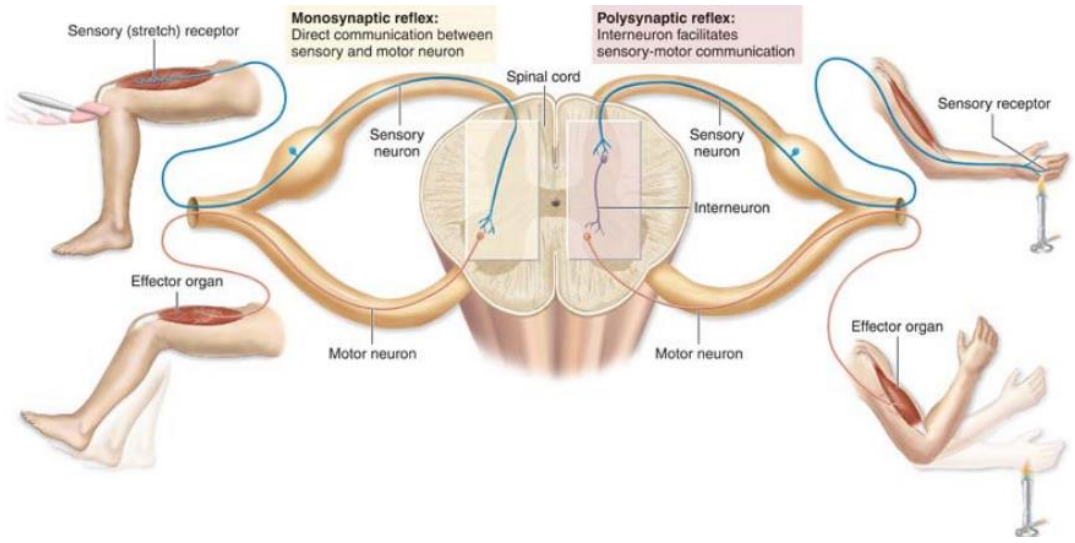
- A receptor
- An afferent neuron
- A reflex center
- An efferent neuron
- An effector

Reflexes with their reflex center in the spinal cord are called spinal reflexes.

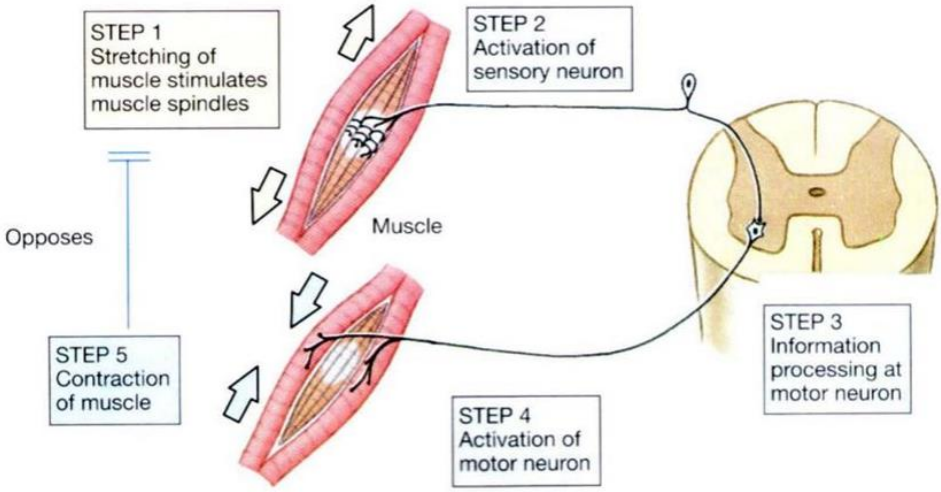
Spinal Reflex

Myotatic (stretch) reflex

Withdrawal (flexion) reflex

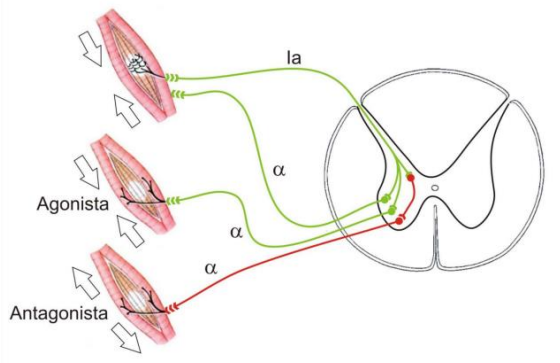


Myotatic (Stretch) Reflex

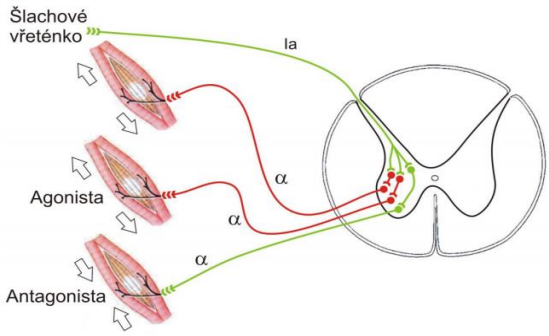


Receptors for the stretch reflex are the **muscle spindles.**

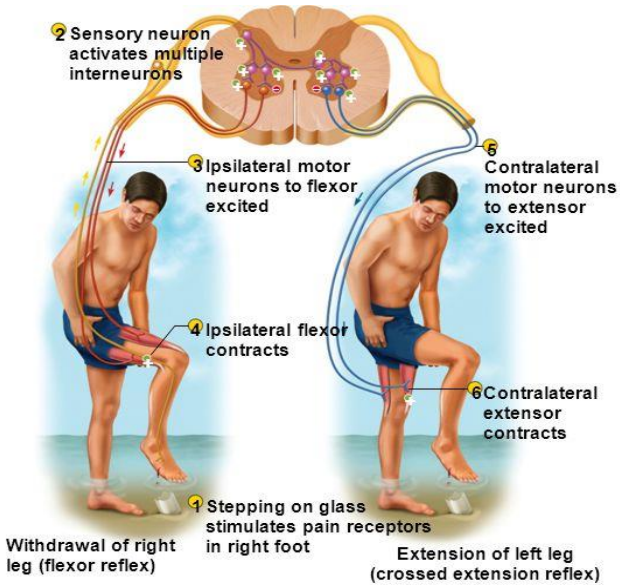
Myotatic (Stretch) Reflex



Reflex loop of Golgi tendon organ
(**inverse myotatic reflex**)

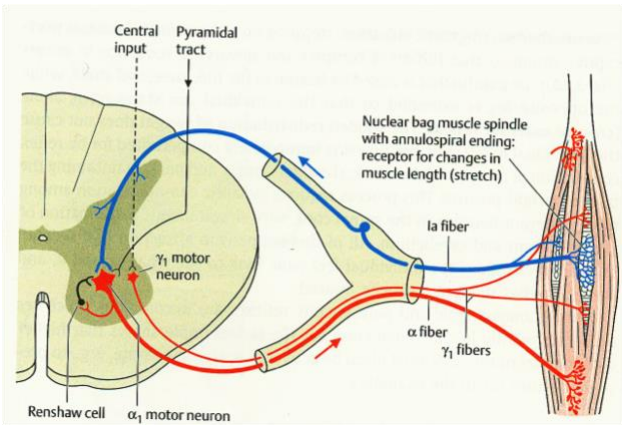


Withdrawal (Flexion) Reflex



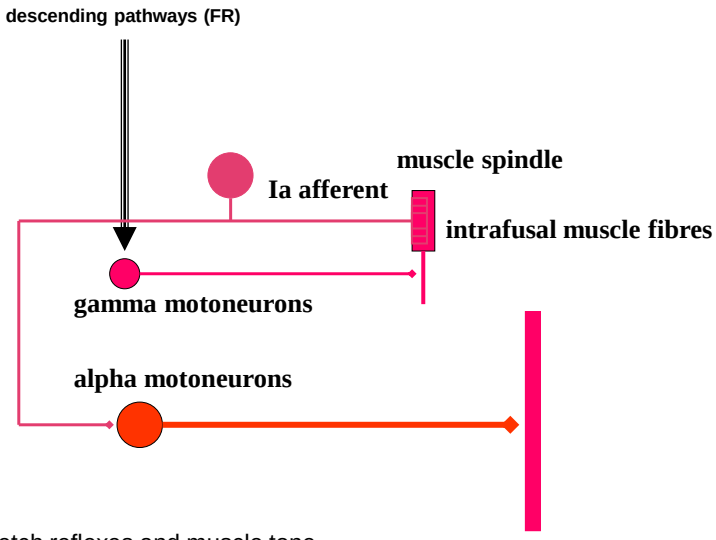
Receptors for the flexion reflex are **nociceptors.**

Motorneurons can inhibit their own activity by Renshaw Cells!



A negative feedback loop to stabilize the motorneurons

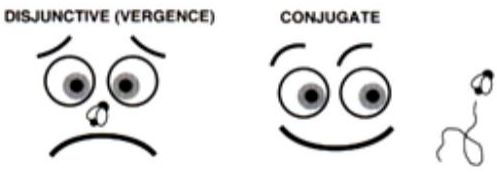
Gamma Loop



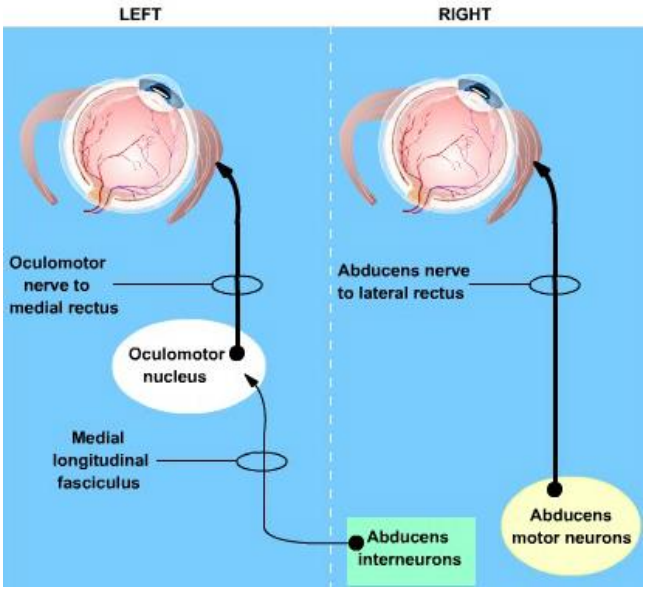
Critical for maintenance of stretch reflexes and muscle tone

Eye Movement

- Eye movements
  - conjugate – both eyes in same direction
  - vergent - during motion of object to and from us
    - convergent
    - divergent



Conjugate Movements



Eye Movement Pathways

- Saccades
  Rapid eye movements, conjugated movement, voluntary or involuntary
- Smooth pursuit movements
  Follows moving visual target, voluntary
- Vestibulo-ocular movements
  Initiated by vestibular mechanisms during brief/rapid head movement
- Vergence movements
  Adjusts for different viewing distance

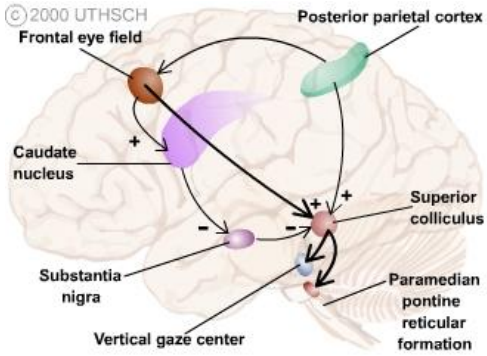
Saccadic Eye Movements

Neurons in the frontal eye field — voluntary and memory-guided saccades

Superior colliculus neurons — reflex orienting saccades

- superior colliculi – information from retina, auditory, and parietal (visual association) area

Correct and send control signals vertical and horizontal gaze centers



- horizontal gaze center – PPRF, abducens lower motor neurons and interneurons
- Vertical gaze center located at RF of the midbrain, lower motor neurons in the oculomotor and trochlear nuclei

Nuclei of the basal ganglion:
superior colliculus/caudate/substantia nigra

Smooth Pursuit Movements

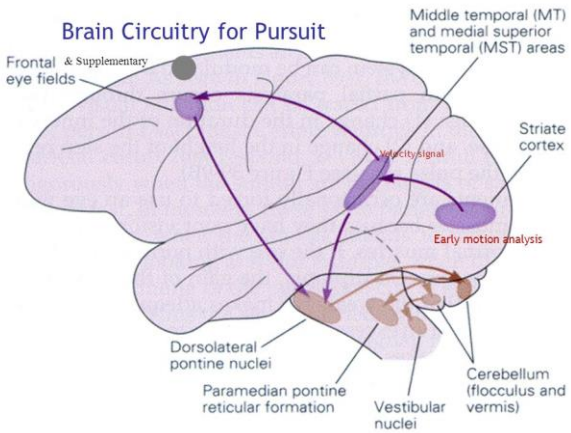
Temporal eye field neurons/ Frontal eye field neurons

Dorsolateral pontine nucleus

Contralateral cerebellum

Vestibular nuclei

Medial longitudinal fasciculus : CN III, IV, VI



Vestibulo-Ocular Movements

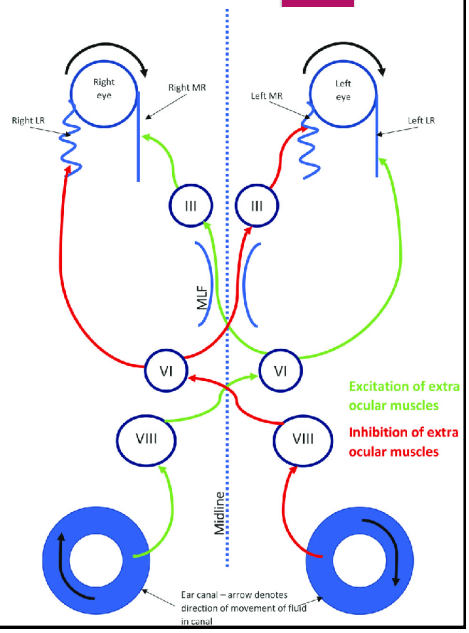
Vestibular mechanisms during head movement

Vestibular Receptors & Vestibular 1° Afferent Neurons

Horizontal Movements: Medial Vestibular Nucleus

Vertical Movements: Superior Vestibular Nucleus

Gaze Stabilization



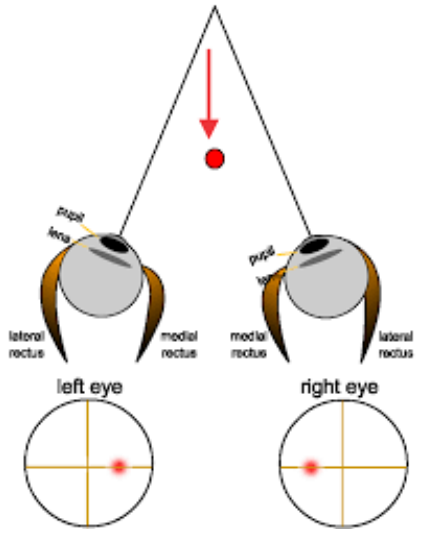
Vergence Movements

Visual system including visual association cortex

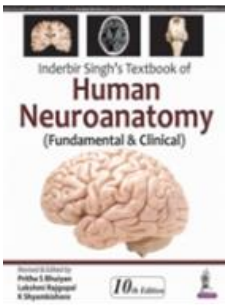
Supraoculomotor nuclei

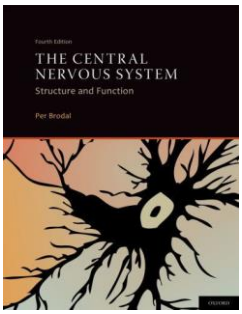
CN III, Medial rectus muscles

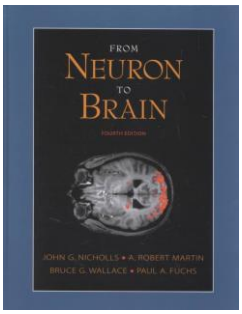
Gaze Shifting



Reading List







Thank you very much for your attention