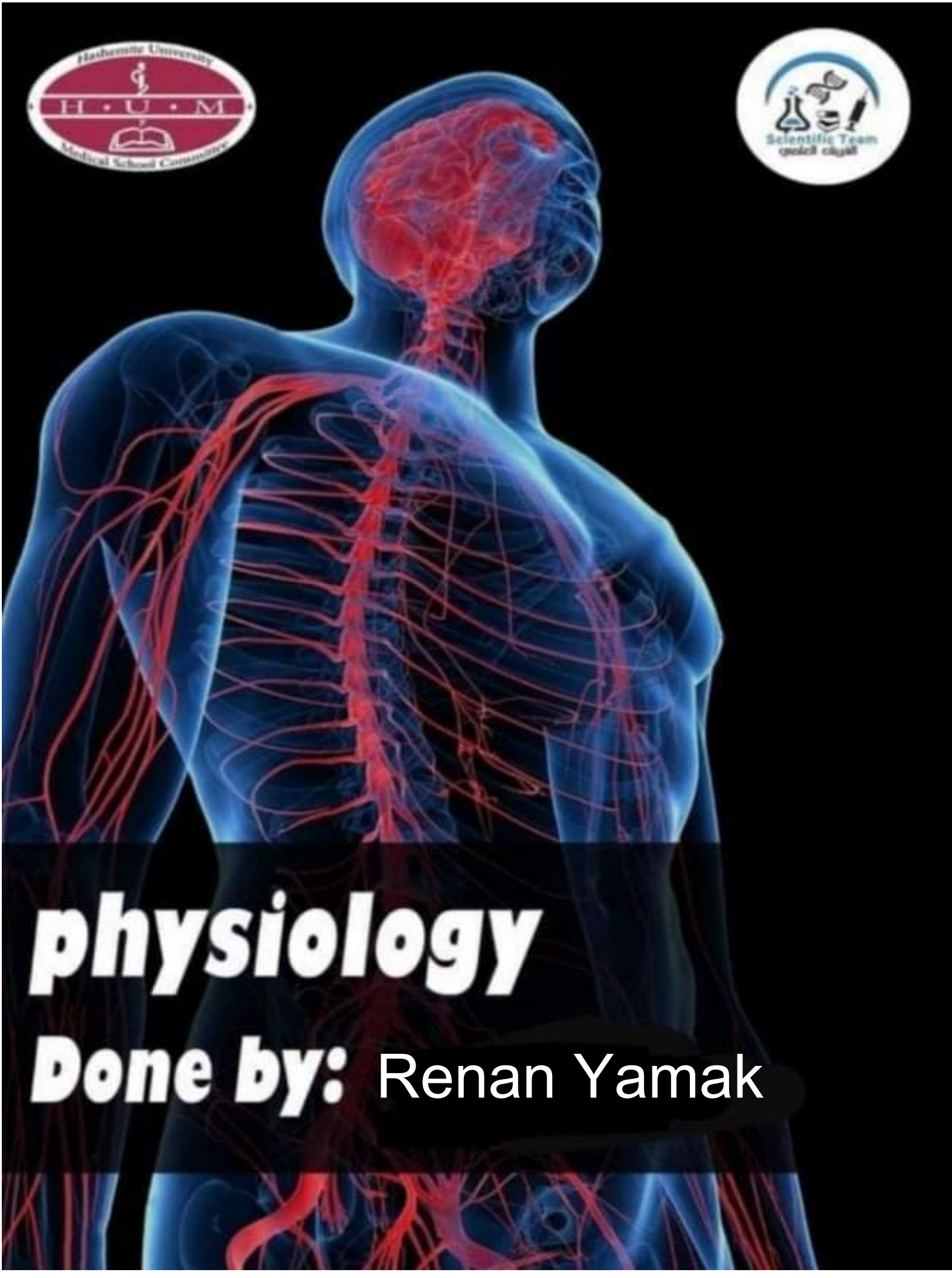

Hashemite University
H · U · M
Medical School Committee
Scientific Team
physiology
Done by: Renan Yamak

It is better to study the anatomy of the cerebellum before studying this lecture.

All what was said during the lecture is written and it is all included.

-Cerebellum always is ipsilateral

Meaning it controls the ipsilateral (same side) of the body

So, lesions of the cerebellum will affect the ipsilateral side

-Efferent and afferent fibres enter and leave the cerebellum through cerebellar peduncles

Anatomical Divisions:

the cerebellum (CB) consists of 3 lobes separated by 2

deep transverse fissures to:

(a) small anterior lobe

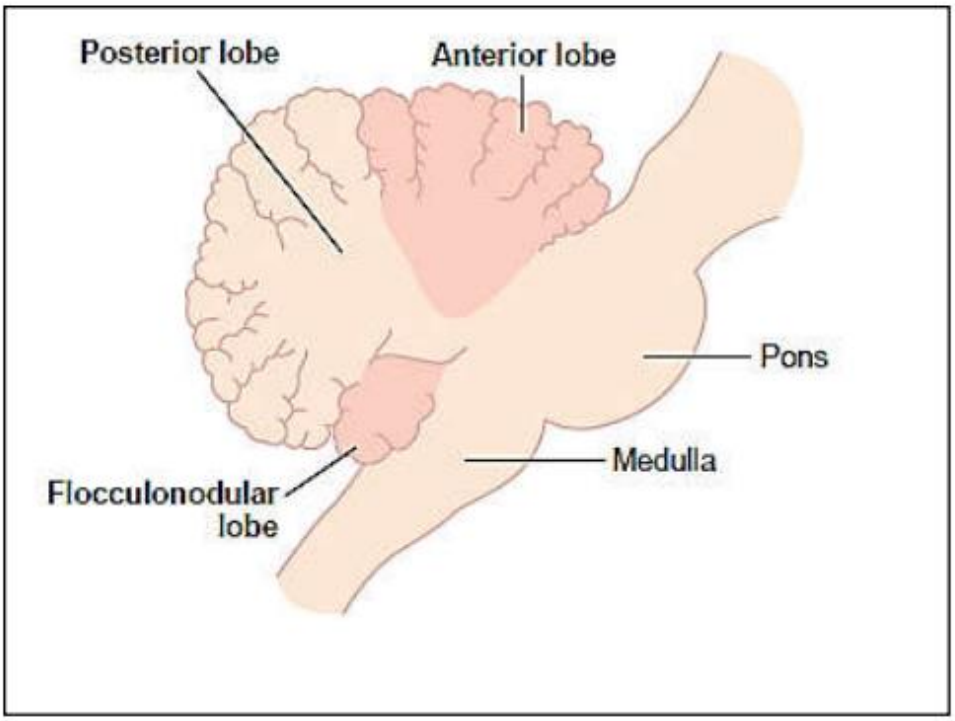
(b) large posterior lobe

(c) flocculonodular lobe (located posteroinferiorly).

3 pairs of peduncles connect the cerebellum to the brain stem (the

superior peduncle to the midbrain. the middle peduncle to the pons. and the

inferior peduncle to the medulla oblongata)



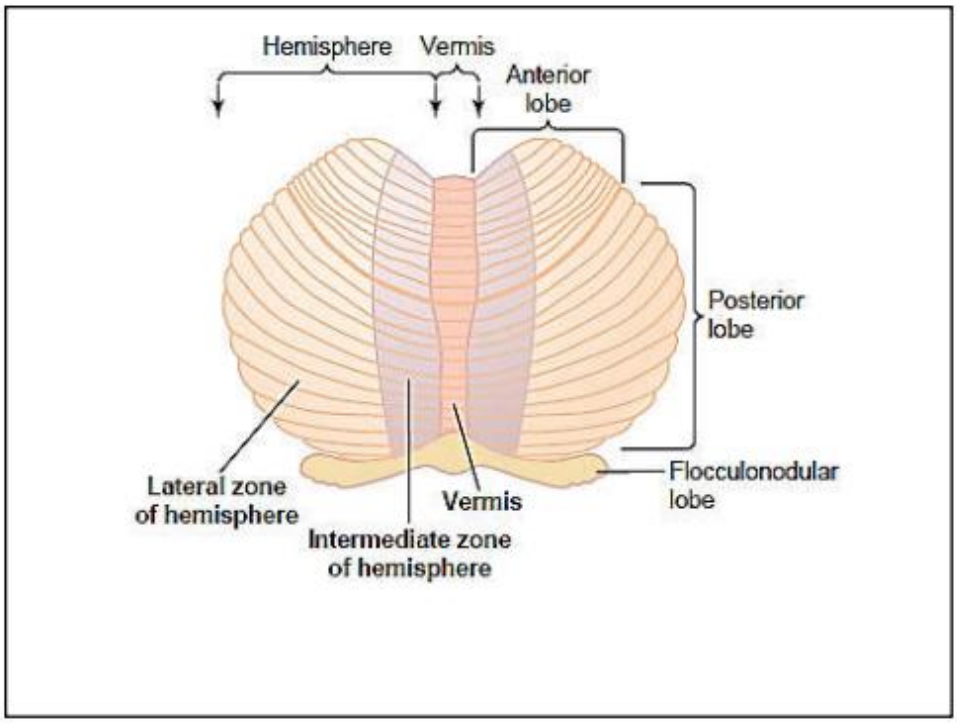
FUNCTIONAL (PHYSIOLOGICAL) DIVISIONS OF THE CB:

functionally:

1-vestibulocerebellum (= archicerebellum) : it consists mainly of the flocculonodular lobe

2-Spinoccrcbcllum (=Intermediate or paleo-cerebellum) : This consist of the intermediate zone of the 2 hemispheres and most of the vermis….(inhibitory supraspinal centre)

3-Cerebrocerebellum (= Lateral or neo-cerebellum) : part of the CB. It consists of the large lateral zones of the 2 hemispheres…..(facilitatory supraspinal centre)



Note:

(facilitatory supraspinal centre): when excited it sends facilitatory signals increasing lower motor neurons tone.

(inhibitory supraspinal centre): when excited it sends facilitatory signals making lower motor neurons tone.

the various parts of the body are topographically represented in the CB:

1-The axial parts of the body lie in the vermal part

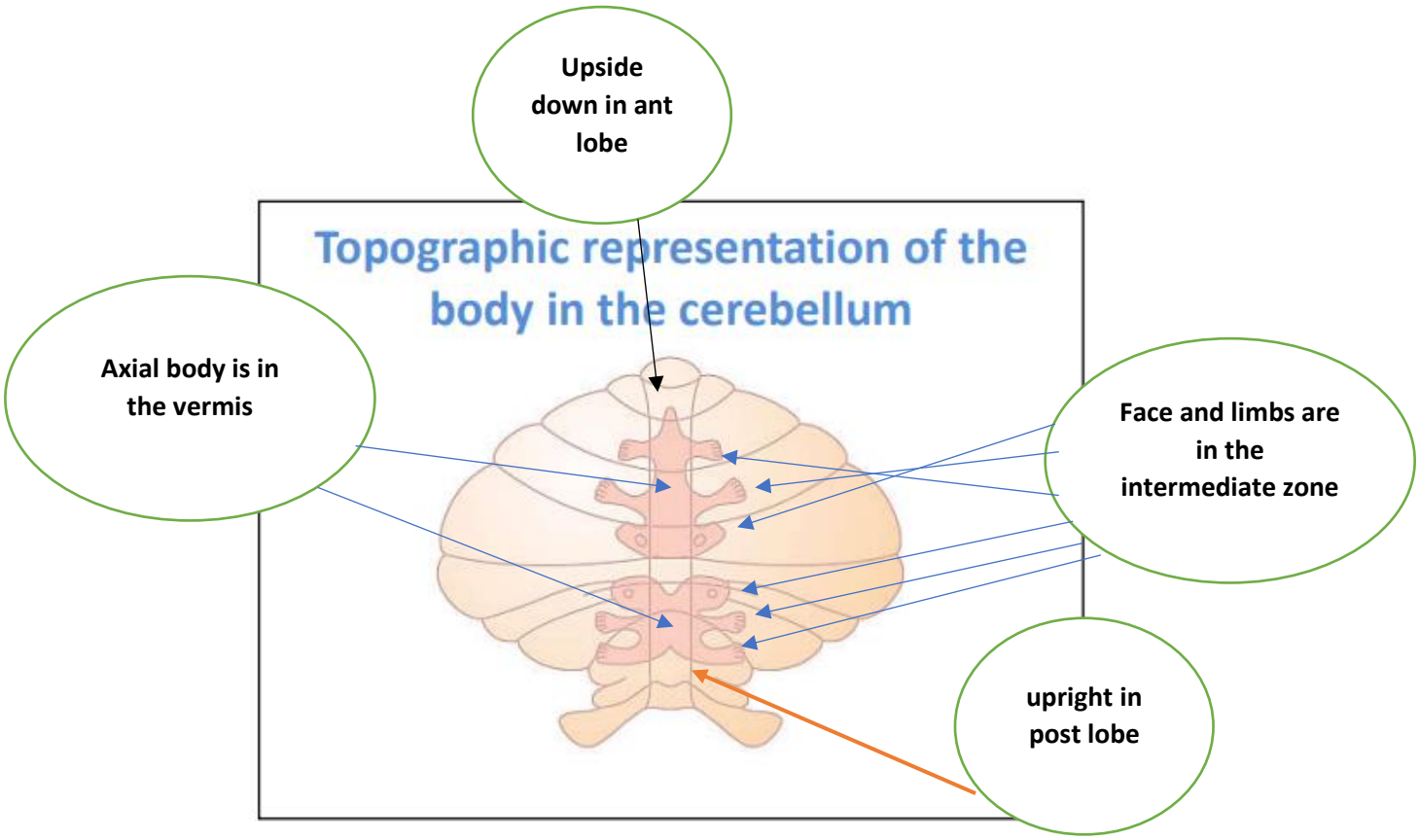
2-the limbs and facial regions lie in the intermediate zones.

3-the body is represented upright in the posterior lobe and upside down in the anterior lobe

Note:

Like cerebral cortex

Areas which are responsible for control fine movement like writing occupies the largest part of the motor cortex of the cerebellum.



The CB has an external layer of gray matter (cerebellar cortex)

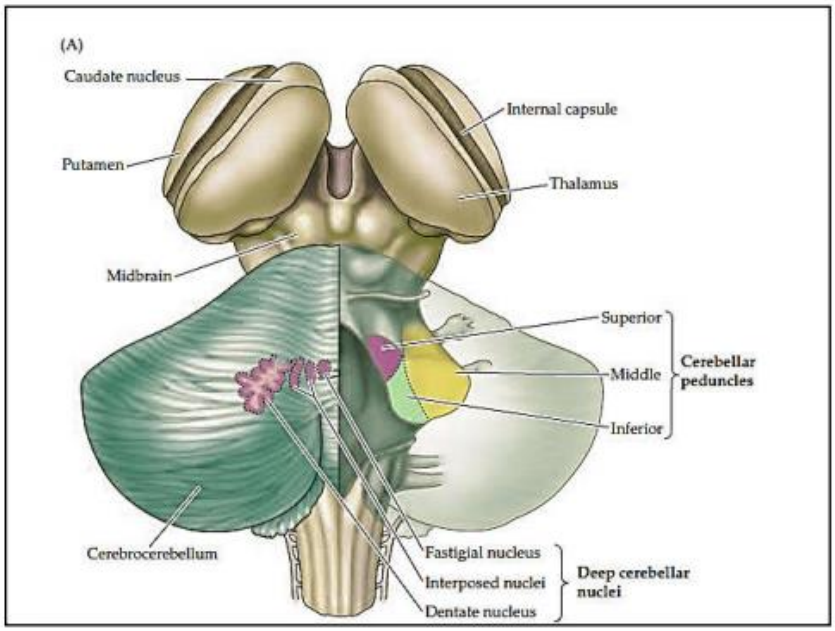
and an inner layer of white matter in which 3 deep nuclei

are embedded:

(a) Dentate nucleus laterally

(b) Fastigial nucleus medially

(c) interposes nucleus (formed of the globose and emboliform nuclei) between the other 2 nuclei.



Connections of the cerebellum:

Note:

Efferent fibres are just from superior and inferior peduncles…. middle has no efferent fibres.

Efferent fibres of the cerebellum always should rely on a nucleus ----there is no direct connection with cerebellum e.g.:

Cerebellum then red nucleus then spinal cord

So, it controls spinal cord through rubrospinal tract

There is no cerebellum spinal tract

Red nucleus connections take the name rubro.

1-Afferent connection:

1-The afferent entering through all the peduncles

2-The afferent entering through the peduncles first relies at cerebellar cortex then discharge to the deep nuclei of the cerebellum (Dentate nucleus/Fastigial nucleus/interposes nucleus)

Note:

cortex consists of 3 layers:

-A superficial molecular layer (contains stellate cells/basket cells/dendrites of the purkinje cells)

-B middle layer of purkinje cells. (contains body of purkinje cells)

C-A deep granular layer. (contains granular cells)

2-afferent fibres always are of 2 forms (climbing and mossy)

3-fibres going to the cortex will rely

1-at the Purkinje cells by 2 ways:

All fibres from different parts (cortex /brainstem/spinal cord) relies first at granular cells then granular cell discharge to Purkinje cells(indirect)-----those are called (mossy fibres)

fibres from inferior olivary nucleus relies directly at Purkinje cells-----those are called (climbing fibres).

2-at deep nuclei of the cerebellum (from both mossy and climbing fibres)

So at the end

Afferent fibres (mossy and climbing fibres) will end on

1-Purkinje cells then Purkinje cells synapse with deep nuclei----(inhibiting them)

2-at deep nuclei---(stimulating them)

The stimulation (facilitatory effect) predominates.

note:

1-remember it like this:

you need to climb the trees to pick the olives so fibres are from inferior olivary nucleus.

the fibres climb so it skips granular cells and goes directly to the Purkinje cells.

The rest are mossy fibres

So we always will end at Purkinje cells.

2-in the indirect pathway (mossy fibres)….granular cells relies at the Purkinje cells and the adjacent stellate cells and basket cells which will excite all of them

stellate cells and basket cells will cause lateral inhibition of the other Purkinje cells (activated accidently by granular cells) which sharpens the output signals from the CB.

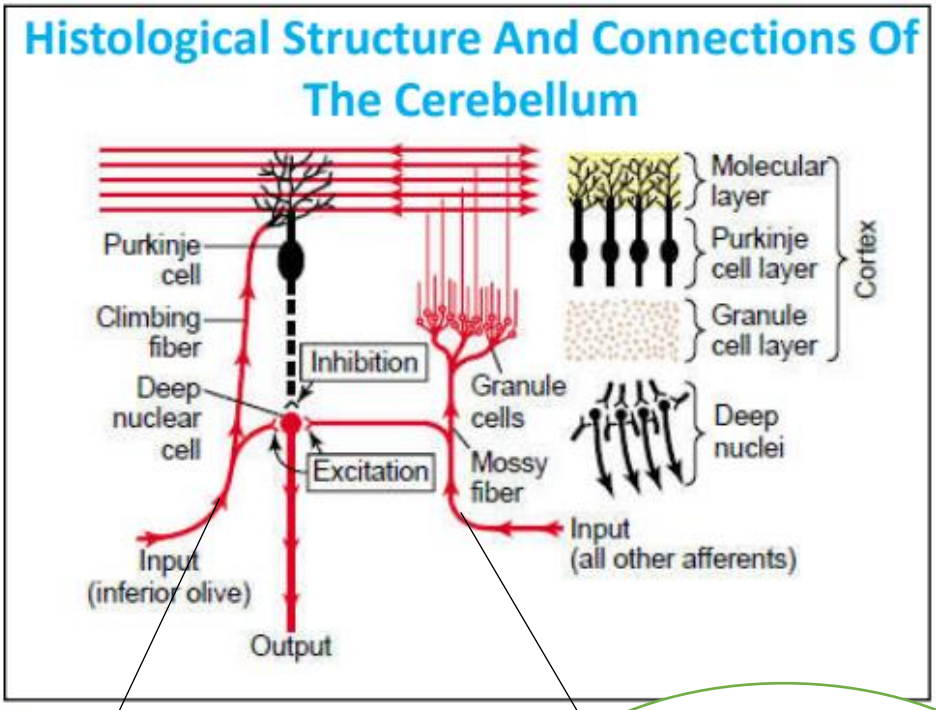
OK now the path is:

Afferent fibres (climbing and mossy) --- cerebellum (through peduncles) ---- the Purkinje cells ----- efferent impulses to the Cerebellar nuclei i.e. dentate, interposes and fastigial nuclei ---- impulses pass to various areas of the brain i.e. brain stem and thalamus. (as efferent fibres)

Now the afferent pathway are mention in the table below.

- **Afferent fibres the pass to the cerebellum are:**

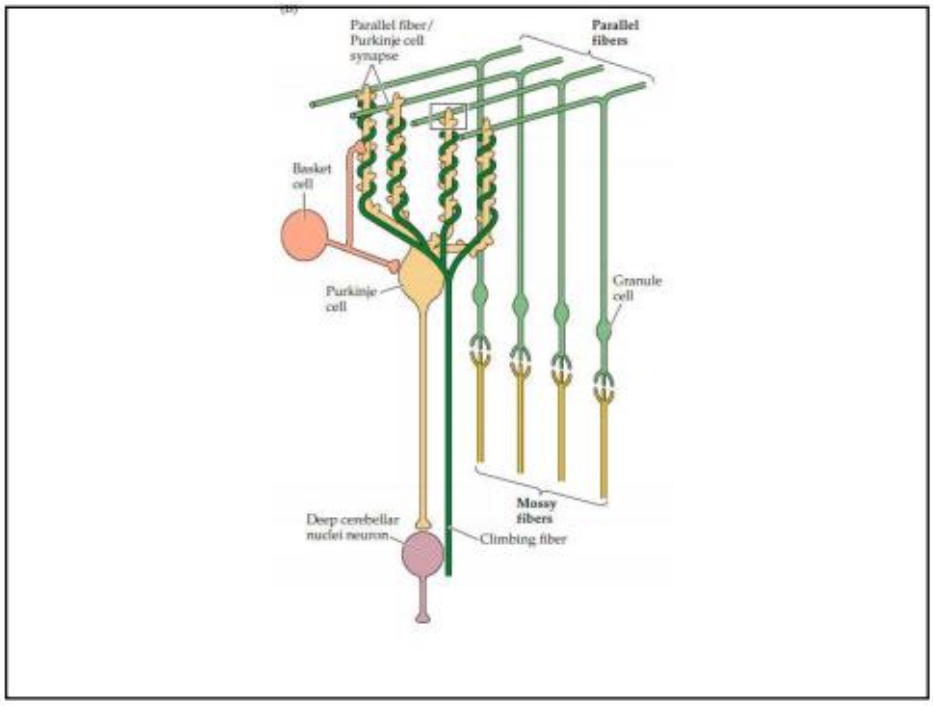
Peduncle	Afferent
1-Superior cerebellar peduncle	Ventral spino-cerebellar tract
2-Middle cerebellar peduncle	Cortico-ponto-cerebellar tract
3-Inferior cerebellar peduncle	A-Dorsal spinocerebellar tract B-Vestibulo-cerebellar tract C-Olivo-cerebellar tract



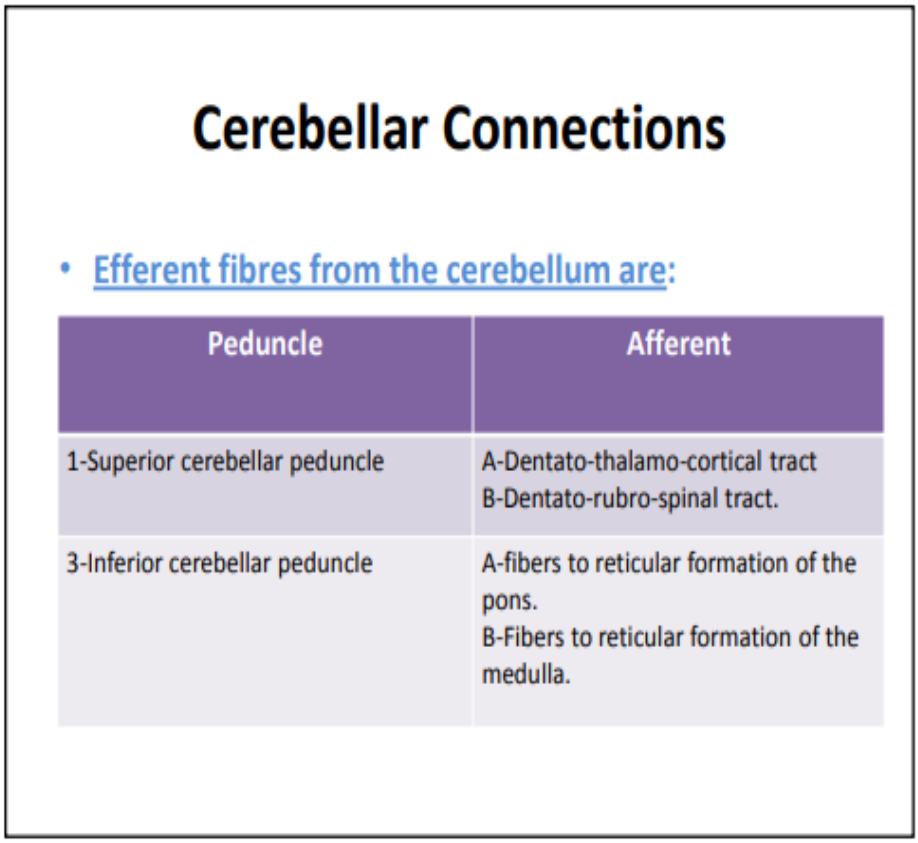
5

Climbing fibres from inferior olive excite both Purkinje cell and Deep nuclear cell and in turn Purkinje cell inhibits the Deep nuclear cell

mossy fibres from other afferents excite (by relying first on granular cell) Purkinje cell and Deep nuclear cell and in turn Purkinje cell inhibits the Deep nuclear cell


Parallel fiber / Purkinje cell synapse
Parallel fibers
Basket cell
Purkinje cell
Granule cell
Mossy fibers
Deep cerebellar nuclei neuron
Climbing fiber

2-Efferent connections:



Cerebellar Connections

- Efferent fibres from the cerebellum are:

Peduncle	Afferent
1-Superior cerebellar peduncle	A-Dentato-thalamo-cortical tract B-Dentato-rubro-spinal tract.
3-Inferior cerebellar peduncle	A-fibers to reticular formation of the pons. B-Fibers to reticular formation of the medulla.

In inferior cerebellar peduncle the doctor also mentioned that there will be also fibres to the vestibular nucleus.

There is no efferent fibres through middle cerebellar peduncle

And note that cerebellar will connect always with the the same side of the body eg:

Left cerebellar with left limbs…etc

-Cortico-pontine-cerebellar tract (afferent fibres)---mossy fibres path

-Dentato-thalamo-cortical tract (efferent fibres)

Through this pathway the cerebellum communicate with the contralateral cerebral motor cortex to control the ipsilateral side of the body.

Dentate nucleus fibres will leave the cerebellum through superior peduncle, then it will cross to the contralateral side of the midbrain then it will rely on the contralateral (with respective to the cerebellum) ventro lateral nuecleus of the thalamus then from there be thalamo cortical fibres will rely on the contralateral motor cortex(respective to cerebellum)

For example:

Left cerebellum---left superior peduncle---crossing(switch to the right-contralateral side-)---right ventrolateral nucleus----right motor cerebral cortex

This crossing makes the cerebellum communicate with the contralateral cerebral motor cortex

Now:

If the cerebellum (as will be explained later on) wants to adjust the movement(prevent excessive action) it will sends it signal through cotical pyramidal tracts and we we now that pyramidal tracts eg(lateral cortical spinal tract) will cross to opposite site to become contralateral with respect to the cerebral motor cortex.

Right cortex---right lateral corticospinal tract---crossing at medullary pyramids—so in spinal cord becomes left lateral corticospinal tract—so it will now control the left side of the body.

Left cerebellum---left superior peduncle---crossing (switch to the right-contralateral side-)---right ventrolateral nucleus----right motor cerebral cortex

right motor cerebral cortex---right lateral corticospinal tract---crossing at medullary pyramids—so in spinal cord becomes left lateral corticospinal tract—so it will now control the left side of the body.

The cerebellum begin in left side and it ends at the left side of the body

So we it is ipsilateral with the body but contralateral with the cerebral cortex.

As we know efferent fibres are from deep cerebellar nuclei so the connection mainly:

1-vestibulocerebellum----fastigial nucleus ----mainly control equilibrium

2-spinocerebellum (paleocerebellum)---- interposes nucleus

3-corticocerebellum (neocerebellum)----Dentate nucleus

Functions of the cerebellum:

A-Functions of the cerebellum in voluntary movements:

1-Servo-comparator function: The cerebellum adjust the performance to match the intention.

When a movement is performed, the spinocerebellum

receives 2 information:

a-Signals from the motor cortex that inform about the intended

plan of movement

b- feedback signals from the periphery about the signals from the cerebral motor cortex and about the performance of the movement

c- the spinocerebellum compare the above informations and if there is an error it will send corrective signals to adjust the performance to match the intention.

2-The braking effect. Damping function : Almost all movements are pendular (due to momentum) so they have a tendency to overshoot. however. the spinocerebellum prevents this by subconscious signals that stop the movement at the intended point. Such damping effect is produced by contraction of the antagonistic muscles through the spinocerebellar stretch.

Explanations:

Suppose that I want to wipe the sweat off my forehead by my hand in order to do that I will flex my arm so my biceps will flex

My arm will continue flexing but mostly will not stop at the intended specific point (my forehead) it could mistakenly end behind my head

This is called overshoot

So, cerebellum at the ideal time contract the antagonising muscles (in this case triceps) preventing the overshoot and making my hand reaching the intended point (my forehead)

It acts like the brakes of the car…so called the braking effect and this is always done automatically in case of simple movement like this without multiple tries so----at subconscious level

3-Planning, prediction and timing function.

Planning: The cerebellum is informed about the desired movement before it starts and the basal ganglia receive a similar information and both provide the plan of execution of the movement.

Prediction: joining the sequential movements and preventing decomposition so that the movement is coordinated.

When you want to open the door

You flex your arm then you immediately pronate your forearm (if it was in the pronated aspect) and then immediately your hand catches the door handle

These are multiple movement happen directly or immediately following each other

No decompaction ; it is smooth and coordinated movements.

Timing: determining when the next movement should begin.

When you are writing in printer or keyboard you press multiple keys in same time and in different times…this coordination is done by the cerebellum…also in playing piano

Note:

There is something called Coordination of ballistic movements

Ballistic movements are

those which occur very rapidly (e.g. the fingers during typing. and the eyes

during reading)

this is done by the tun on turn off signals of the mossy fibres

okay it is someway difficult to explain but I will do my best

mossy fibres synapse on

1-Deep cerebellar niece (DCN)…(one synapse)

2-granular cell (1st synapse) then granular cell synapse on purkinge cells (2nd synapse) then purkinge cell synapse on DCN (3RD synapse)

so mossy-DCN pathway is faster that mossy-purkinge-DCN because in the latter pathway there is more synaptic delay (1 synapse vs 3 synapses)

so when a movement (e.g. lateral movement of the eye to the left) is decided this will happen:

cortex send the intended movement to the cerebellum through mossy fibres

mossy-DCN pathway will work faster than mossy-purkinge-DCN

eye will move to the left by the contraction of the muscles

then to prevent overshooting mossy-purkinge-DCN now will act causing inhibition of the muscle so the eye stop in the left

note that we didn't use the antagonistic muscle pathway because this is used in pre planed movement which is slow as in the open the door example

but rapid movement like the eyes will be done by this way (tun on turn off signals of the mossy fibres)

cortex--- mossy fibres--- mossy-DCN pathway---activation---contraction--- lateral movement of the eye to the left—the eye is moving---- mossy-purkinge-DCN pathway---- inhibition---the eye stop—no overshooting

B-Other functions:

1-Function in equilibrium-----(vestibulocerebellum):postural reflexes

2-Function in muscle tone:

-Spinoccrcbcllum---inhibitory---it decrease the muscle tone

-Cerebrocerebellum ---facilitatory----it increases the muscle tone

The facilitatory effect predominates

The neocerebellar syndrome:

-The neocerebellar syndrome: Due to damage of the deep cerebellar nuclei as well as the cerebellar cortex.

- Manifestations occur on the same side of the lesion…(cerebellum is ipsilateral)

A-Ataxia: motor Ataxia it includes the following:

- Disturbance of Posture and Gait : loss of vestibulocerebellum function

a- head is tilted to the side of the lesion.

b- unsteady drunken gait (zigzag line) .

C- patient tends to fall towards the side of the lesion .

- Dysarthria : Slurred or Scanning Speech = Staccato speech

The speech is decomposed

- Rebound phenomena : Inability to stop the movement at the proper time = inability to put on the brake .

- Adiadochokinesia Inability to do rapid successive movements e.g. repeated supination and pronation

- Decomposition of movements : Inability to do a complex movement that involves simultaneous motion at more than one joint Test : Heel – knee test

-Intention tremors: Mechanism: Dysmetria initiates gross correction action ◊ correction overshoot to the other side ◊ So fingers oscillates back and forth Appears only during movement Absent : Rest and sleep

- Dysmetria :

----------> hypermetria

X

----------> hypometria

-Nystagmus : This is tremor of the eye ball, which occurs when the patient attempts to fix his gaze on an object to the side of his head (Horizontal nystagmus). It is due to absence of damping function.

We loss the effect of braking in dysmetria

If the intended point is the X

We will note reach it from the first time

So either we will bypass it (hypermetria)

Or get before to (hypometria)

In nystagmus we will loss the inhibitory effect on the muscle so muscle will not relax or it keeps contracted making the eye moving constantly

In Intention tremors you will try to reach your goal the x but you overshoot every time

And it is happens always during the perfomnace of the movement

Note:

in parkinsonism it happen during the rest

B-Hypotonia: Marked hypotonia on the side of the lesion due to loss of the facilitatory effect of the cerebellum on the stretch effect.

We said the cerebellum exerts mainly facilitatory effect

So its loss will lead to decrease in tone----hypotonia

The Doctor put videos about cerebellar lesions on the Facebook

Good Luck