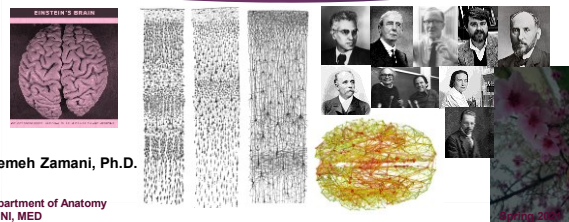


Welcome to Clinical anatomy of the head, neck and neuronal pathways
Lecture #11



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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

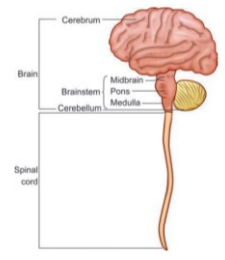
Necessary components of proper motor control

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



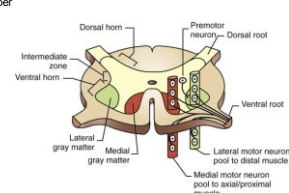
- o Spinal cord
- o Brain stem
- o Cortex
- o Cerebellum
- o Basal ganglia

Levels of Movement Regulation



Lower Motor Neurons – Spinal Cord

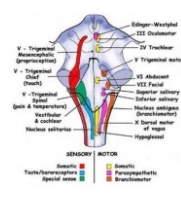
- o α motoneurons: innervate the extrafusal muscle fiber
- o γ motoneurons: innervate intrafusal muscle fibers
- o Somatotopic organization
 - o medial column – axial muscles
 - o lateral column – limb muscles
 - o anteriorly – extensors
 - o posteriorly – flexors



Lower Motor Neurons – Brain Stem

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

Nucleus	Type	Nerve	Muscles
Oculomotor	Somatic	III Oculomotor	Levator palpebrae superioris, superior rectus, medial rectus, inferior rectus, inferior oblique
Trochlear	Somatic	IV Trochlear	superior oblique
Trigeminal	Somatic	V Trigeminal	Temporalis, masseter, digastric (anterior belly), mylohyoid, medial and lateral pterygoids, tensor palati, tensor tympani
Abducens	Somatic	VI Abducens	Lateral rectus
Facial	Branchiomotor	VII Facial	Muscles of facial expression, buccinator, digastric, occipitofrontalis, stylohyoid, digastric (posterior belly), platysma
Vagus	Branchiomotor	X Vagus	Stylopharyngeus
Accessory	Branchiomotor	XI Accessory	Muscles of pharynx
Hypoglossal	Somatic	XII Hypoglossal	Muscles of larynx, Sternocleidomastoid, trapezius



Monkhouse, Cambridge: Cambridge University Press 2005

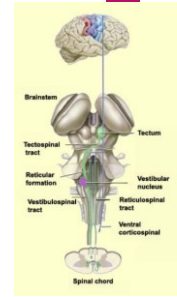
Supraspinal System of Movement Control

- o Medial system
 - bilateral
 - terminates on the interneurons or the medial column of lower motor neurons
 - controls maintenance of balance and postural movements
- o 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



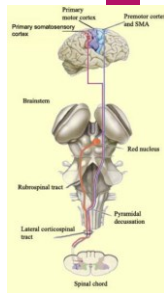
Medial System

- o Cortical pathways
 - **Anterior corticospinal tract**
medial column of lower motor neurons
- o 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

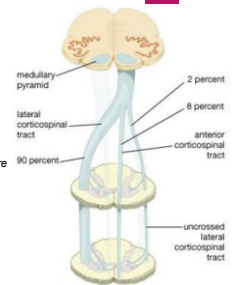
- o Cortical pathways
 - **Lateral corticospinal tract**
- o Subcortical pathways
 - **Rubrospinal tract** (Red nucleus of mid brain)
contralaterally descends to the lateral column
facilitatory to flexors of upper limb



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

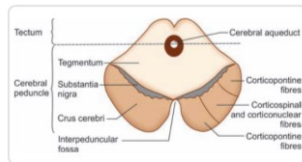
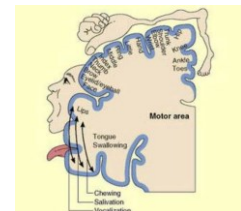
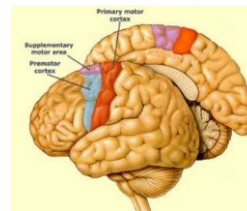


Figure 5.14: Transverse section of the midbrain showing its main subdivisions

Motor Cortex



Connections of the Cerebellum and Basal Ganglia

Motor Systems

- Cerebellum
- Basal Ganglia

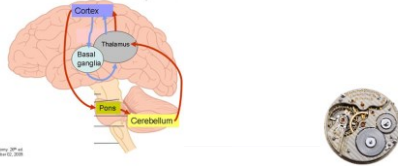


Figure 14.12 © Pearson Education, Inc. © 2011

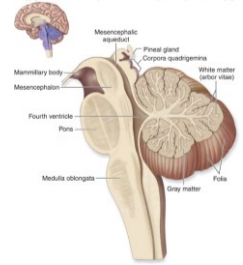
Cerebellum

Functions:

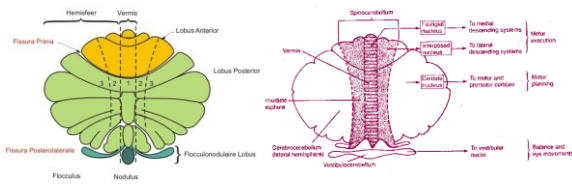
- Maintenance of balance and equilibrium
- Muscle tone
- Coordination of voluntary movements
- Motor learning

Damage to cerebellum:

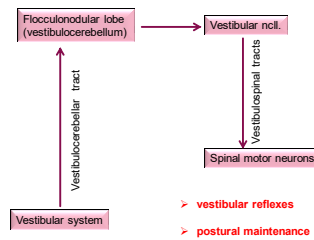
- Inability to maintain the equilibrium of the body
- Difficulty to touch his nose with a finger
- Unable to fix the gaze on an object



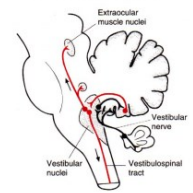
Cerebellum Anatomical Division



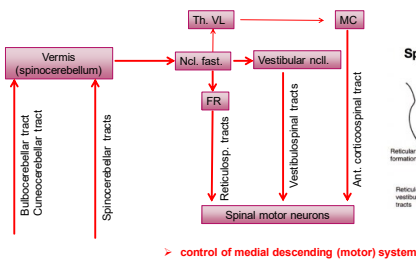
Connections of the Vestibulocerebellum



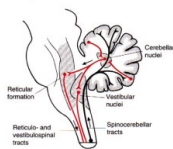
Vestibulocerebellum



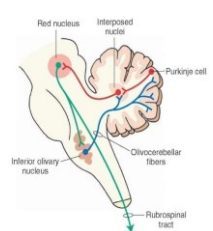
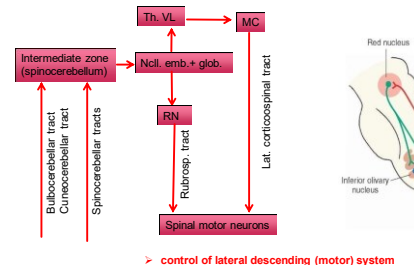
Connections of the Spinocerebellum – Median Zone



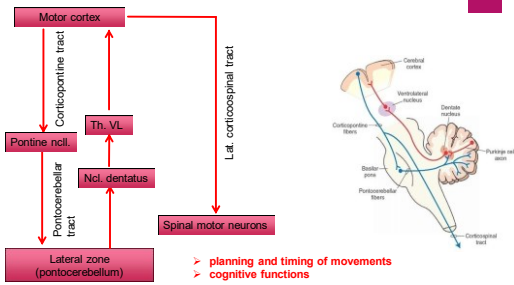
Spinocerebellum



Connections of the Spinocerebellum – Paramedian Zone



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

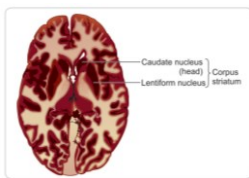


Cerebellar Disorders

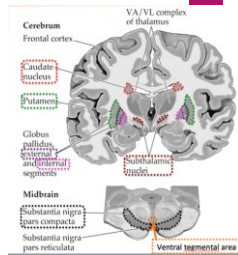
- Ataxia** - errors in the force, direction, speed and amplitude of movements, loss of coordination
- Dysmetria** - „overshooting or undershooting“ - the hand may travel past the target
- Hypotonia** - decreased muscle tone
- Adiadochokinesia** - inability to perform rapid alternating movements
- Intention tremor** - involuntary movement caused by alternating contractions of opposing muscle groups



Basal Ganglia

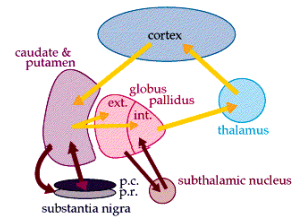


- o Caudate nucleus
- o Lentiform nucleus (putamen and the globus pallidus)
- o Substantia nigra
- o Ncl. subthalamic



Basal Ganglia Connections

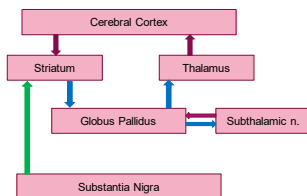
- Connections
- o Direct pathway
 - o Indirect pathway
 - o Nigrostriatal pathway



Basal Ganglia Connections

Transmitters

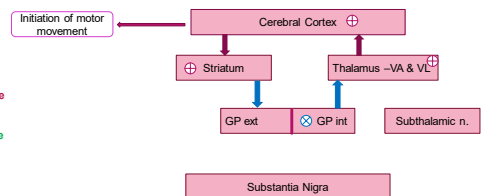
- o **Glutamate**: corticostriatal & thalamostriatal
- o **GABA**: striatopallidal & pallidothalamic
- o **Dopamine**: nigrostriatal pathway



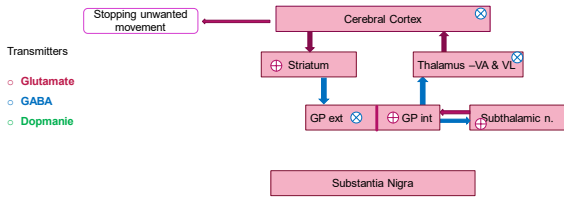
Basal Ganglia Connections- Direct Pathway

Transmitters

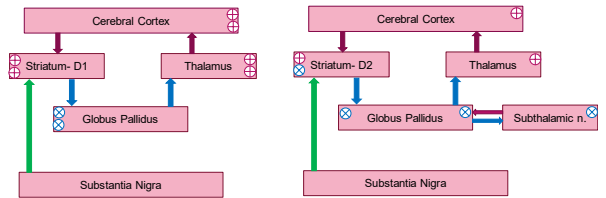
- o **Glutamate**
- o **GABA**
- o **Dopamine**



Basal Ganglia Connections- Indirect Pathway



Basal Ganglia Connections- Nigrostriatal Pathway



Spinal Reflex Motor

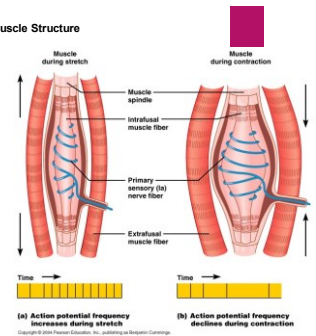
- **Type of afferents**
 - somatic spinal reflexes
 - visceral spinal reflexes
- **Type of somatosensor**
 - proprioceptive reflexes
 - exteroceptive reflexes
- **Number of involved spinal segments**
 - monosegmental spinal reflexes
 - polysegmental spinal reflexes
- **Number of synapses**
 - monosynaptic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



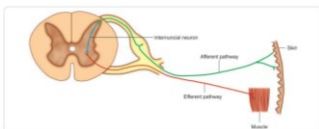
Skeletal Muscle Structure

Intrafusal muscle fibers are proprioceptors
 Innervated by gamma motoneurons

Extrafusal muscle fibers generate movement
 Innervated by alpha motoneurons



Spinal Reflex

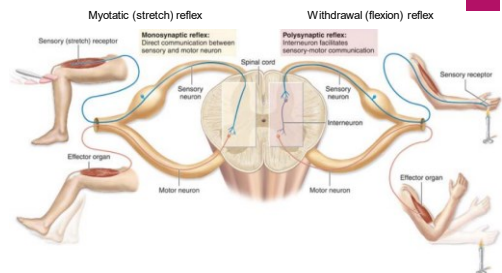


- Structural components:
- A receptor
 - An afferent neuron
 - A reflex center
 - An efferent neuron
 - An effector

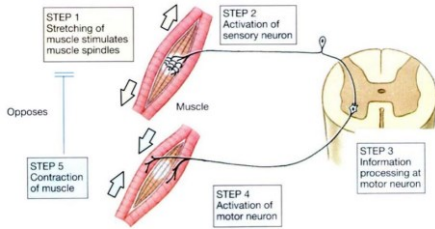
Reflexes with their reflex center in the spinal cord are called spinal reflexes.



Spinal Reflex

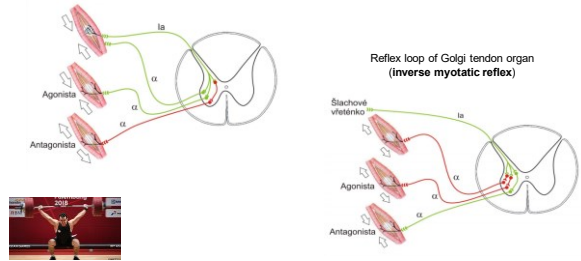


Myotatic (Stretch) Reflex

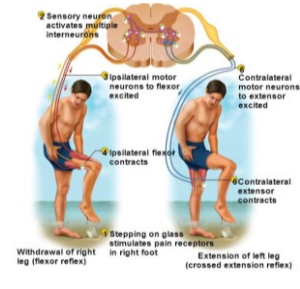


Receptors for the stretch reflex are the muscle spindles.

Myotatic (Stretch) Reflex



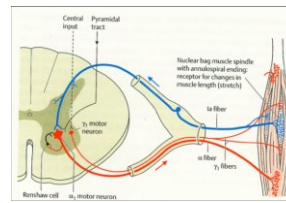
Withdrawal (Flexion) Reflex



Receptors for the flexion reflex are nociceptors.



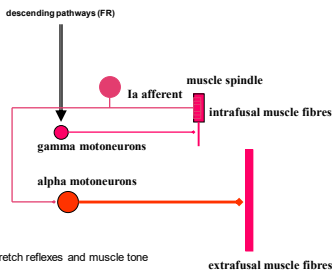
Motorneurons can inhibit their own activity by Renshaw Cells!



A negative feedback loop to stabilize the motorneurons



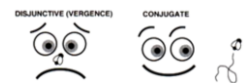
Gamma Loop



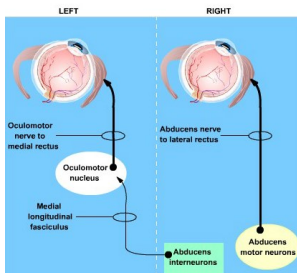
Critical for maintenance of stretch reflexes and muscle tone

Eye Movement

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



Conjugate Movements



Eye Movement Pathways

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

Saccadic Eye Movements

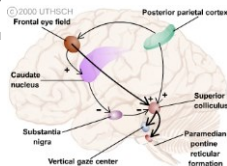
Neurons in the frontal eye field
Superior colliculus neurons

- voluntary and memory-guided saccades
- reflex orienting saccades

superior colliculi – information from retina, auditory, and parietal (visual association) area
Correct and send control signals vertical and horizontal gaze centers

- o horizontal gaze center – PPRF, abducens lower motor neurons and interneurons
- o 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

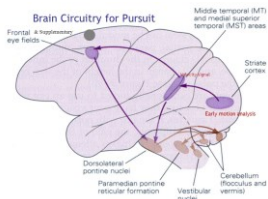
Temporal eye field neurons/ Frontal eye field neurons

Dorsolateral pontine nucleus

Contralateral cerebellum

Vestibular nuclei

Medial longitudinal fasciculus : CN III, IV, VI



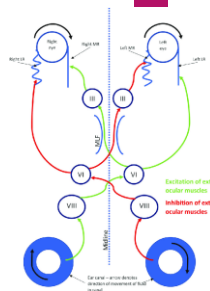
Vestibulo-Ocular Movements

Vestibular mechanisms during head movement

Vestibular Receptors & Vestibular 1^o Afferent Neurons

Horizontal Movements: Medial Vestibular Nucleus

Vertical Movements: Superior Vestibular Nucleus



Gaze Stabilization

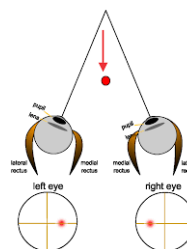
Vergence Movements

Visual system including visual association cortex

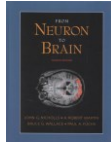
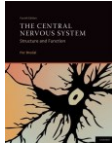
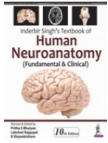
Supraoculomotor nuclei

CN III, Medial rectus muscles

Gaze Shifting



Reading List



Thank you very much for your attention