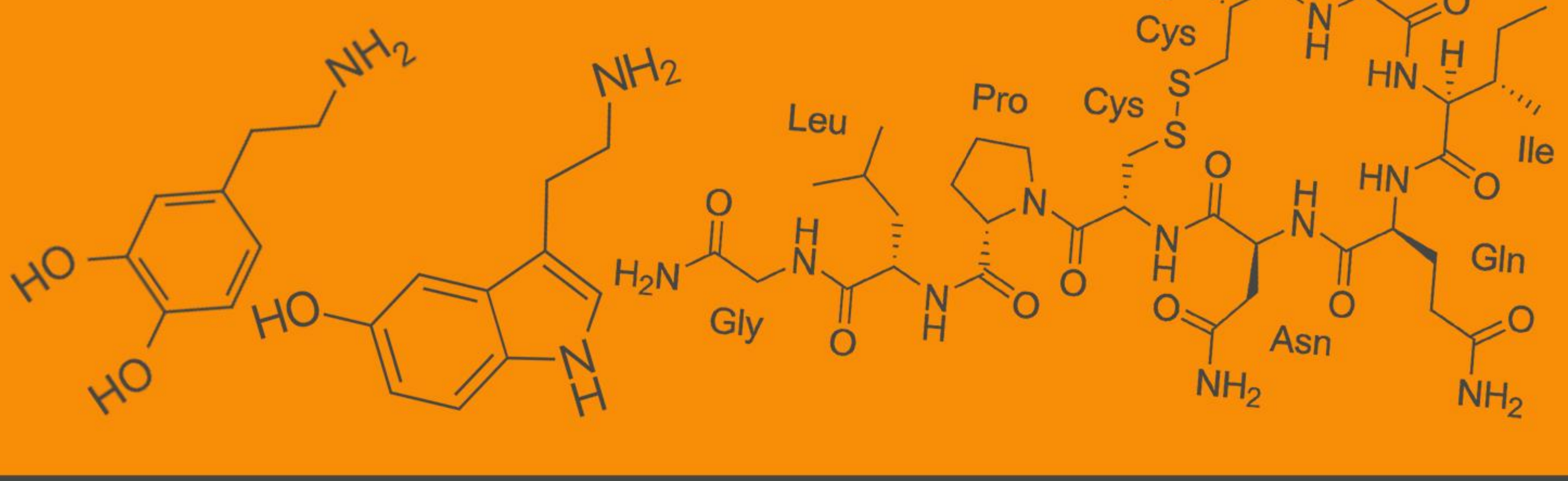


MEDICINE438's CNSPHYSIOLOGY

LECTURE IV: Physiology of Motor Tracts

EDITING FILE GSLIDES

IMPORTANT MALE SLIDES EXTRA FEMALE SLIDES LECTURER'S NOTES

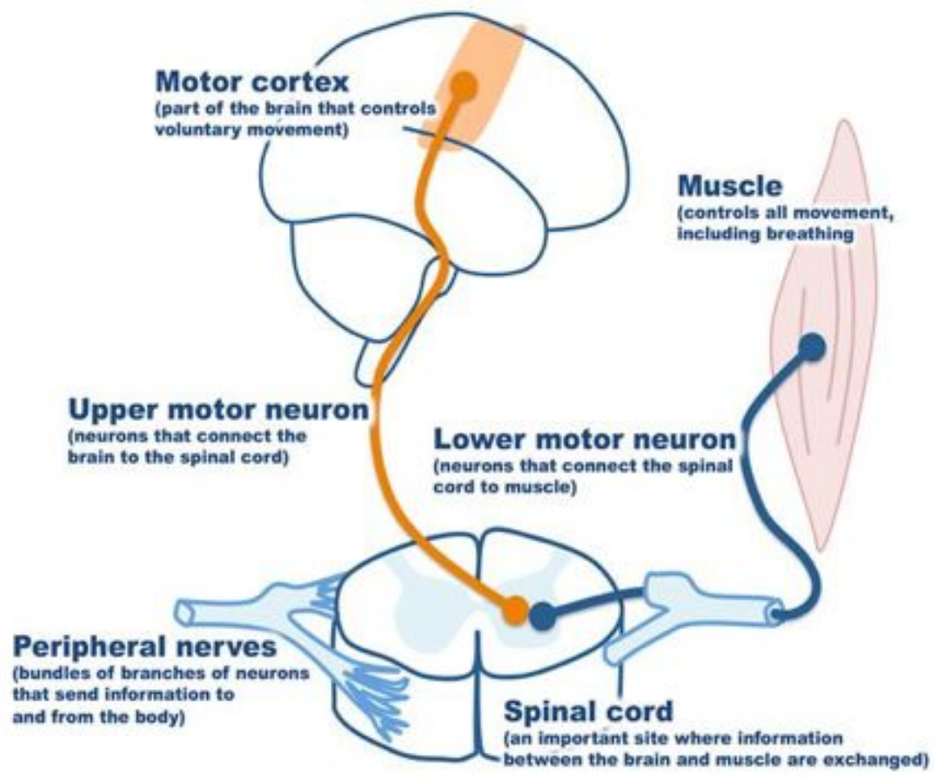
1 PHYSIOLOGY OF MOTOR TRACTS

Lecture Four

In order to initiate any type of voluntary movement there will be 2 levels of neuron that your body will use and they are:

Upper Motor Neurons (UMN)

These are the motor neurons whose cell bodies lie in the motor cortex, or brainstem, and they activate the lower motor neuron



Lower Motor Neurons (LMN)

These are the motor neurons of the spinal cord (AHCs) and brain stem motor nuclei of the cranial nerves that innervates skeletal muscle directly.

Figure 4-1

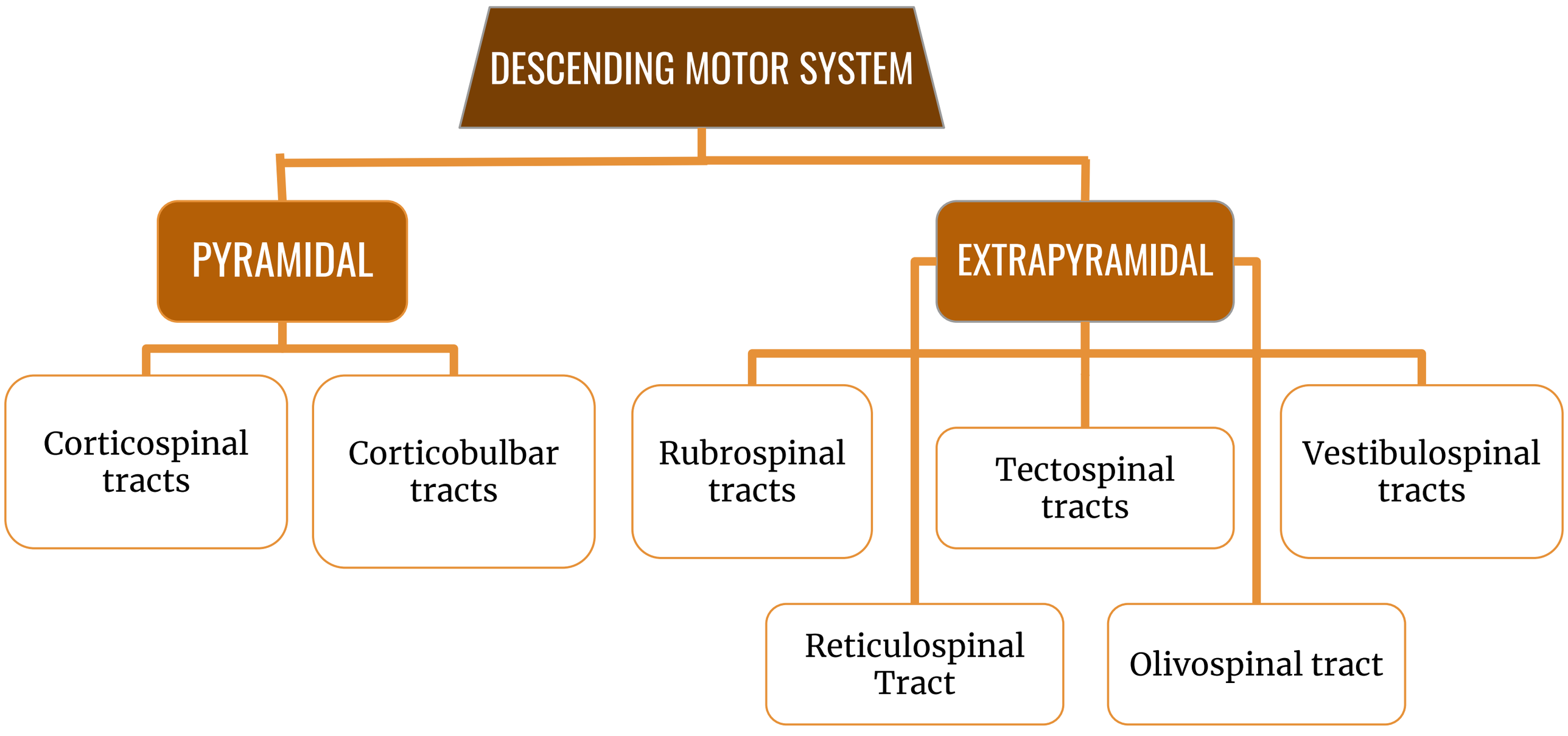
The descending motor system (pyramidal,Extrapyramidal)has a number of important sets these are named according to the origin of their cell bodies and their final destination;

pyramidal

Originates from the cerebral cortex and descends to the spinal cord (the corticospinal tract) passes through the pyramids of the medulla and therefore has been called the "the pyramidal tract "

extra pyramidal

- The rest of the descending motor pathways do not travel through the medullary pyramids[1] and are therefore collectively gathered under the heading:"the extrapyramidal tracts"
- Responsible for subconscious gross movements(swinging of arms during walking)



FOOTNOTES

1. They are collections of white matter in the medulla that appear triangular due to crossing of motor tracts. Therefore they are termed "medullary pyramids".

MOTOR AREAS

Area of representation is proportional with the complexity of function done by the muscles. Therefore muscles of the hands & speech occupy 50% of this area.

Occupies the Precentral Gyrus & contains large, giant highly excitable Betz cells.
MI of one side controls skeletal muscles of the opposite side of the body.

The neurons of this area are arranged in vertical columns, each column has 6 distinct layers of cells, the pyramidal cells that give rise to the corticospinal fibers all lie in the 5th layer.

THE PRIMARY MOTOR AREA (MI. MOTOR AREA 4)

- Facial area is represented bilaterally, but rest of the representation is generally unilateral
- Feet are at the top of the gyrus and face at the bottom , arms and the hand area in the mid portion

Betz cells axons send short collaterals back to the cortex to inhibit adjacent regions of the cortex when the Betz cells discharge, thereby "sharpening" the excitatory signal.

- The Betz cells fibers transmit nerve impulses to the spinal cord at a velocity of ~70m/s, the most rapid rate of transmission of signals from the brain to the cord.
- Betz cells in motor area 4

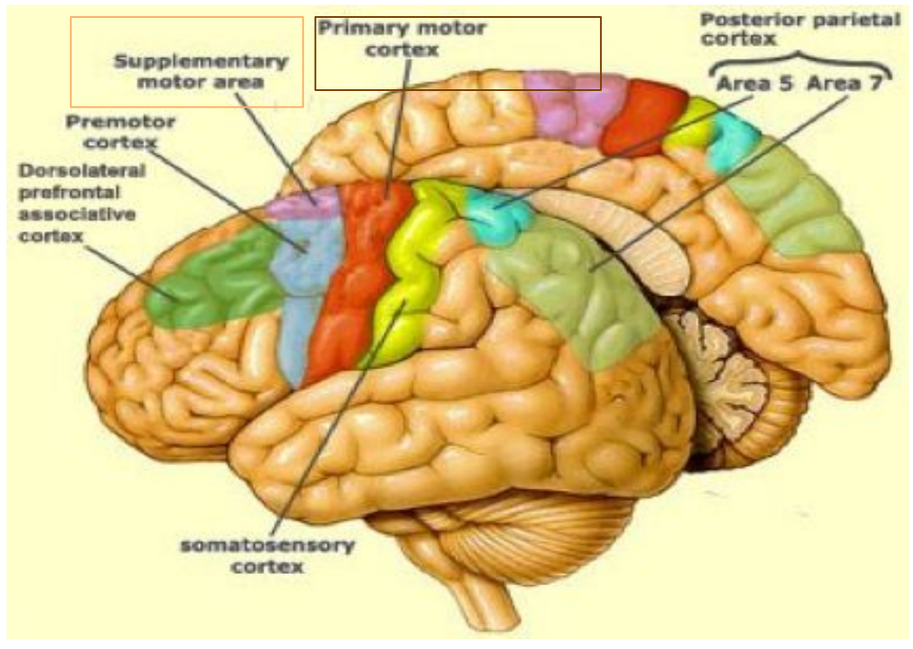


Figure 4-2

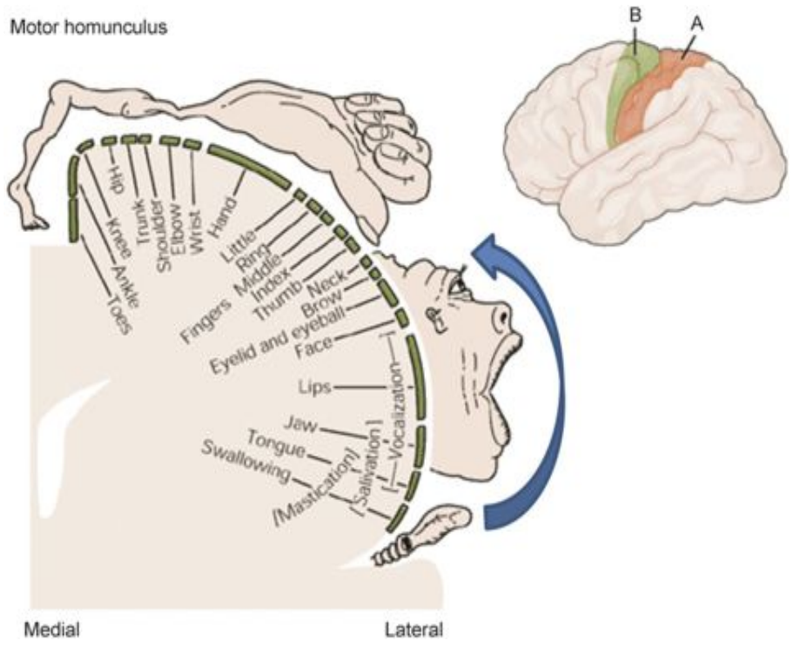


Figure 4-3

THE PREMOTOR AREA (AREA 6)

1 Lies in front of the primary motor area & below supplementary motor area.

2 Simulation of the premotor area produces complex coordinated movements, such as setting the body in a certain posture to perform a specific task.
Example: when writing, your body sits in a specific posture to aid. + playing piano

3 It works in association with the supplementary motor area, establishing the motor programs[1] necessary for execution of complex movements.

A few highly specialized motor centers have been found in the premotor areas of the human cerebral cortex:

PREMOTOR AREA	LOCATION	FUNCTION
Broca's Area for speech	Broca's Area	Speech
Frontal Eye Movements Area	Above Broca's area in the frontal lobe	Controls voluntary movements of the eye
Head rotation Area	Just above the eye movement area in the motor cortex	Directing the head toward different visual objects
Hand skills Area	Above the head rotation area	Hand skills

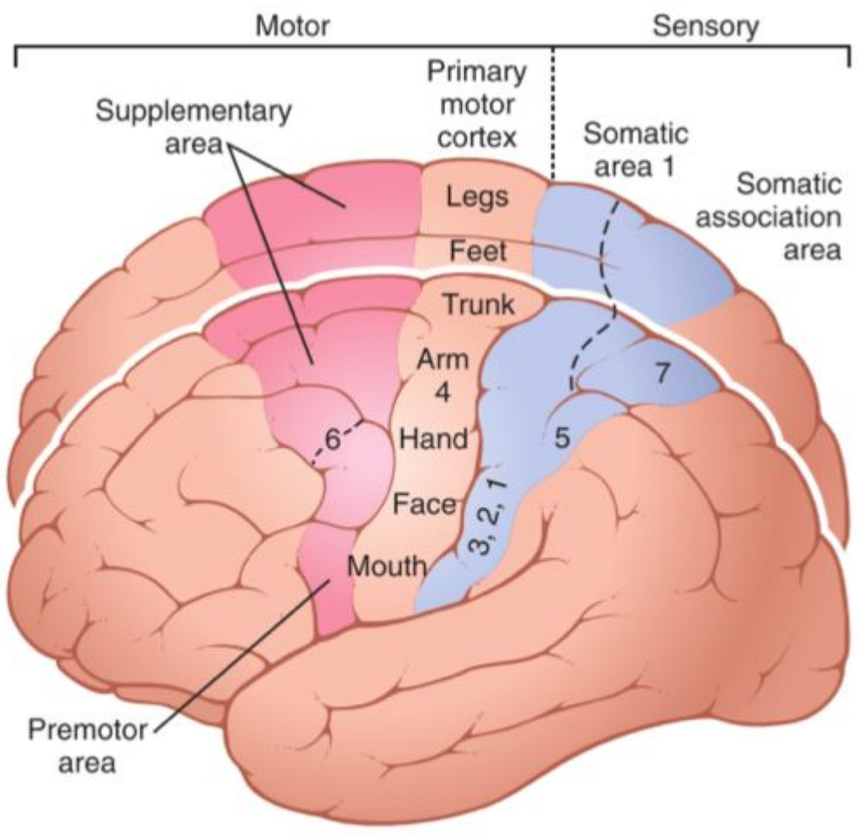


Figure 4-4

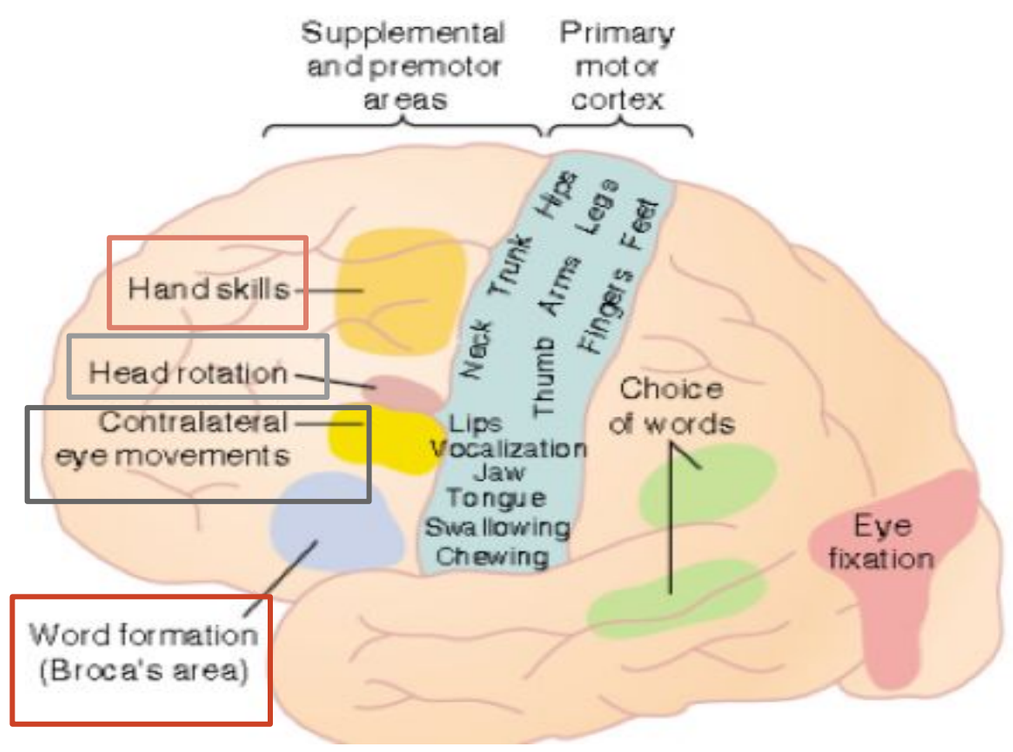


Figure 4-5

FOOTNOTES

1. Motor programs means abstract representations of movements before the movements actually occur, the supplementary motor area becomes active one second before voluntary movement. Which means the brain already drew a mental representation of the movement before its actual occurrence, the consequences of these findings are controversial to the point of questioning the notion of free will..

THE SUPPLEMENTARY MOTOR AREA

This area make motor programs for axial muscles. It provides background adjustment for finer motor control of the arms and the hands by the premotor area and primary motor cortex.

Concerned with planning & programming motor sequences.

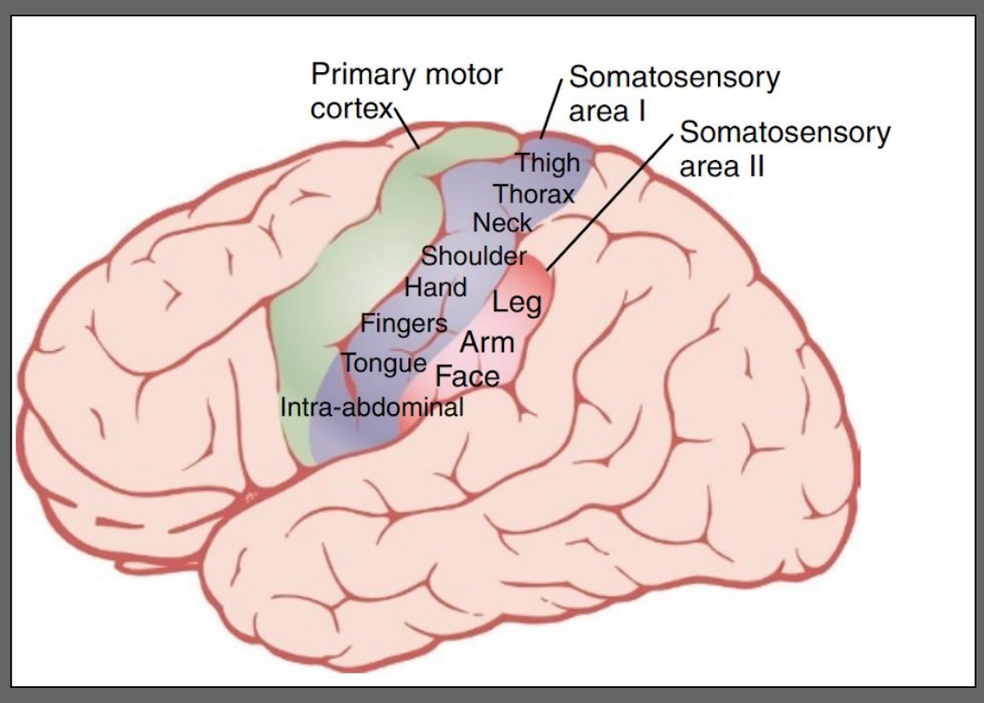
- Simulation of this area leads to bilateral (bimanual) grasping movements of both hands simultaneously.

Located on the lateral side of the brain in front of area 4 and above the premotor area & extends on the medial side of the cerebral hemisphere.

BOX 4-1: GUYTON AND HALL

SOMATOSENSORY CORTEX

- In general sensory signals all terminate within the somatosensory cortex, which lie in the parietal lobe directly posterior to the central sulcus which divides the frontal lobe from the parietal lobe, signals are received from ascending nerve fibers, the somatosensory cortex lies immediately posterior to primary motor cortex.
- This area allows for a high degree of interpretation of signals which are relayed from the periphery of the body.
- A major share of the actions of primary motor areas are in response of signals relayed from the somatosensory cortex, it feeds the motor cortex with signals that initiate motor activities .



- The figure shows distinct somatosensory areas, namely somatosensory area I and II, this division is due to different sensations received from different parts of the body found in each area. However area I is much more extensive and important than area II, so in common literature the somatosensory cortex usually refers to area I.
- The proportion of areas represented here is in direct proportion with the number of their specialized sensory receptors.
- Stimulation of some areas associated with somatosensory cortex can cause an awake person to experience complex body sensations like the feeling of an object like a knife or a ball.

BOX 4-2: GANONG'S

PHANTOM LIMB PAIN In 1551 a military surgeon wrote that the patients with amputated limbs say they still feel pain in the amputated parts, of which they complain strongly and wonder. This is an early description of phantom limb pain, which is a pain that is received from a limb that is no longer there, between 50% to 80% of amputees experience phantom sensations usually in the region of the amputated limb. Phantom sensation can occur after extraction of a tooth, or amputation of breasts or even a removal of an eye! The current theory to explain this, is that the brain reorganizes itself when a sensory stimulus is cut off. The ventral posterior thalamic nucleus
(position of cell bodies of 3rd order neurons) is one example. Studies of people with amputated legs reveal that regions of the thalamus that used to receive sensations from leg now respond to stimulus from the thigh, others revealed remapping of the somatosensory cortex, where areas previously occupied by the leg for example belong to the thigh after amputation. Therefore, sensations relayed to these areas are perceived to come from the amputated limb, but they are really are from the thigh.

CORTICOSPINAL (PYRAMIDAL TRACTS) & CORTICOBULBAR TRACTS

- 30% Motor area 4 (Primary motor area) (M1)
- 30% Premotor areas & supplementary cortex tracts
- 40% Parietal cortex (Somatic sensory area 3,1,2)
- 3% of the fibres are large myelinated fibres, derived from the large , highly excitable pyramidal Betz cells of M1 .

These fibers form monosynaptic connections with motor neurons of the spinal cord.

- But most of pyramidal fibers are unmyelinated
- Fibers from the cerebral cortex descend in Corona Radiata[1] to Internal Capsule Genu, and the anterior ⅔ of the posterior limb, then to Brain Stem (Midbrain, Pons, Medulla Oblongata).

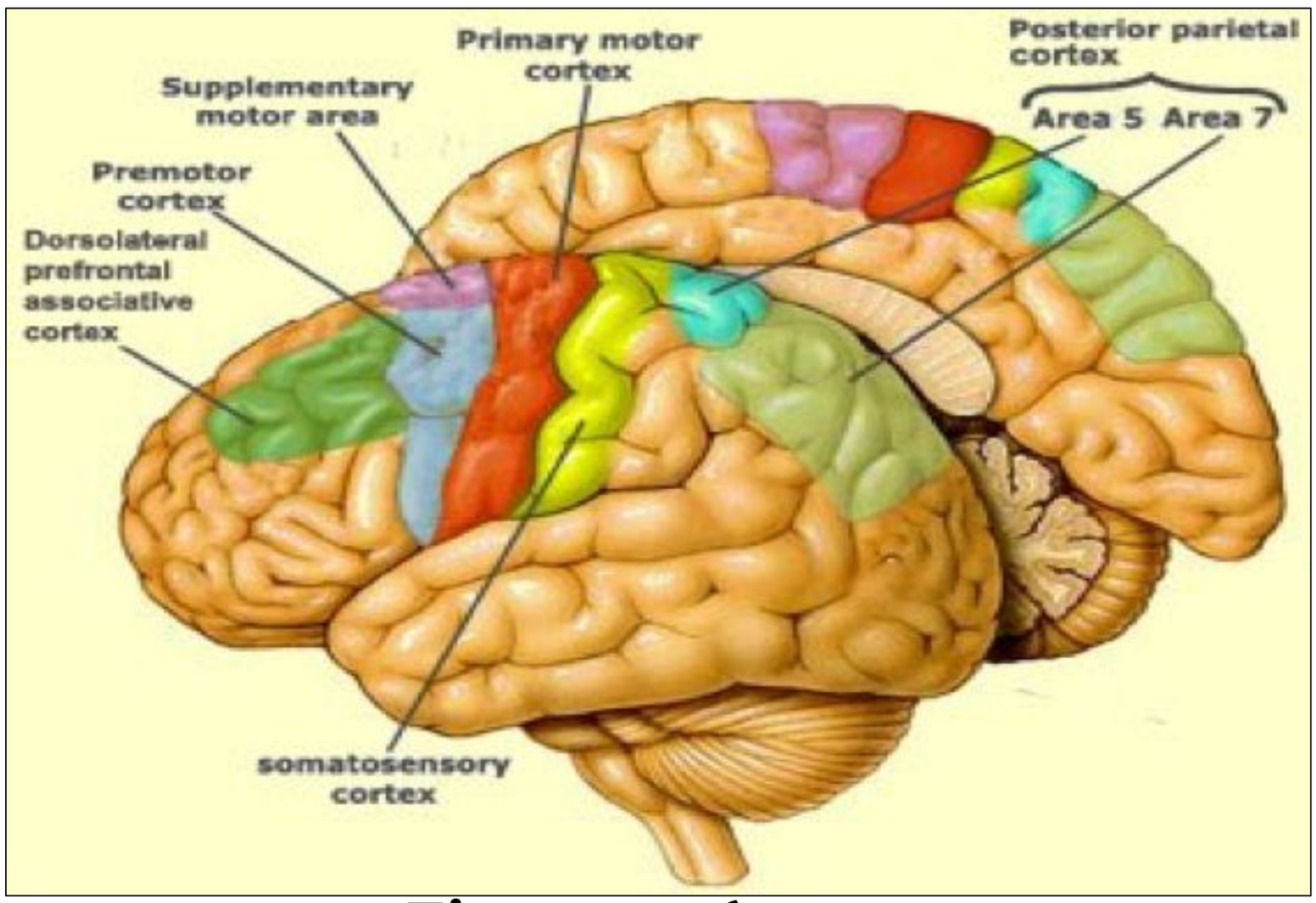


Figure 4-6

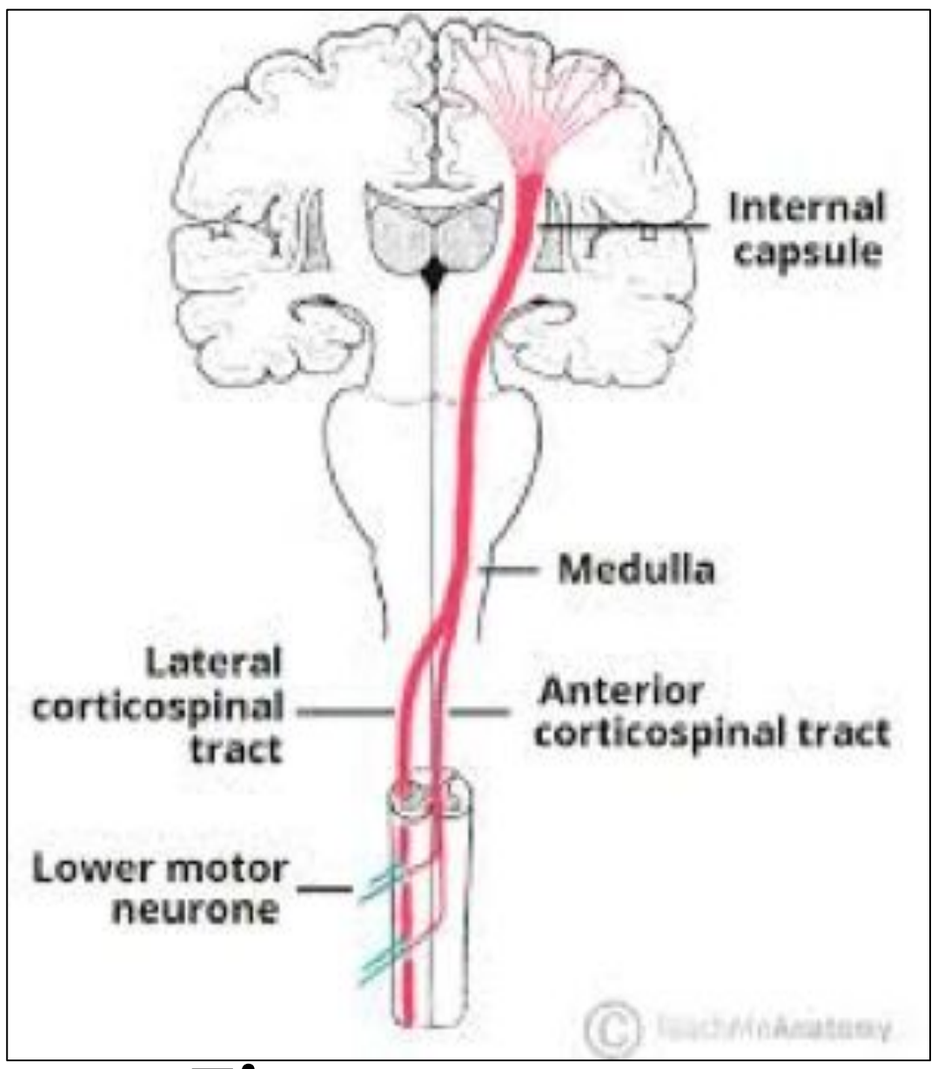


Figure 4-7

IN THE BRAINSTEM (MIDBRAIN, PONS, MEDULLA OBLONGATA)

1 Corticobulbar[2] tract carries information to motor neurons of the cranial nerve (terminates on cranial nerve nuclei of opposite side) (decussating just before they reach their target nuclei)

2 Corticospinal tracts (Pyramidal) Descends through the midbrain and pons, Then in the lower medulla oblongata the fibers form pyramids so called pyramidal tract

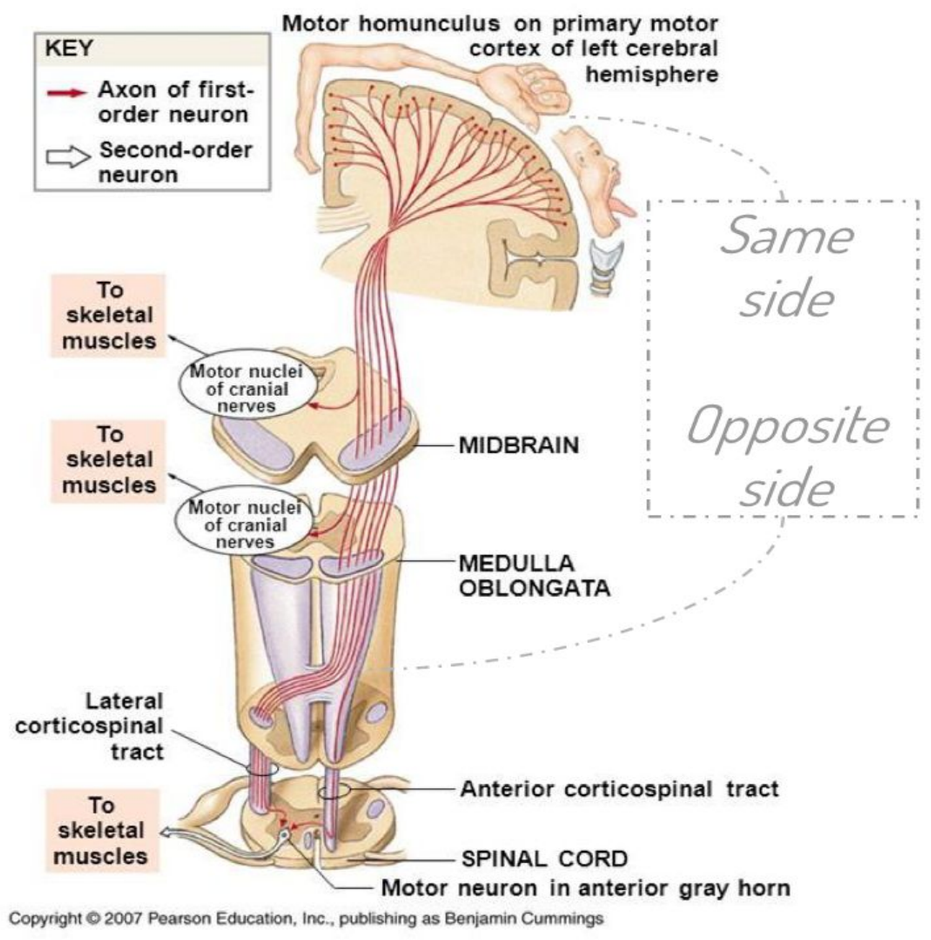


Figure 4-8

FOOTNOTES

1. Corona Radiata is a white matter sheet present in the brain that is unique in its position as a pathway of transmission signals from the cortex, it connects the upper with the lower regions of the brain therefore it is mostly made from corticospinal tract fibers. It continues as the internal capsule, which is a white matter structure, it is divided into posterior and anterior limb, the former leads to the brain stem, therefore corticospinal tract follow this pathway.
2. The bulb is a classic term for the **medulla oblongata** and in modern clinical usage the word **bulbar** is retained for terms that relate to the **medulla oblongata, therefore cortico=cortex, bulbar=medulla,** however it also supplies cranial nerve nuclei within other regions of the brainstem.

6 PHYSIOLOGY OF MOTOR TRACTS

Lecture Four

CORTICOSPINAL TRACTS (PYRAMIDAL) DIVIDES INTO

1. LATERALS CORTICOSPINAL TRACTS	2. VENTRAL (ANTERIOR) CORTICOSPINAL TRACTS
• 80% of fibers cross midline in pyramids • Pass laterally in spinal cord white matter • Ends directly (not via interneurons = monosynaptic connections) on motor neurons (AHCs) of the opposite side here the lower motor neurons (LMNs) of the corticospinal cord are located. • Then peripheral motor nerves carry the motor impulses from the anterior horn to the voluntary muscles • The fibers pass laterally in spinal cord white matter, so they control distal limb muscles • **FUNCTION** controls and initiates fine discrete skilled movements of fingers and toes.	• Remaining 20% fibers does not cross midline • Cross at level of their termination to synapse with interneurons, that synapse with motor neurons (AHCs) of opposite side. • Pass medially in ventral horn so control axial & proximal limb muscles. • So corticospinal tract(ANT & LAT) supply skeletal muscles of the opposite side • **FUNCTION** These fibers control the axial and proximal limbs muscles so it concern with control of posture.

Origin : Sensory cortex, primary Motor Cortex, premotor & supplementary cortex

↓

Internal capsule

↓

Cerebral Peduncle (midbrain)

↓

Pons

→

Medullary Pyramid

→

Pyramidal Decussation

→

Lat.Cross & Vent. Uncross White matter in spinal cord

↑

Ant. Horn of spinal cord through a interconnection

↑

α motor neuron of opposite side

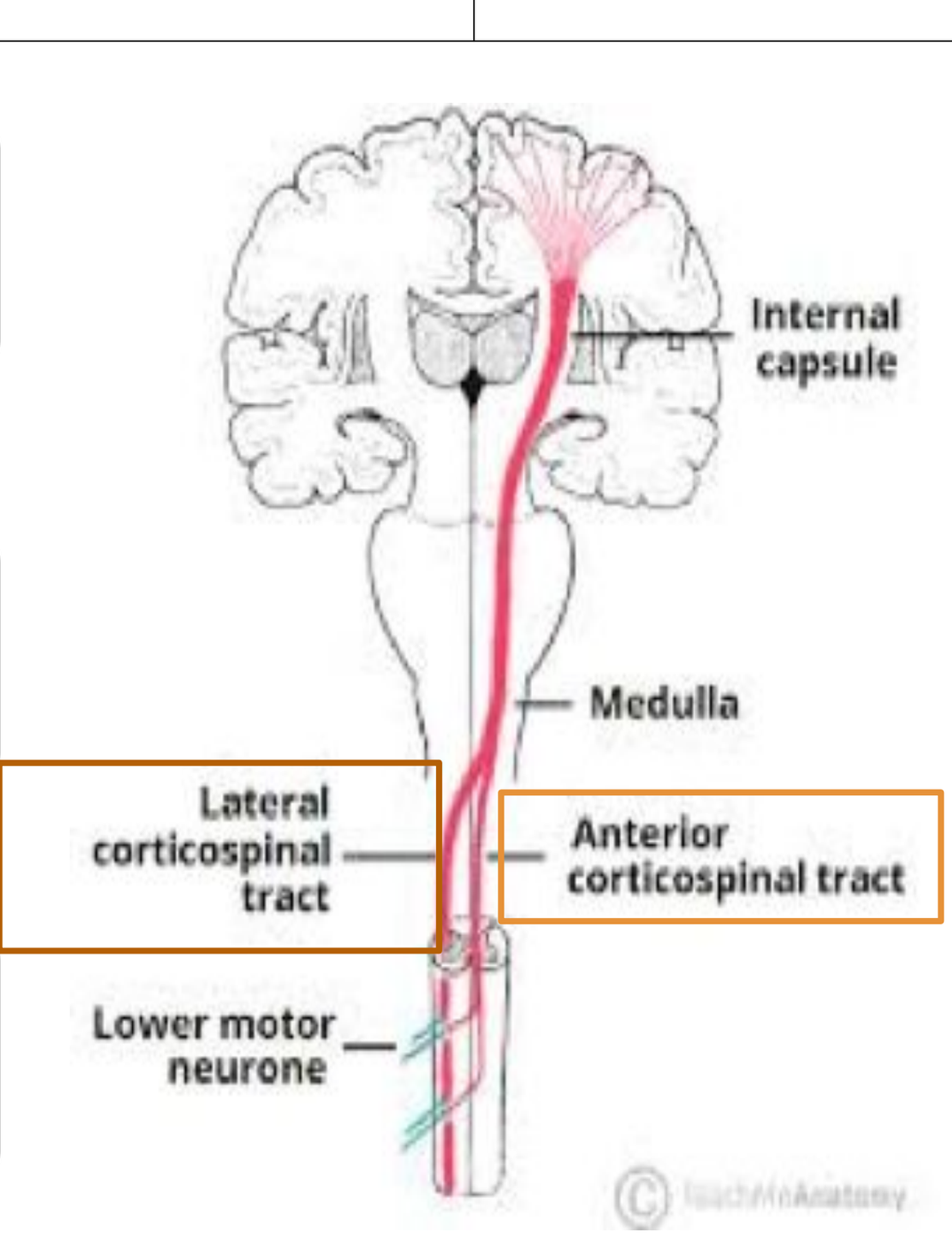


Figure 4-9

Lecture Four

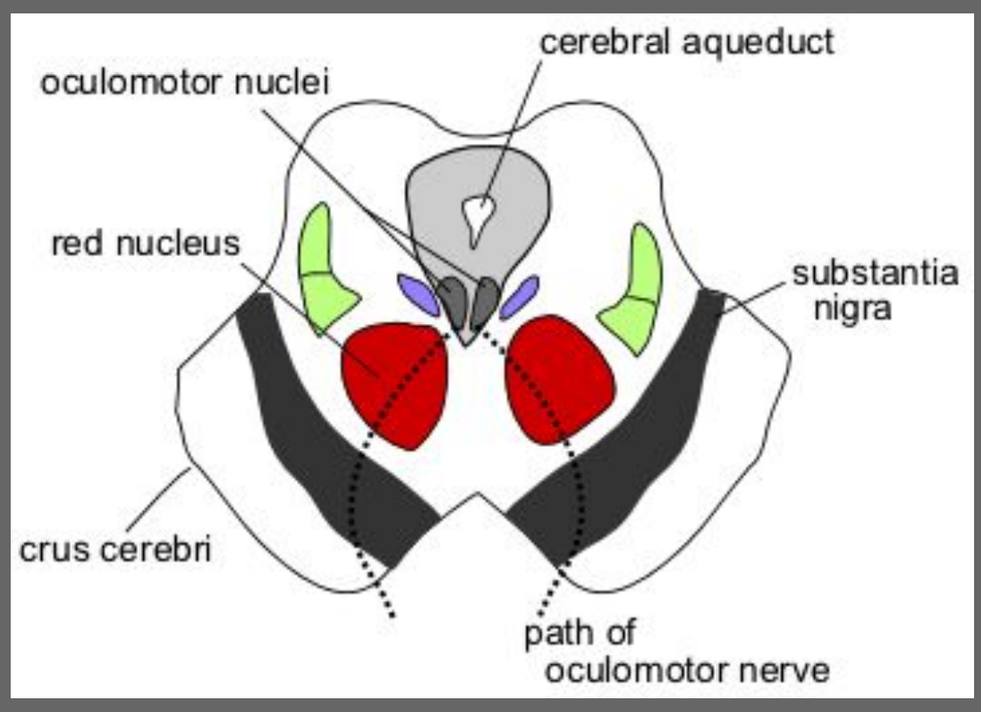
FUNCTIONS OF CORTICOSPINAL TRACTS

1. Initiation of fine ,discrete, skilled voluntary movements
2. lateral corticospinal tracts (main bulk of the tract) control distal muscles of limb as fingers & thumb & toes which concerned with fine skilled movement) e.g Painting ,writing, picking up of a small object etc.
3. Ventral corticospinal tracts control posture of axial & proximal limb muscle for balance, climbing, walking
4. Effect on stretch reflex:- Facilitate muscle tone through gamma motor neurons
5. Fibers originate from parietal lobe are for sensory-motor coordination
6. facilitate their tone, and are involved in facial expression mastication and swallowing.

BOX 4-3: NEUROANATOMY: AN ILLUSTRATED COLOR TEXT & GUYTON AND HALL

THE RED NUCLEUS

- The midbrain is divided into tectum (latin for roof), and tegmentum (latin for floor), the tectum is further divided into superior and inferior colliculus, and the tegmentum is formed of the red nucleus, periaqueductal grey matter and the substantia nigra (parkinson's disease affect neurons within this area).
- The red nucleus is red due to the presence of iron in hemoglobin or ferritin.
- The red nucleus is located centrally within the tegmentum, it is associated with motor control. It receives afferent neurons from corticospinal tract, called cortico-rubral tract, ruber in latin means "red", therefore it is used to indicate the red nucleus with the prefix rubro, and the suffix rubral.
- The fibers from the corticospinal tracts (rubrospinal) synapse with the motor neurons of the lower portion of the red nucleus, the fibers of these neurons form a new tract that extends to the spinal cord - the *rubrospinal tract.*



Excitation of the Spinal Cord Motor Control Areas by the Primary Motor Cortex and Red Nucleus	Vertical Columnar Arrangement of the Neurons in the Motor Cortex.
Function of Each Column of Neurons:	Each column has six distinct layers of cells The pyramidal cells that give rise to the corticospinal fibers all lie in the fifth layer of the cortical surface.
Function of Each Column of Neurons;	- Each column of cells functions as a unit & as integrative processing system, using information from multiple inputs to determine the output response from the column. - Each column can function as an Amplifying system to stimulate large numbers of pyramidal fibers to the same muscle or to synergistic muscles simultaneously.

Each Column Of Cells Excites Two Types Of Pyramidal Cell Neurons:

THE DYNAMIC NEURONS	THE STATIC NEURONS
are excited at a high rate for a short period at the beginning of a contraction, causing the initial rapid development of contraction.(start the action)	The static neurons fire at a much slower rate, but continue firing at this slow rate to maintain the force of contraction as long as the contraction is required.
Greater percentage of dynamic neurons is in the red nucleus	Greater percentage of static neurons is in the primary motor cortex.
The neurons of the red nucleus have similar dynamic and static characteristics	

REMOVAL OF (AREA PYRAMIDALIS) OF THE PRIMARY MOTOR CORTEX

- Removal of a the area that contains the giant Betz pyramidal cells (Area Pyramidalis) causes loss of voluntary control of discrete movements of the distal segments of the limbs, especially of the hands and fingers (This does not mean that the hand and finger muscles themselves cannot contract (paralysis) rather, the ability to control the fine movements is gone).
- That is because area pyramidalis is essential for voluntary initiation of finely controlled movements, especially of the hands and fingers

EXTRAPYRAMIDAL TRACTS

Tracts other than corticospinal tract & are outside pyramids Origin/ motor area 4, premotor area 6, Suppressor area 4

→ **CORONA RADIATA to**

→ **INTERNAL CAPSULE to**

↓

BASAL GANGLIA to BRAIN STEM

↓

BULBOSPINAL TRACTS descend to spinal cord as :

→

A. Rubrospinal tract.
B. Vestibulospinal Tract.
C. Reticulospinal Tract
D. Tectospinal Tract.
E. Olivospinal Tract

EFFECTS OF LESIONS IN THE MOTOR CORTEX OR IN THE CORTICOSPINAL PATHWAY(THE STROKE):

- The motor control system can be damaged by the "stroke "
- Muscle Spasticity Caused by Lesions That Damage Large Areas Adjacent to the Motor Cortex. (refer to BOX 4-3)
- Most lesions of the motor cortex, especially those caused by a stroke, involve the primary motor cortex & adjacent parts of the brain such as the basal ganglia .
- The primary motor cortex normally exerts a continual tonic stimulatory effect on the motor neurons of the spinal cord; when this stimulatory effect is removed, hypotonia results.

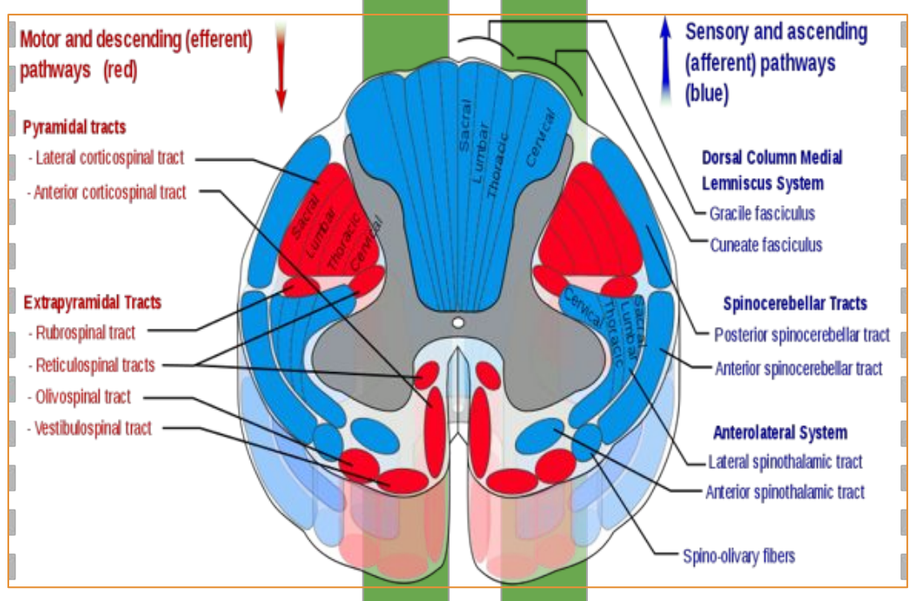


Figure 4-10

BOX 4-3: GUYTON AND HALL

The spasm that occurs after a stroke to the motor cortex and adjacent area results from damage to accessory pathways from the extrapyramidal tracts, these pathways inhibit the vestibular and the reticular brain stem nuclei, therefore in the absence of these inhibitory pathways these nuclei become excessively active and cause excessive excitation of muscles.

RUBROSPINAL TRACTS

It receives fibers from Ipsilateral cortical motor area (corticobulbar[1] pathway)

The red nucleus located in the mesencephalon

It receives direct fibers from the primary motor cortex through the corticorubral tract Basal ganglia &some branching fibers from the corticospinal tract (These fibers synapse in the lower portion of the red nucleus, the magnocellular portion)

The rubrospinal[1] fibers terminate mostly on interneurons of the cord gray matter, along with the corticospinal fibers, but some of the rubrospinal fibers terminate directly on anterior motor neurons

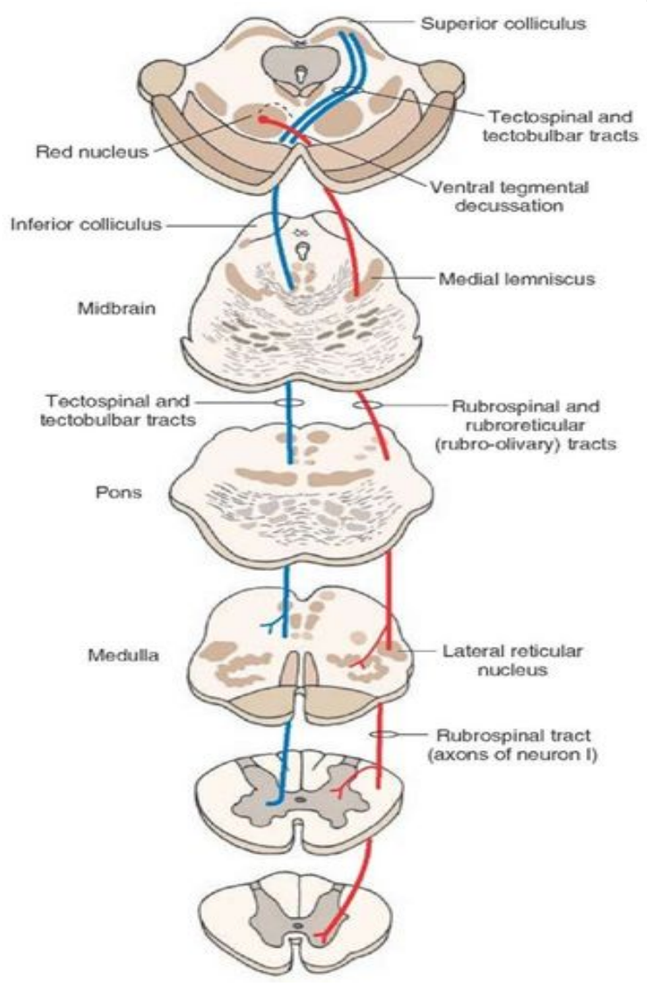


Figure 4-11

The rubrospinal tract, which crosses to the opposite side in the lower brain stem into the lateral columns of the spinal cord together with corticospinal tract

FOOTNOTES

1. Corticobulbar, bulbar refers to the medulla, an old term for the medulla oblongata.Rubro in rubrospinal refers to the red nucleus as was explained in Box 4-3.

FUNCTION OF THE CORTICORUBROSPINAL SYSTEM: (as same as corticospinal that's if the there is a damage in corticospinal tract this will do the function)

1. The corticorubrospinal pathway serves as an accessory route for transmission of discrete signals from the motor cortex to the spinal cord. When the corticospinal fibers are destroyed, discrete fine control of the fingers movements can still occur but impaired.

2. This tract is excitatory for flexors & inhibitory for extensors (anti-gravity muscles).

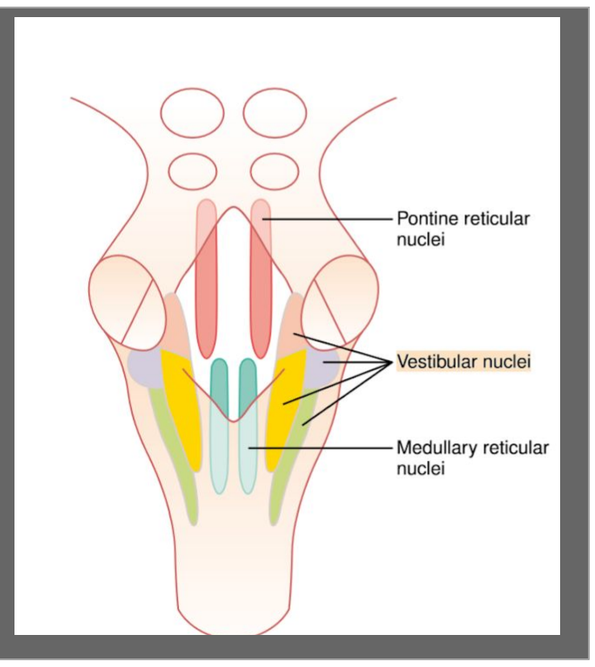
3. Rubrospinal tract lies in the lateral columns of the spinal cord, along with the corticospinal tract. Therefore, together are called the **lateral motor system** of the cord, in contradistinction to a vestibulo-reticulospinal system, which lies mainly medially in the cord and is called the **medial motor system** of the cord

BOX 4-3: GUYTON AND HALL & GANONG'S

THE VESTIBULAR NUCLEI

The vestibular system of the brain is divided into vestibular apparatus and central vestibular nuclei, the vestibular apparatus within the inner ear detects movement and position, whereas the vestibular nuclei is concerned with maintaining the position of head in space.

- Vestibular nuclei are (posterior and anterior) are the nuclei of the vestibular nerve, a branch of the 8th cranial nerve, vestibulocochlear, which divides into vestibular and cochlear branches..
- They lie within the pons and medulla, as seen in the figure. Their specific function is to control specific signals to different different antigravity muscles for maintenance of equilibrium in response to signals from the vestibular apparatus.



VESTIBULOSPINAL TRACTS

Fibers originate in vestibular nuclei in pons (which receive inputs from inner ear, Vestibular Apparatus and cerebellum)

Vestibular nuclei tracts are always excitatory to Gamma Efferent (where is Red nucleus is always inhibitory

General Functions

- Controls Postural & righting reflexes.
- Excitatory to ipsilateral spinal motor neurons-that supply axial & postural muscles
- Control eye movements

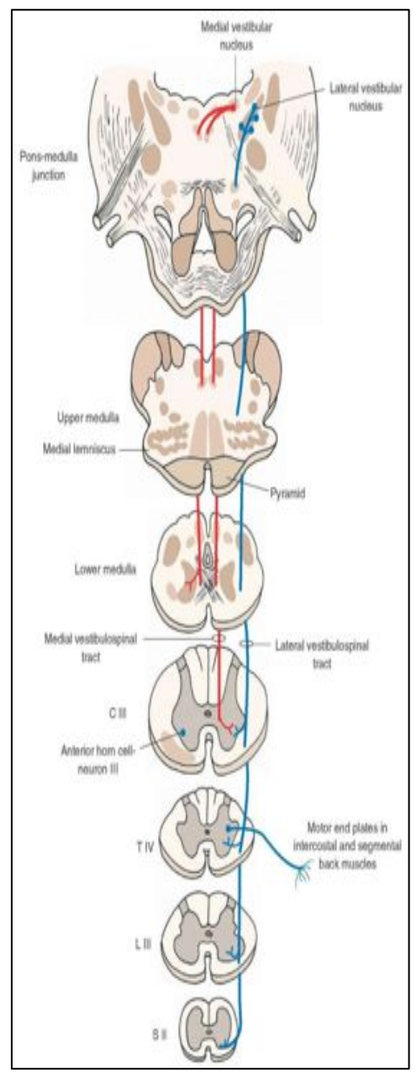


Figure 4-12

FUNCTIONS OF VESTIBULOSPINAL TRACTS

THE LATERAL VESTIBULOSPINAL	THE MEDIAL VESTIBULOSPINAL TRACT
- Cells of origin: Lateral Vestibular Nucleus - Axons descend in the ventral white column of the spinal cord FUNCTION This tract mediates excitatory influences upon extensor motor neurons to maintain posture & righting reflexes	- Cells of origin: Medial Vestibular Nucleus - As its axons descend in the ventral white column of spinal cord to end at the cervical segments of the spinal cord. - Some fibers form part of the Medial Longitudinal Fasciculus fibers in brain stem that link vestibular nuclei to nuclei supplying the extraocular muscle. [1] FUNCTION for coordination of head and eye movements

TECTOSPINAL TRACTS[1]

From superior colliculi in the tectum of midbrain (for VISUAL reflexes) & from inferior colliculi of midbrain (for AUDITORY reflexes)

Ends on Contralateral Cervical motor neurons

Function: Mediate/facilitate turning of the head and neck in response to visual or Auditory stimuli (the response will be toward the stimulus)

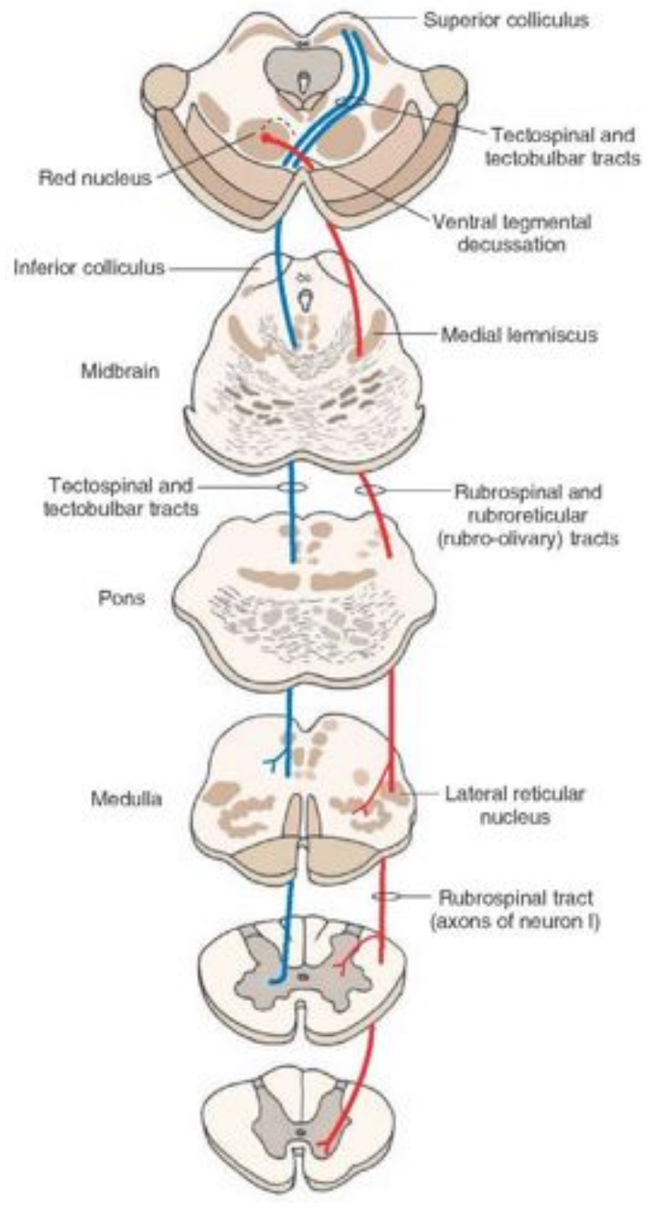


Figure 4-13

RETICULOSPINAL TRACT

- Tract arises from The reticular formation which makes up a central core of the brainstem
- It contains sensory & motor neuronal groups
- Pontine and medullary nuclei project to the AHC of the spinal cord via Reticulospinal Tract

FOOTNOTES

1. Tectospinal: The prefix tecto- refers to the tectum of the midbrain, refer to Box 4-2 for further clarification.

TYPES OF RETICULOSPINAL TRACTS

Pontine (Medial) Reticulospinal Tract	Medullary (Lateral) Reticulospinal Tract
- Cells of origin: Pontine Reticular Formation which has high excitability & they receive strong excitatory signals from the vestibular nuclei . - Axons descend in anterior(ventral)white column of spinal cord - Pontine Reticulospinal Tract increases Gamma efferent activity (excitatory to axial & antigravity, extensor muscles of the body & inhibitory for flexores & increases muscle tone) - it causes powerful excitation of antigravity muscles	- Cells of origin: Medullary Reticular Formation - Axons descend in lateral white column of spinal cord on both sides - It receives strong input from: 1. The corticospinal tract 2. The rubrospinal tract - These activate the medullary reticular inhibitory system to counterbalance the excitatory signals from the pontine reticular system - Medullary Reticulospinal Tract inhibits Gamma efferent activity (transmit inhibitory signals to antigravity extensor muscles & decreases muscle tone) .

OLIVOSPINAL TRACT

- It arises from inferior olivary nucleus of the medulla & is found only in the cervical region of the spinal cord (supplies neck muscles) of unknown function , facilitate muscle tone
- Secondary olivocerebellar fibers transmit signals to multiple areas of the cerebellum

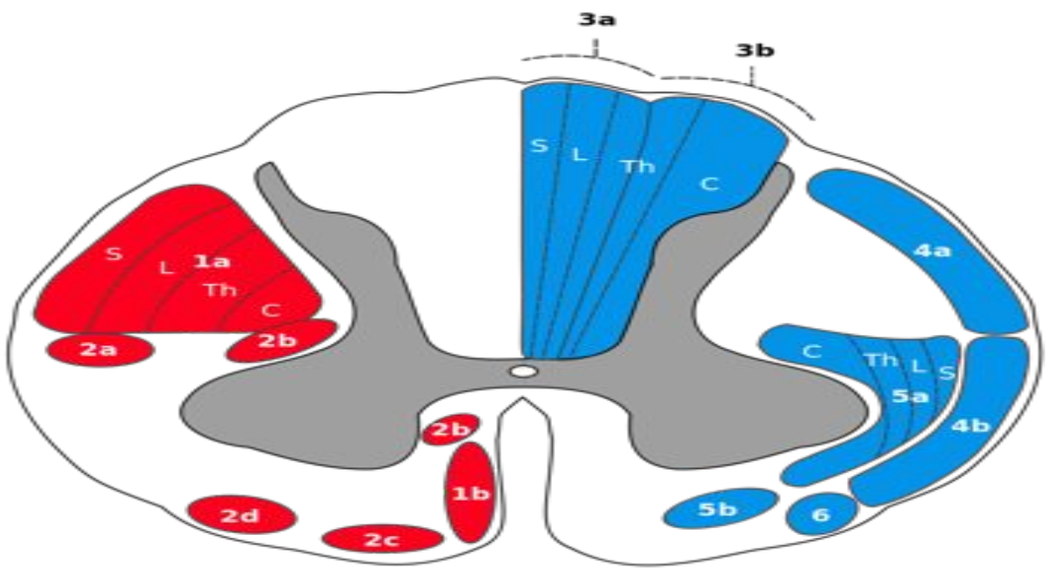


Figure 4-14

EXTRAPYRAMIDAL SYSTEM

1. Help pyramidal tract in initiation of voluntary movement
2. Share in planning and programming of voluntary movement
3. Responsible for subconscious gross movements(swinging of arms during walking)
4. Keep equilibrium and adjust body posture
5. Regulation of muscle tone.
6. Sets the postural background needed for performance of skilled movement.
7. controls subconscious gross movement.

QUIZ

MEDICINE438's
CNSPHYSIOLOGY

1. Which one of the following represents the highest area point in the primary motor area ?

A) Lips
B) Head
C) Thumb
D) Trunk

2. the incoming signals enters the cortex through...

A) Neuronal layer 6
B) Neuronal layer 1
C) Neuronal layer 4
D) Neuronal layer 3

3. Damage to the Broca's area results in inability to

A) Speech
B) Read the words
C) Hear the words
D) Comprehend the words

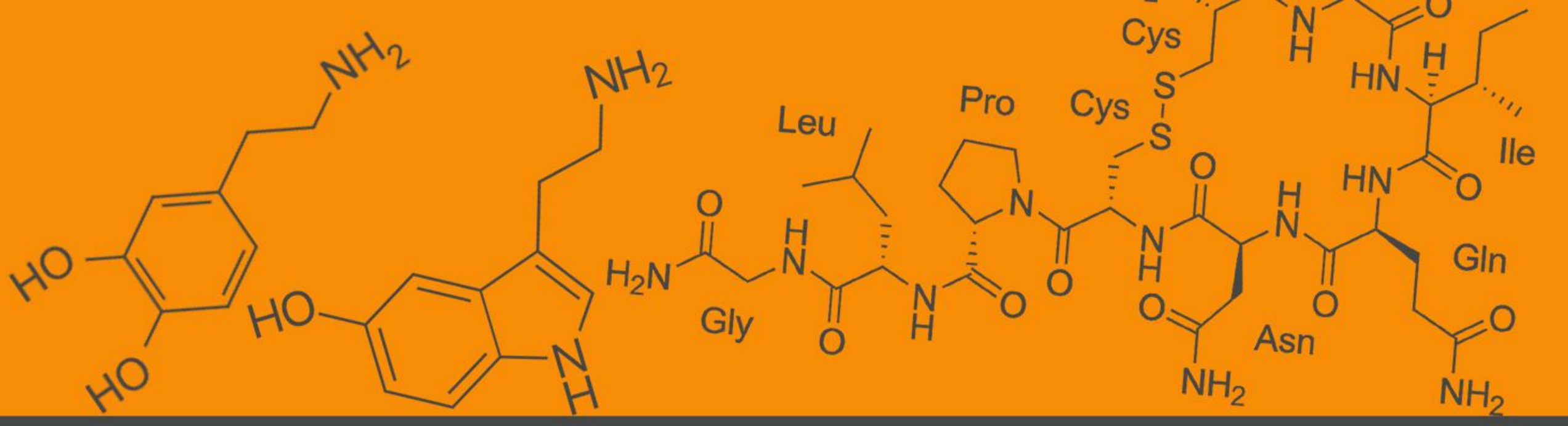
4. coordination of head and eye movements is function of

A) Medial vestibulospinal tract
B) Pontine (Medial) Reticulospinal tract
C) Tectospinal tracts
D) The lateral vestibulospinal tract .

5. where we can find betz cell ?

A) Primary area
B) Premotor area
C) Supplementary cortex
D) Somatic sensory area

ANSWER KEY: A, C, A, A, A



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