Physiology of motor tracts

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Dr.Najeeb's videos for this Lecture are highly recommended

Download this book for better tract diagrams HERE

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Recommended Videos!

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Objectives

UPON COMPLETION OF THIS LECTURE, STUDENTS SHOULD BE ABLE TO DESCRIBE :

✧THE UPPER AND LOWER MOTOR NEURONS.

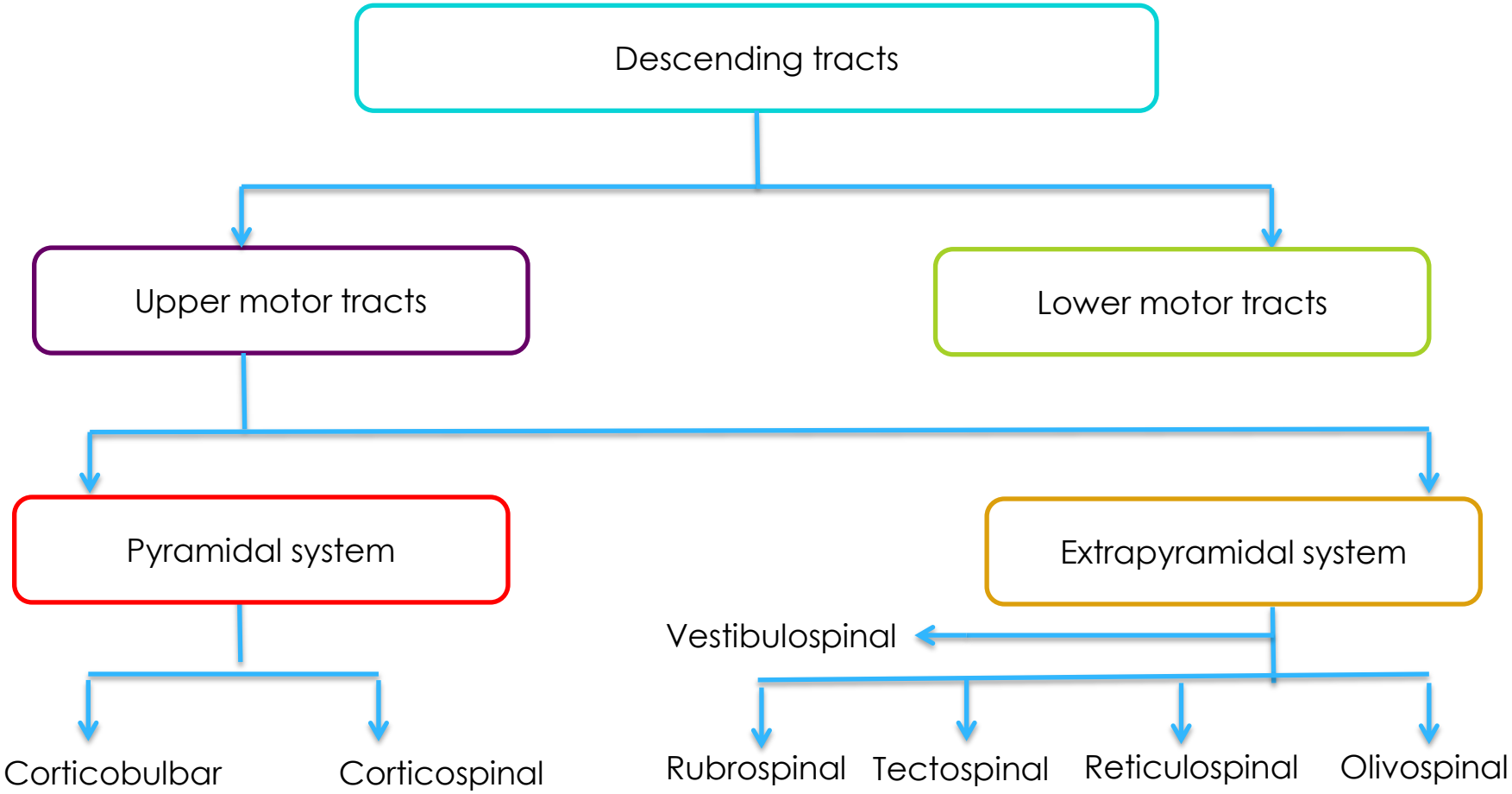
✧THE PATHWAY OF PYRAMIDAL TRACTS (CORTICOSPINAL & CORTICOBULBAR TRACTS)

✧THE LATERAL AND VENTRAL CORTICOSPINAL TRACTS.

✧FUNCTIONAL ROLE OF CORTICOSPINAL & CORTICOBULBAR TRACTS

✧STATIC AND DYNAMIC SIGNALS OF PYRAMIDAL TRACTS

✧THE EXTRAPYRAMIDAL TRACTS AS RUBROSPINAL , VESTIBULOSPINAL ,RETICULOSPINAL AND TECTSPINAL TRACTS.

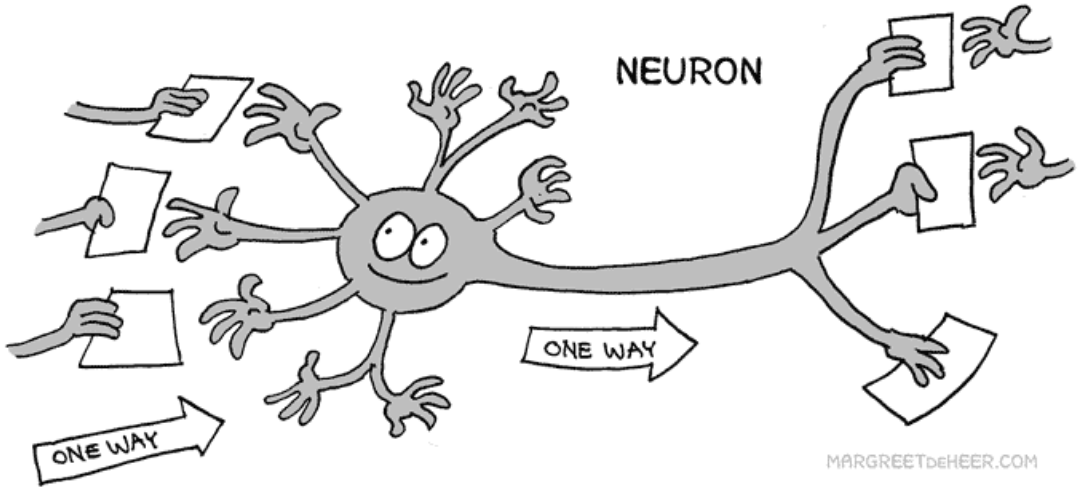

Descending tracts
Upper motor tracts
Lower motor tracts
Pyramidal system
Extrapyramidal system
Vestibulospinal
Corticobulbar
Corticospinal
Rubrospinal
Tectospinal
Reticulospinal
Olivospinal

Mind Map

Introduction

Motor neurons in our body are concerned with taking commands that are produced by our brain through fibers known as the "descending fibers". In this lecture we'll have a-wonderful journey about how this system sends commands through these fibers and how our fingers start moving when we want them to move

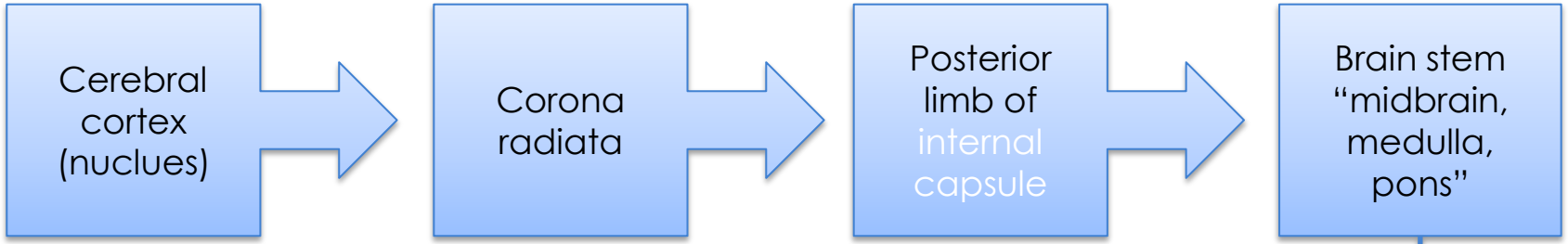
"Descending fibers are that fibers that travel downward from the brain to spinal cord.



Upper motor neuron and Lower motor neuron differences

According to	Upper motor neuron	Lower motor neuron
Cell body	Cortex of the brain	grey matter of the spinal cord and brain stem.
Synapse	Upper motor neurons form synapses with the lower motor neurons	lower motor neurons form synapses with the muscles in the body.
Classified	Upper motor neurons are classified according to the pathways they travel in. for example : Corticospinal , corticobulbar tract	Lower motor neurons are divided into two groups, the alpha and gamma motor neurons.
Carried information	Upper motor neurons carry information from brain centers that control the muscles of the body	lower motor neurons carry information passed to them from the upper motor neurons.

Upper motor tracts



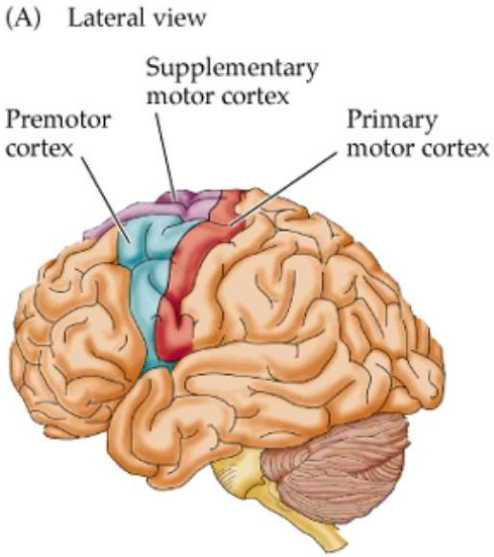
1) Corticobulbar tract
terminates on LMNs (cranial nerve motor nuclei of opposite side &carries information to them)
"decussating just before they reach their target nuclei"
FUNCTION : control face, neck muscles, facilitate their tone , and involved in facial ,mastication * ,swallowing

2) Corticospinal tracts (pyramidal)
descends through the midbrain and pons.

Then in the lower medulla oblongata the fibers form pyramids so tracts originate from them are called pyramidal tract

* Chewing

Corticospinal Tract



Origin:

- 30% Primary motor cortex
- 30% Pre-motor area & supplementary motor area
- 40% parietal cortex " somatosensory cortex"

Premotor area (motor association area):

→ Its stimulation produces complex coordinated movements, such as setting the body in certain posture to preform a specific task.

Supplementary cortex:

→This area projects mainly m1 and is concerned with planning, programming motor sequences & *Bimanual activity .

* Any activity with the use of the two hands

More Characteristics about Corticospinal Tract

- 3% of the corticospinal tract are large myelinated derived from the large ,giant, highly excitable pyramidal Betz cells in motor area 4.

- The Betz cells fibers transmit nerve impulses to the spinal cord at a velocity of about 70 m/sec. However, the other 97 % are mainly smaller fibers conduct tonic signals to the motor areas of the cord.

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

* SEE Slide 12 to understand it clearly

Corticospinal tract

LATERAL CORTICOSPINAL TRACTS
These are 80% of fibers that cross midline in pyramids.

Function: Controls fine discrete skilled movements of fingers and toes

NB/So both corticospinal tract(ANT& LAT) supply skeletal muscles of the opposite side
"Because the decussation"

VENTRAL (ANTERIOR) CORTICOSPINAL

Remaining 20% fibers does not cross midline, they cross at level of termination to synapse with interneurons , that synapse with motor neurons (AHCs) of opposite side specially in in the neck or in the upper thoracic region.

FUNCTION: control axial & proximal limb muscles.
may be concerned with control of bilateral postural movements

Corticospinal termination

DIFFERENT LEVELS IN INTERNEURONS OF THE GREY MATTER

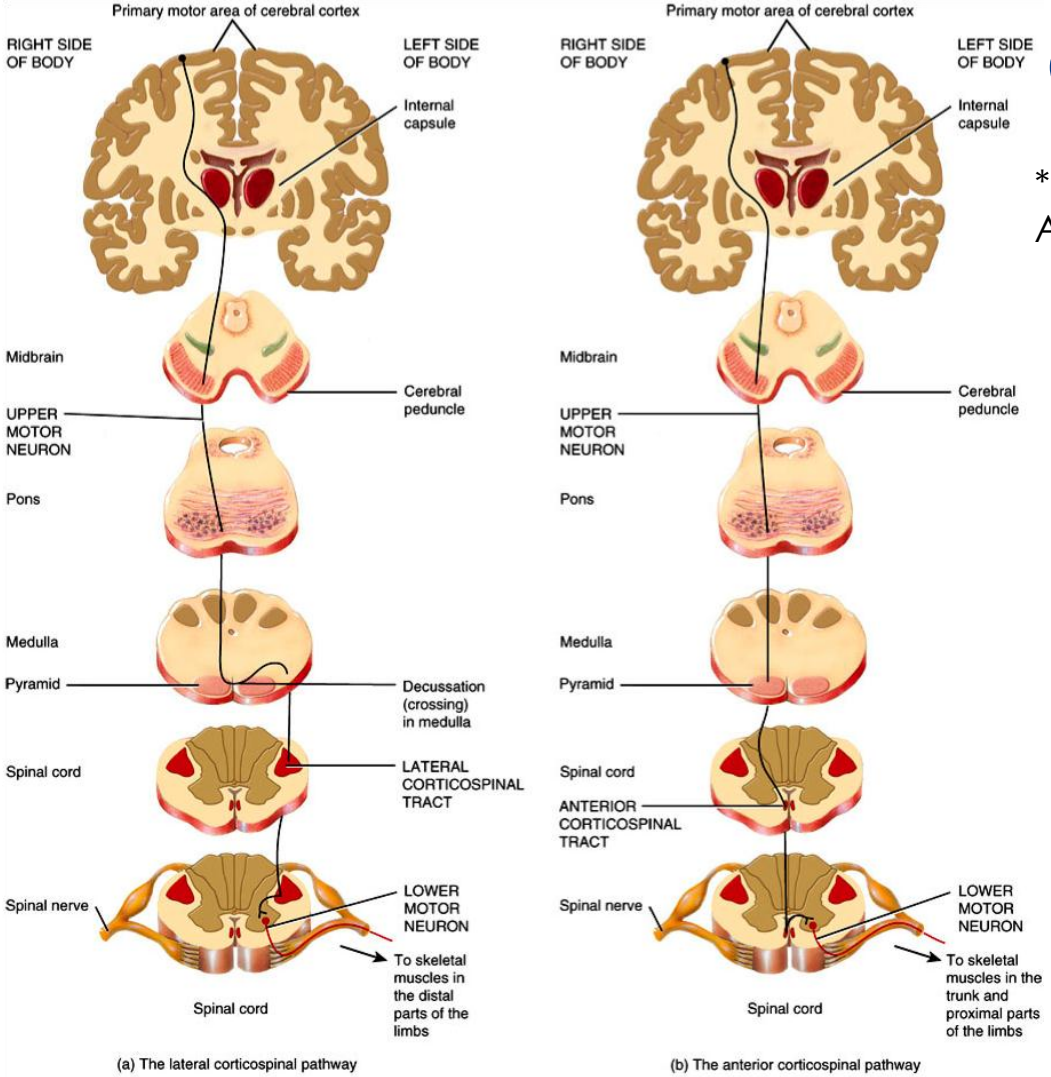
AT SENSORY NEURONS OF DORSAL HORN

TERMINATE DIRECTLY ON THE ANTERIOR MOTOR NEURONS THAT CAUSE MUSCLE CONTRACTION.

In the Anterior horn the lower motor neurons (LMN) of the corticospinal tract are located. Then peripheral motor nerves carry the motor impulses from the anterior horn "site of motor tracts" to the voluntary muscle (Axial & proximal end).

Corticospinal Tract

** You have to read the past 2 slides. And try to compare to this diagram.



Functions of corticospinal tracts

1) Initiation of fine, discrete, skilled voluntary movements

2)

- Lateral corticospinal tract → control Distal limbs eg.fingers for skill movement
- Anterior corticospinal tract: → control posture and axial & proximal muscle for walking ..etc

3) effect on stretch reflex: facilitate muscle tone through gamma motor neuron

4) those fibers originate from parietal lobe are for sensory- motor coordination

- In the cervical enlargement large numbers of corticospinal and rubrospinal fibers terminate directly on the AHCs to activate direct hands and fingers muscle contraction.
- The primary motor cortex has an extremely high degree of representation for fine control of hand, finger, and thumb actions.

Excitation of the Spinal Cord Motor Areas by the Primary Motor Cortex and Red Nucleus

The motor cortex is arranged into thousands vertical columns, each column has six distinct layers of cells.

- Layer 5 (from cortical surface) give origin for the pyramidal cells that give rise to the corticospinal fibers.
- the input signals enter cortex by way of layers 2 and 4.
- Layer 6 gives rise to fibers that communicate with other regions of the cerebral cortex .

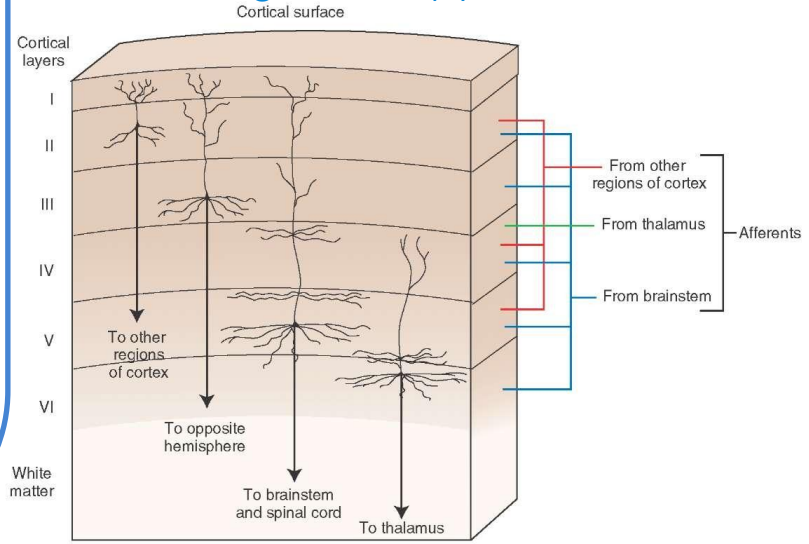
Function of Each Column of Neurons:

Each column of cells functions as an integrative processing - unit& as an amplifying system to stimulate large numbers of pyramidal fibers to the same muscle or to synergistic muscles simultaneously.

Use information from multiple input sources to determine the - output response

Here we have in the picture
one vertical column with 6 layers , The lowest part of the picture represent the white matter of the brain, and the upper part is the gray matter.

… REMEMBER :
5 → origin of the pyramidal cells



Dynamic and Static Signals Are Transmitted by the Pyramidal Neurons.

If a strong signal is sent to a muscle to cause initial rapid contraction, then a much weaker continuing signal can maintain the contraction for long periods thereafter.

To do this, each column of cells excites two populations of pyramidal cell neurons:

(1) Dynamic neurons

The dynamic neurons are excited at a high rate for a short period at the beginning of a contraction, causing the initial rapid development of force

(2) Static neurons *

They fire at a much slower rate & continue firing at this slow rate to maintain the force of contraction as long as the contraction is required.

* The static neurons have greater percentage in the primary cortex area

Lesions of the Primary Motor Cortex (Area Pyramidalis).

CASE 1 :

Removal of the Primary cortex area Without damage to premotor area & supplementary area

✧Functions Lost :

loss of voluntary control of discrete movements of the distal segments of the limbs, especially of the hands and fingers.

✧Function preserved:

Gross postural and limb "fixation" movements can still occur

✧Primary Motor Cortex (Area Pyramidalis) is essential For :

Voluntary initiation of finely controlled movements, especially of the hands and fingers.

✧Results in → Hypotonia

CASE 2 :

Removal of the Primary cortex area With damage to the other part of the brain eg. Basal ganglia . (Most lesions such as that caused by stroke)

✧ Results in → muscle spasticity

The reason for muscle spasticity :

Damage to accessory nonpyramidal pathways.

↓

Activation of vestibular and reticular brain stem motor nuclei (Normally they are inhibited)

↓

excessive spastic tone in the involved muscles.

Extrapyramidal tracts

Extrapyramidal tracts are the all tracts other than corticospinal tract & are outside pyramids.

(Its pathway)

Motor area 4 , premotor are 6 , 4 suppressor

↓

Corona radiata

↓

Internal capsule

↓

Basal ganglia

↓

Brain stem

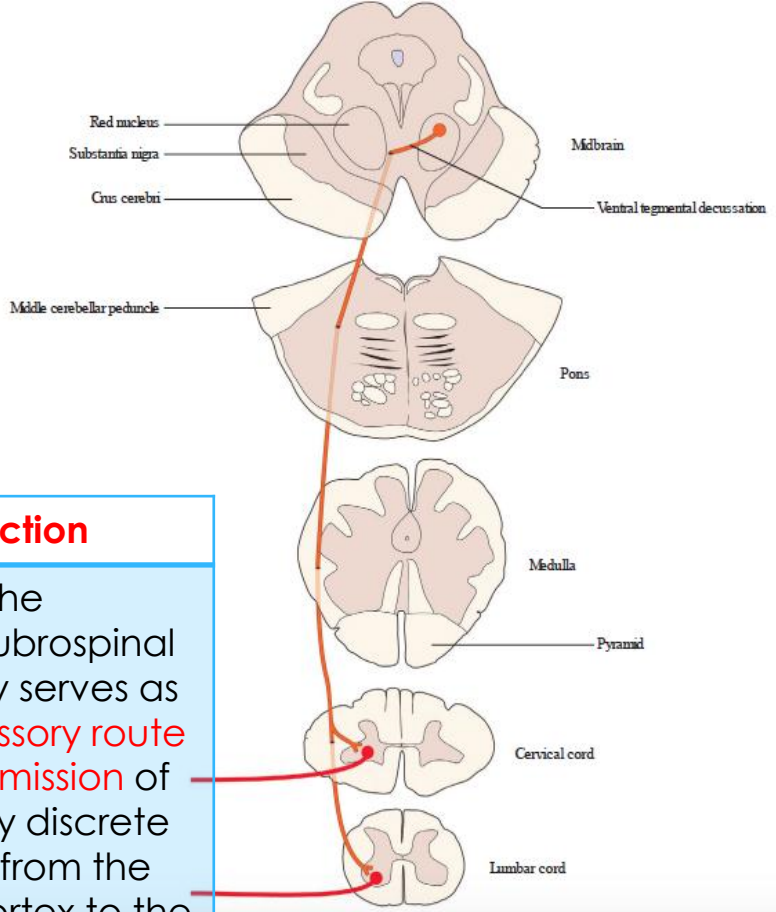
Extrapyramidal tracts type

- Rubrospinal tract
- Vestibulospinal tract
- Reticulospinal tract
- Tectospinal tract
- Olivospinal tract

Extrapyramidal system functions:
1- sets the postural background needed for performance of skilled movements
2- controls subconscious gross movements

Rubrospinal tract

Origin	pathway	Function
From Red nucleus (in midbrain tegmentum) which is connected by fibers with cerebral cortex .	Red nucleus → decussating at the level of red nucleus → pass down through pons & medulla → ends in anterior horn of spinal cord. The fibers pass laterally in the spinal cord .	The corticorubrospinal pathway serves as An accessory route for transmission of relatively discrete signals from the motor cortex to the spinal cord.



Vestibulospinal tracts

Origin	pathway	Function
From vestibular nucleus (situated in the pons & medulla). - fibers originate in vestibular nuclei in pons (which receive inputs from inner ear, vestibular apparatus and cerebellum).	- Axons descend in the ipsilateral (same side) ventral white column of spinal cord.	1.Excitatory to ipsilateral spinal motor neurons that supply axial&postural muscles 2. Controls postural& righting reflexes 3.Control eye movments

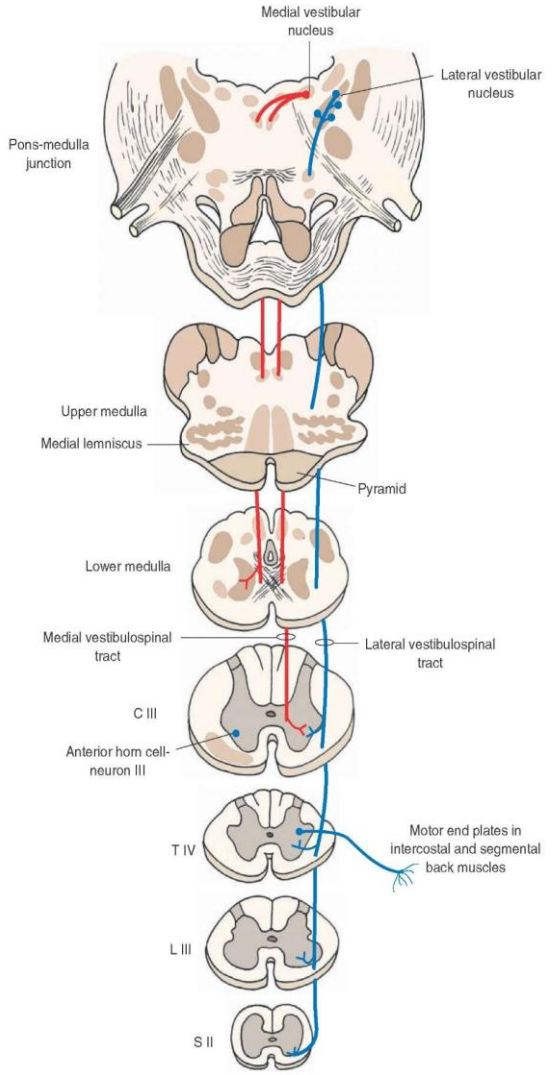
Vestibulospinal tract devide into:

(1) Lateral vestibulospinal tract

(2) Medial vestibulospinal tract

Vestibulospinal tracts

According to	Lateral vestibulospinal tract	Medial Vestibulospinal tract
Cells of origin	Lateral Vestibular Nucleus	Medial Vestibular Nucleus
Pathway	Axons descend in the ipsilateral ventral white column of spinal cord	As its axons descend ipsilaterally in the ventral white column of spinal cord , they form part of the Medial Longitudinal Fasciculus fibers in brain stem that link vestibular nuclei to nuclei supplying the extra-ocular muscles
Function	mediates excitatory influences upon extensor motor neurons to maintain posture	coordination of head and eye movements



Role of the vestibular nuclei to excite the anti-gravity muscles

All the vestibular nuclei function in association with the pontine reticular nuclei to control the antigravity muscles.

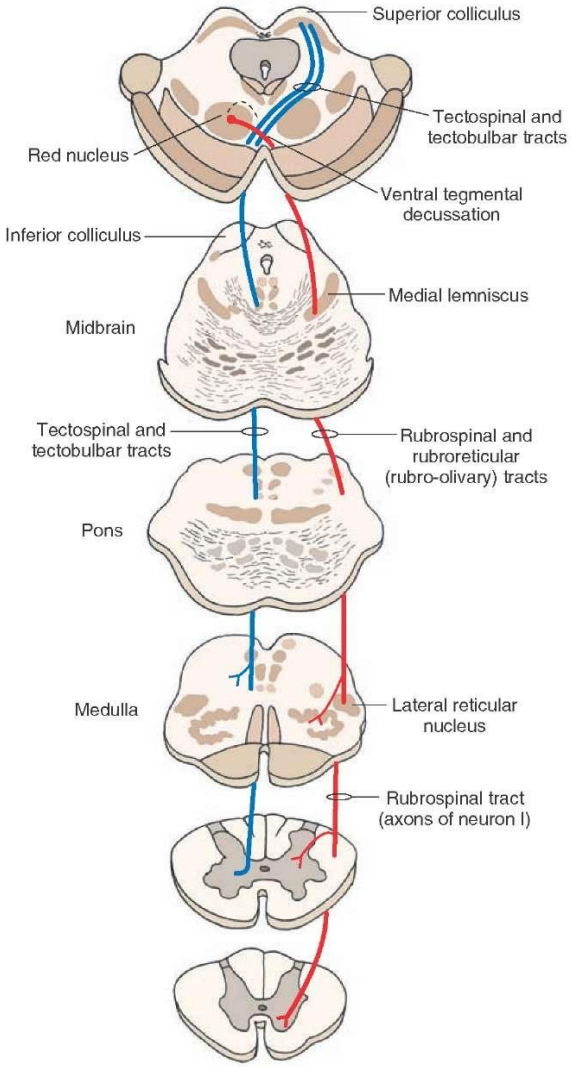
The vestibular nuclei transmit strong excitatory signals to the antigravity muscles by the lateral and medial vestibulospinal tract in the anterior coulmn of the spinal cord

Without this support the pontine reticular system would lose much of its excitation of the axial antigravity muscles.

The specific role of the vestibular nuclei, How ever. Its to selectivley control the exitatory signals to the antigravity muscles to maintain equilibrium in response to signals from the vestibular apparatus

Tectospinal tract

Origin	pathway	Function
from superior (VISUAL) & inferior colliculi (AUDITORY) of midbrain. (Tectum) →midbrain →brainstem	Superior & inferior colliculi → near medial longitudinal fasciculus → ends on Contralateral cervical motor neurons.	Mediate/facilitate turning of the head in response to visual or Auditory stimuli. (Ex. Hearing the sound from the Tv and you move your head to it)



Reticulospinal Tract

Origin	pathway	Function
Pontine and medullary nuclei. It makes up a central core of the brainstem, contains many different neuronal groups	Pontine and medullary nuclei projects to the AHCs of the spinal cord via Reticulospinal Tract.	Influence motor functions as voluntary & reflex movement. Excitatory or inhibitory to muscle tone.

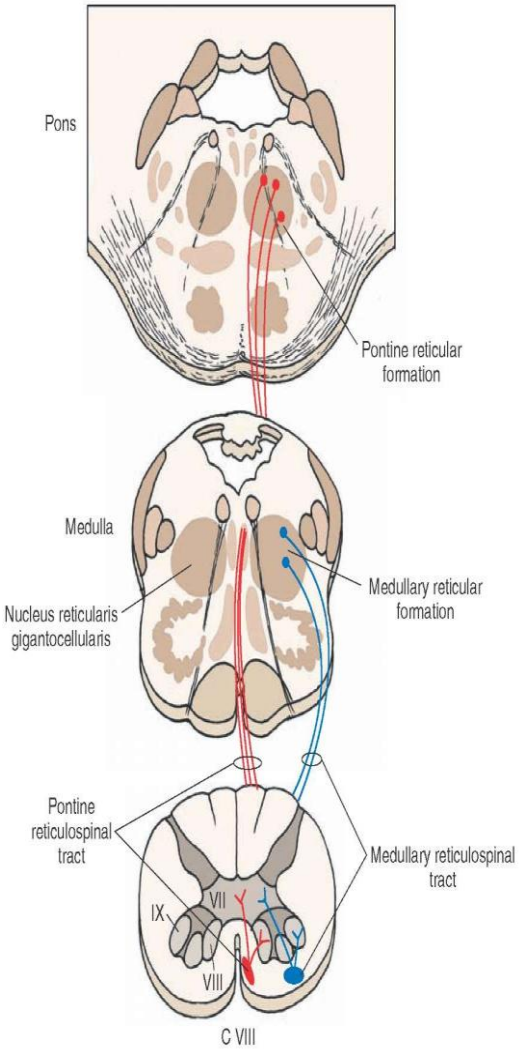
Reticulospinal tract devide into:

(1) Pontine (medial) reticulospinal tract

(2) Medullary (Lateral) Reticulospinal Tract

Reticulospinal Tract

According to	Lateral (pontine) Reticulospinal tract	Medial Reticulospinal tract
Cells of origin	Pontine Reticular Formation	Medullary Reticular Formation
Receive input from :	✧ Vestibular nuclei ✧ Deep nuclei of the cerebellum.	✧ The corticospinal tract ✧ The rubrospinal tract.
Function	- Increases Gamma efferent activity,(excitatory = increases muscle tone). - Exciting anti-gravity, extensor muscles.	Inhibits Gamma efferent activity (inhibitory= decreases muscle tone). - Inhibiting anti-gravity, extensor muscles.



Olivospinal tracts

Origin	Function	
It arises from inferior olivary Nucleus of the medulla & is found only in the cervical region of the spinal cord (supply neck muscles) .	unknown function (intermediate pathway - in the strio-olivo-spinal connections). function are unknown yet but it is said - that it make a link between basal ganglia, inferior olivary nucleus and spinal cord.	**NB. Secondary olivocerebellar fibers transmit signals to multiple areas of the cerrebellum.**

FUNCTION OF EACH TRACT: (IMPORTANT)

Corticospinal Tract → " Initiation of fine,discrete skilled voluntary movements "

Rubrospinal tract → "accessory route for transmission of relatively discrete signals from the motor cortex to the spinal cord"

Vestibulospinal tracts → "Controls Postural & righting reflexes"

Tectospinal tract → "Mediate/facilitate turning of the head in response to visual or Auditory stimuli"

Reticulospinal Tract → 1. "Influence motor functions as voluntary & reflex movement"
2. "Excitatory or inhibitory to muscle tone"

MNEMONIC

"VIP MAKED YOU STAND"
V= VESTIBULARSPINAL (VESTIBULAR NUCLEI)
P= PONTINE RETICULARSPINAL SYSTEM
STAND= CONTROL AGAINST ANTIGRAVITY MUSCLE

Summary

1- Lower motor neuron terminates in
A. Joint
B. Muscle
C. Viscera
D. Pleura

2-Origin of pyramidal cells is
A. 3rd layer
B. 1st layer
C. 5th layer
D. 6th layer

3-Corticobulbar tracts function
A. Control face and neck muscles
B. Increase muscle tone
C. Axial and trunk muscle movement
D. Pain senstation

4-Origin of rubrospinal tract
A. Red nucleus
B. Superior caleculus
C. Inferior caleculus
D. B&C

5- Olivospinal tract could be find
A. Lumbar only
B. Sacral only
C. Thoracic only
D. Cervical region

6-A patient have a lesion caused by stroke, the patient properly will have ?
A. Semiplagia
B. Hypotonia
C. Muscle spasticity
D. Muscle weakness only

7- Which of the following cells are found in the primary cortex area ?
A. Red nucleus
B. Betz cells
C. Vestibular nucleus
D. Second cranial neurons.

8- Vestibular cells give rise to neurons that activate :
A. Pontine Reticulospinal tracts
B. Medullary Reticulospinal tracts
C. Olivospinal tracts
D. Inferior caleculus neculi.

1.B
2.C
3.A
4.A
5.D
6.C
7.B
8.A

MCQs

1-What's the function of the lateral corticospinal cord?

. Controls fine discrete skilled movements of fingers and toes

2-The function of Dynamic neurons?

. causing the initial rapid development of force

3- Numerous one of the extrapyramidal system function?

. sets the postural background needed for performance of skilled movements

4- Secondary olivocerebellar fibers transmit signals to multiple areas of the?

.Cerebellum

SAQs

THANK YOU FOR CHECKING OUR WORK!

BEST OF LUCK

Done By:

- Faisal AlJebreen
- Moath Aleisa

"A man and women cannot become a competent surgeon without the full knowledge of human anatomy and physiology, and the physician without physiology and chemistry flounders along in an aimless fashion, never able to gain any accurate conception of disease, practicing a sort of popgun pharmacy, hitting now the malady and again the patient, he himself not knowing which."

Sir William Osler (1849–1919)