# Physiology

## Modified (4)

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# Neurophysiology

# Cerebellum and brain stem

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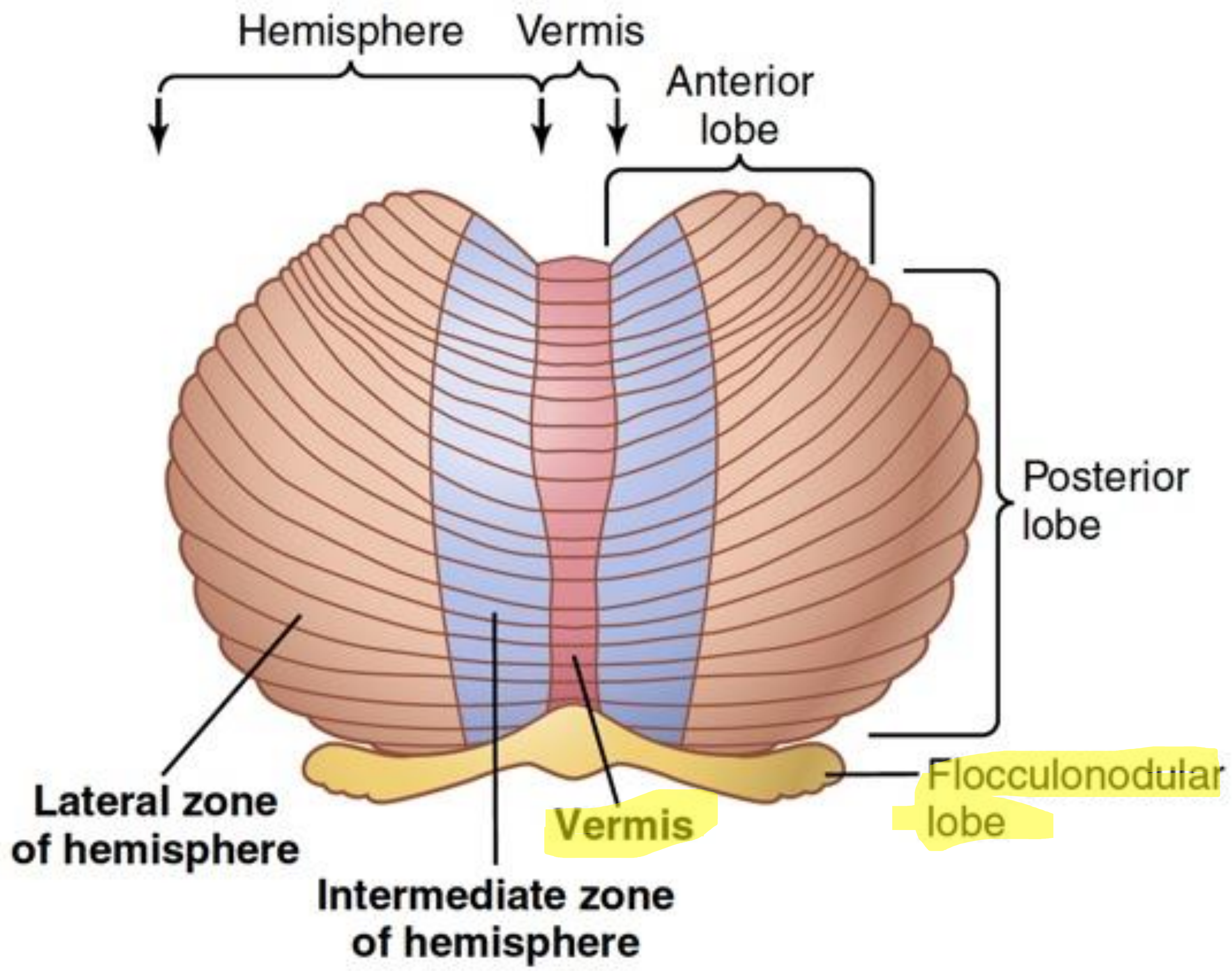
# Functional subdivisions of the cerebellum


Hemisphere
Vermis
Anterior
lobe
Posterior
lobe
Flocculonodular
lobe
Lateral zone
of hemisphere
Intermediate zone
of hemisphere
Vermis

# Vestibulocerebellum

Related to controlling & coordinating the equilibrium & postural movement

- This level consists principally of the flocculonodular cerebellar lobes and adjacent portions of the vermis.

- It provides neural circuits for most of the body’s equilibrium and postural movements.

# Vestibulocerebellum

- loss of the flocculonodular lobes and adjacent portions of the vermis of the cerebellum causes extreme disturbance of equilibrium and postural movements.

- In people with vestibulocerebellar dysfunction, equilibrium is far more disturbed during performance of rapid motions than during inactivity, especially when these movements involve changes in direction of movement.

# Vestibulocerebellum

- It is important in controlling balance between agonist and antagonist muscle contractions of the spine, hips, and shoulders during rapid changes in body positions.

It's important to coordinate the contraction in the agonist & antagonist muscles specifically those in the spine, hip and shoulders when we are talking about equilibrium & postural balance

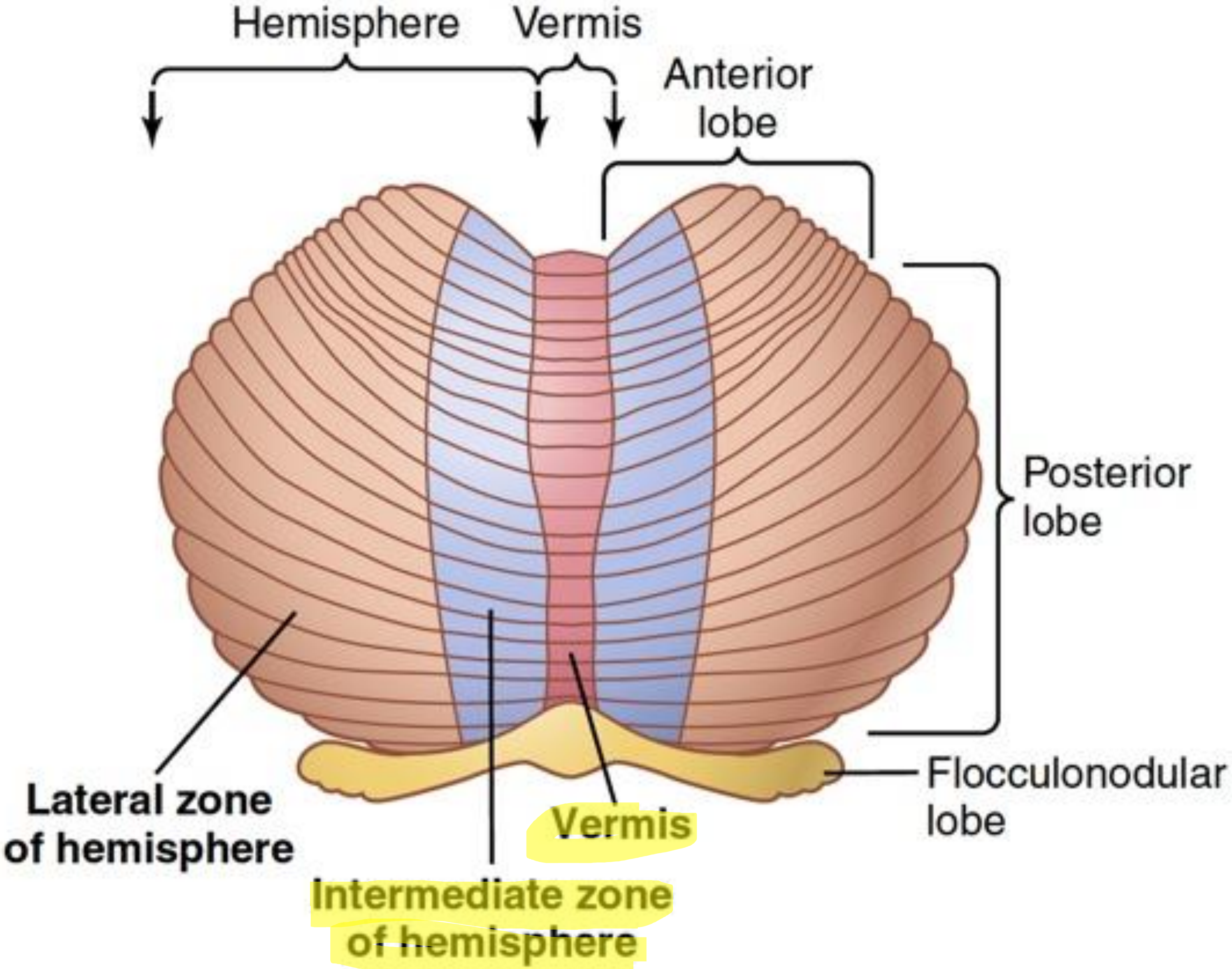
# Vestibulocerebellum

- during control of equilibrium, it is presumed that information from both the body periphery and the vestibular apparatus is used in a typical feedback control circuit to provide anticipatory correction of postural motor signals necessary for maintaining equilibrium even during extremely rapid motion.

# Spinocerebellum

- This level consists of most of the vermis and the intermediate zones.

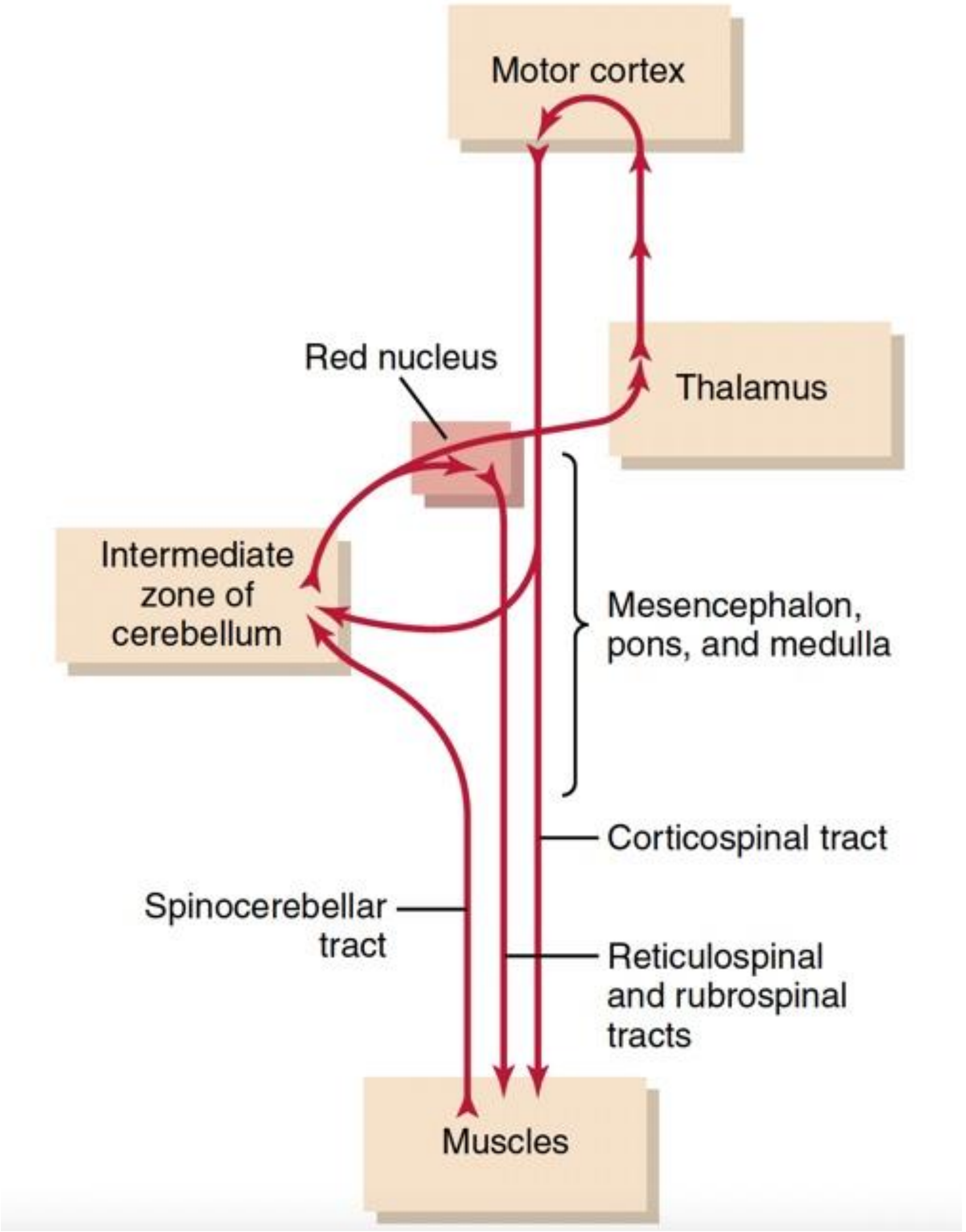
- It mainly helps coordinate the reciprocal contractions of agonist and antagonist muscles in the peripheral portions of the limbs, especially in the hands, fingers, and thumbs.



Hemisphere
Vermis
Anterior lobe
Posterior lobe
Flocculonodular lobe
Lateral zone of hemisphere
Intermediate zone of hemisphere
Vermis

The way of spinocerebellar works is by getting information from the motor cortex about the intention of the plan of movement and it will get also actual information from the periphery of the body and then the intermediate zone of cerebellum will compare these information then decide if there is any corrective feedback, if there is any discrepancy then the corrective feedback will come through interposed deep nuclei (intermediate zone) or fastigial nuclei (vermis), these output information will come through the red nucleus (magnocellular part) then through the rubrospinal tract to join the corticospinal tract to periphery and another signal will go to the thalamus through ventromedial & ventrolateral nuclei to the cerebral cortex to do the appropriate correction

- it’s important to plan for the movement and insure smooth and dampening of these types of movement in the distal limbs to prevent overshooting & to maintain these movement on the intended points specifically



# Spinocerebellum

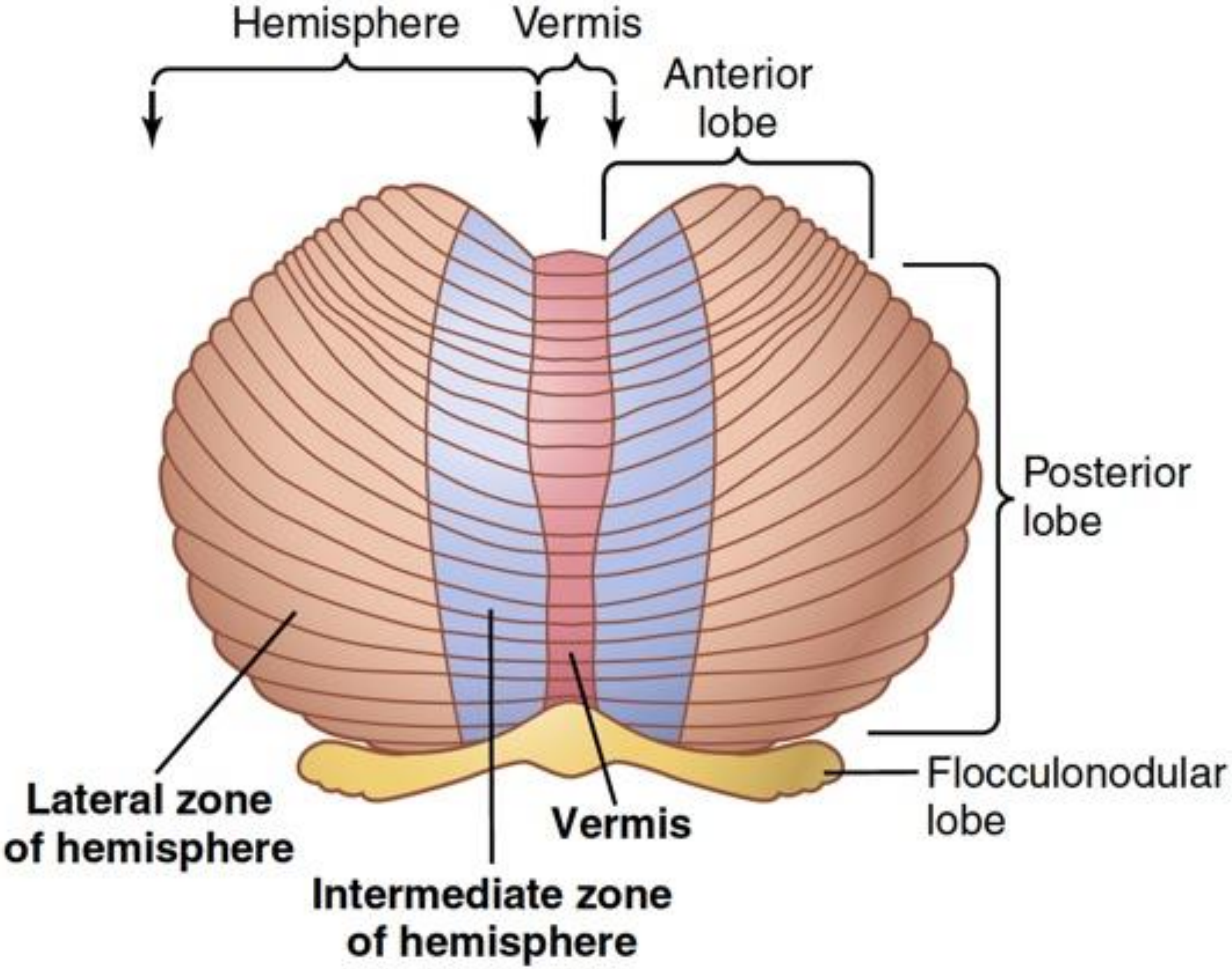
- After the intermediate zone of the cerebellum has compared the intended movements with the actual movements, the deep nuclear cells of the interposed nucleus send corrective output signals
- (1) back to the cerebral motor cortex through the thalamus.
- (2) to the magnocellular portion of the red nucleus that gives rise to the rubrospinal tract.

# Ballistic movements

- Ballistic movements are controlled by having the entire movement preplanned and set into motion to go a specific distance and then to stop.

- The major changes occur in these ballistic movements when the cerebellum is removed are the movements are slow to develop and to stop.

Very quick types of movement like typing, and what the cerebellum does in this case it kind of learning then will prepare a “preplan” for this sequence of movements specifically when does this movement start and end
-any lesion in the intermediate zone of cerebellum will result in really slowing the initiation of movements & at the end associated with weakness



Hemisphere
Vermis
Anterior lobe
Posterior lobe
Flocculonodular lobe
Lateral zone of hemisphere
Vermis
Intermediate zone of hemisphere

# Cerebrocerebellum

- This level consists of the lateral zones of the cerebellar hemispheres.
- It receives all its input from the cerebral cortex, no direct input from the peripheral parts of the body.

From cerebral cortex to the cerebellum mainly the dentate nucleus then via the thalamus go back to the cortex

- It transmits its output information back to the brain, functioning in a feedback manner to plan sequential voluntary body and limb movements.

# Cerebrocerebellum

- destruction of the lateral zones of the cerebellar hemispheres, along with their deep nuclei, the dentate nuclei, can lead to extreme incoordination of complex purposeful movements of the hands, fingers, and feet and of the speech apparatus.
- these portions of the cerebellum are concerned with two other important but indirect aspects of motor control:
- (1) planning of sequential movements.
- (2) “timing” of the sequential movements.

# Planning

Not only planning as we are moving ,but also in anticipation of the next movement before starting

- the lateral cerebellar zones appear to be involved not with what movement is happening at a given moment but with what will be happening during the next sequential movement a fraction of a second or perhaps even seconds later.
- one of the most important features of normal motor function is one's ability to progress smoothly from one movement to the next in orderly succession.
- In the absence of the large lateral zones of the cerebellar hemispheres, this capability is seriously disturbed for rapid movements.

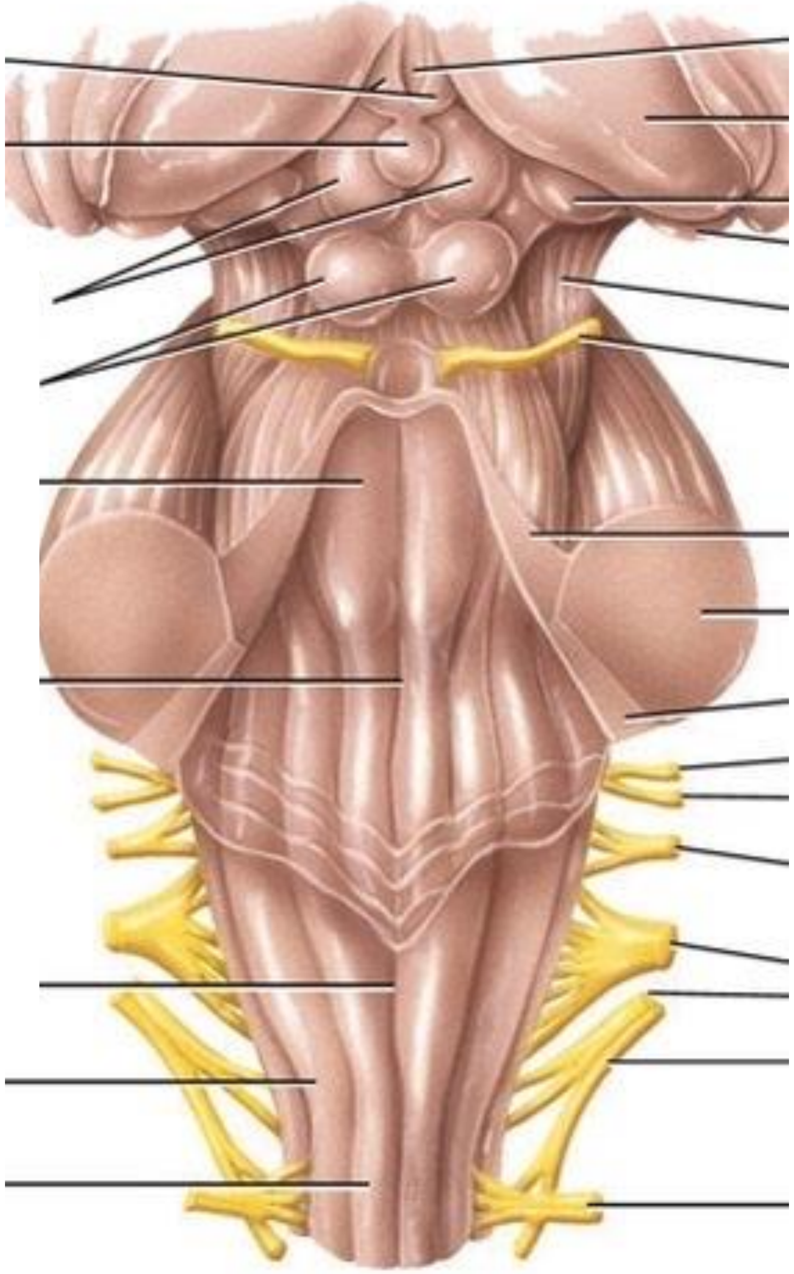
# Timing

- Another important function of the lateral zones of the cerebellar hemispheres is to provide appropriate timing for each succeeding movement.
- In the absence of these cerebellar zones, one loses the subconscious ability to predict how far the different parts of the body will move in a given time.
- Without this timing capability, the person becomes unable to determine when the next sequential movement needs to begin.

- As a result, the succeeding movement may begin too early or, more likely, too late.
- Therefore, lesions in the lateral zones of the cerebellum cause complex movements (e.g., those required for writing, running, or even talking) to become incoordinate and lacking ability to progress in orderly sequence from one movement to the next.
- Such cerebellar lesions are said to cause failure of smooth progression of movements.

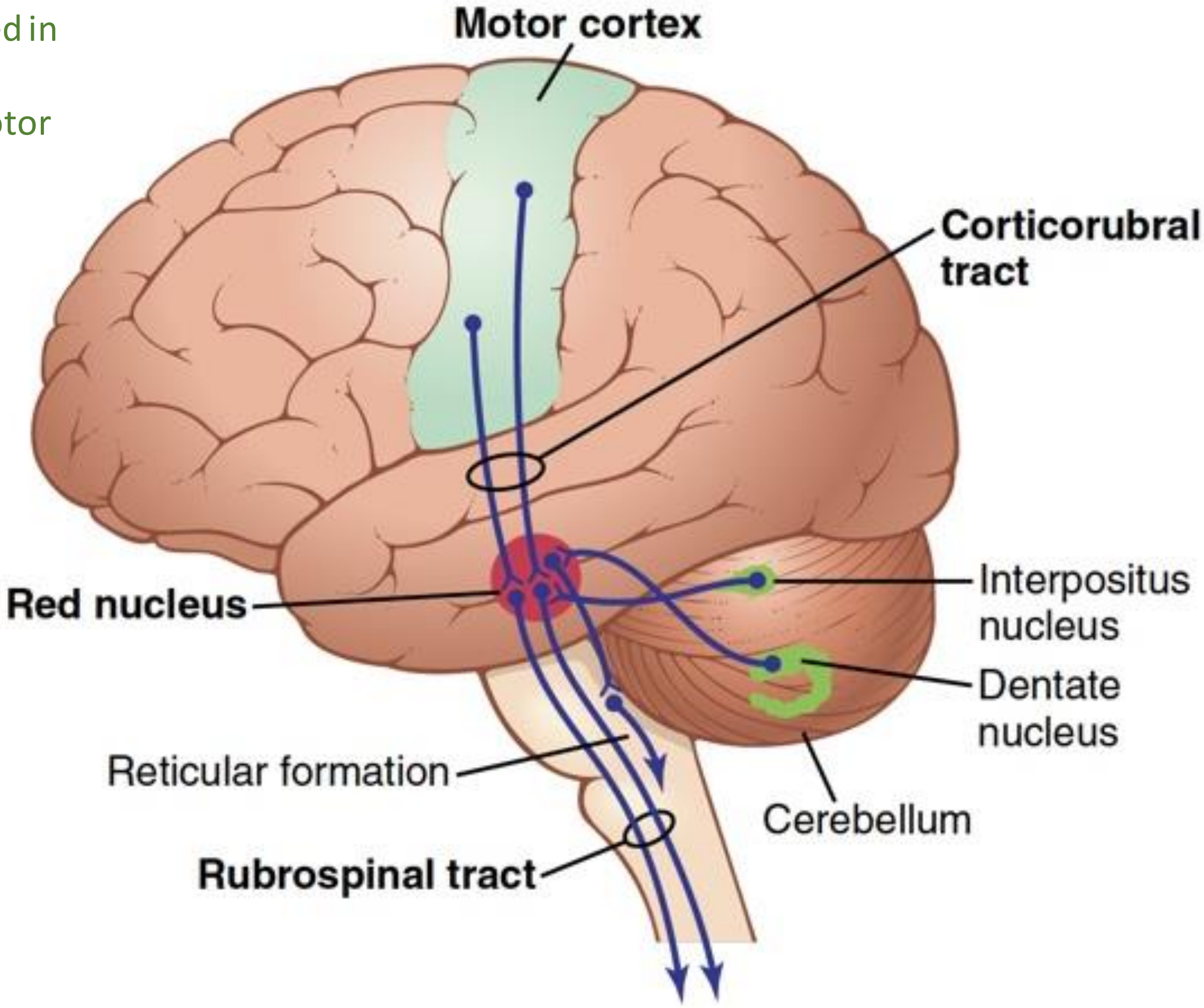
# Predictive function of cerebrocerebellum

- The cerebrocerebellum also helps to “time” events other than movements of the body.
- For example, the rates of progression of both auditory and visual phenomena (predict how far is this object from you) can be predicted by the brain.
- the cerebellum is particularly helpful in interpreting rapidly changing spatiotemporal relations in sensory information.



# Brain stem :medulla, pons and midbrain

When talking about Motor function of the brain stem it's important to mention the red nucleus located in the mid brain
Red nucleus receive inputs from the primary motor cortex mainly in the magnocellular part



# Red nucleus

- Red nucleus receives a large number of direct fibers from the primary motor cortex through the corticorubral tract, as well as branching fibers from the corticospinal tract as it passes through the mesencephalon.
- These fibers synapse in the lower portion of the red nucleus, the magnocellular portion, which contains large neurons similar in size to the Betz cells in the motor cortex.

# Red nucleus

- The neurons of the red nucleus have similar dynamic and static characteristics, except that a greater percentage of dynamic neurons is in the red nucleus and a greater percentage of static neurons is in the primary motor cortex.

- This may be related to the fact that the red nucleus is closely allied with the cerebellum, and the cerebellum plays an important role in rapid initiation of muscle contraction

# Red nucleus

- The magnocellular portion of the red nucleus has a somatographic representation of all the muscles of the body, as does the motor cortex.
- Therefore, stimulation of a single point in this portion of the red nucleus causes contraction of either a single muscle or a small group of muscles.
- However, the fineness of representation of the different muscles is far less developed than in the motor cortex.

# Red nucleus

- These large neurons then give rise to the rubrospinal tract, which crosses to the opposite side in the lower brain stem and follows a course immediately adjacent to the corticospinal tract into the lateral columns of the spinal cord.

# Red nucleus

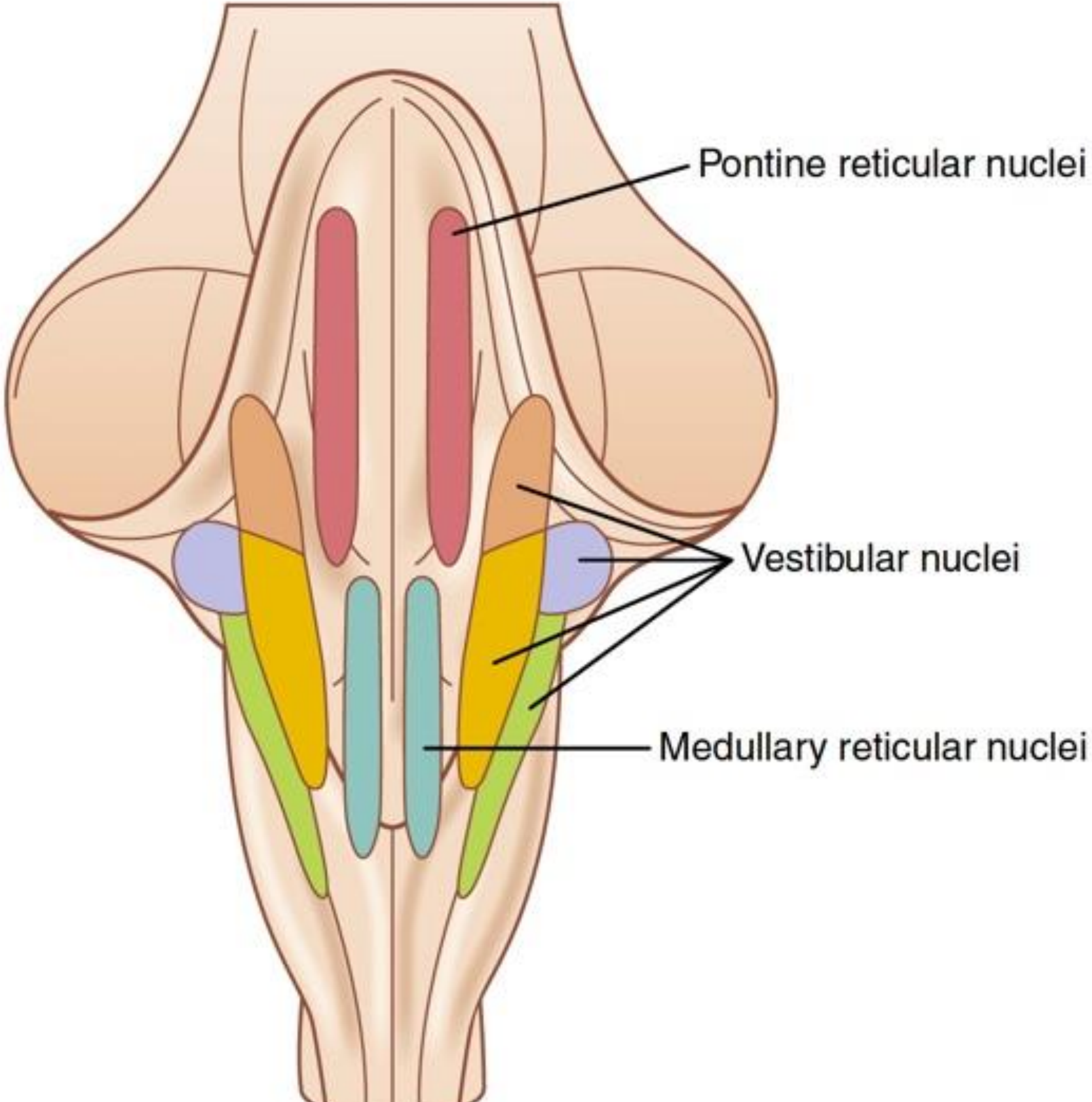
- The rubrospinal fibers terminate mostly on the interneurons of the intermediate areas of the cord gray matter, along with the corticospinal fibers, but some of the rubrospinal fibers terminate directly on anterior motor neurons, along with some corticospinal fibers.
- The red nucleus also has close connections with the cerebellum, similar to the connections between the motor cortex and the cerebellum.

# Red nucleus

- The corticospinal and rubrospinal tracts together are called the lateral motor system of the cord, in contradistinction to a vestibuloreticulospinal system, which lies mainly medially in the cord and is called the medial motor system of the cord.

# Red nucleus

- The corticorubrospinal pathway serves as an accessory route for transmission of relatively discrete signals from the motor cortex to the spinal cord.
- When the corticospinal fibers are destroyed but the corticorubrospinal pathway is intact, discrete movements can still occur, except that the movements for fine control of the fingers and hands are considerably impaired.


Pontine reticular nuclei
Vestibular nuclei
Medullary reticular nuclei

# Reticular nuclei

- The reticular nuclei are divided into two major groups:
- (1) pontine reticular nuclei. Excite the antigravity muscles
- (2) medullary reticular nuclei. Inhibit the antigravity muscles

- Reticular nuclei function mainly antagonistically to each other, with the pontine exciting the antigravity muscles and the medullary relaxing these same muscles.

# Pontine reticular nuclei

- The pontine reticular nuclei transmit excitatory signals downward into the cord through the pontine reticulospinal tract in the anterior column of the cord.

- The fibers of this pathway terminate on the medial anterior motor neurons that excite the axial muscles of the body, which support the body against gravity: the muscles of the vertebral column and the extensor muscles of the limbs.

# Pontine reticular nuclei

- The pontine reticular nuclei have a high degree of natural excitability.
- In addition, they receive strong excitatory signals from the vestibular nuclei, as well as from deep nuclei of the cerebellum.
- Therefore, when the pontine reticular excitatory system is unopposed by the medullary reticular system, it causes powerful excitation of antigravity muscles throughout the body.

# Medullary reticular nuclei

- The medullary reticular nuclei transmit inhibitory signals to the same antigravity anterior motor neurons via the medullary reticulospinal tract, located in the lateral column of the cord.
- The medullary reticular nuclei receive strong input collaterals from the following:
- (1) the corticospinal tract; (2) the rubrospinal tract; and (3) other motor pathways.

# Medullary reticular nuclei

- These tracts and pathways normally activate the medullary reticular inhibitory system to counterbalance the excitatory signals from the pontine reticular system, so under normal conditions the body muscles are not abnormally tense.

# Reticular nuclei

- The excitatory and inhibitory reticular nuclei constitute a controllable system that is manipulated by motor signals from the cerebral cortex and elsewhere to provide necessary background muscle contractions for standing against gravity and to inhibit appropriate groups of muscles as needed so that other functions can be performed.

# Vestibular nuclei

- 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 via the lateral and medial vestibulospinal tracts in the anterior columns of the spinal cord.
- Without this support of the vestibular nuclei, the pontine reticular system would lose much of its excitation of the axial antigravity muscles.

# Vestibular nuclei

- The specific role of the vestibular nuclei is to selectively control the excitatory signals to the different antigravity muscles to maintain equilibrium in response to signals from the vestibular apparatus.

What is special about the excitation of this nuclei to the antigravity muscle is the **selectively** in action to different antigravity muscles to maintain equilibrium

# Vestibular signals

- Most of the vestibular nerve fibers terminate in the vestibular nuclei.
- Some fibers pass directly to the brain stem reticular nuclei and also to the cerebellar fastigial and flocculonodular lobe nuclei.
- The fibers that end in the brain stem vestibular nuclei synapse with neurons that send fibers into the cerebellum, the vestibulospinal tracts and other areas of the brain stem, particularly the reticular nuclei.

# Vestibular signals

- The flocculonodular lobes of the cerebellum are especially concerned with dynamic equilibrium signals from the semicircular ducts.

- severe injury to either the lobes or the ducts causes loss of dynamic equilibrium during rapid changes in direction of motion but does not seriously disturb equilibrium under static conditions.

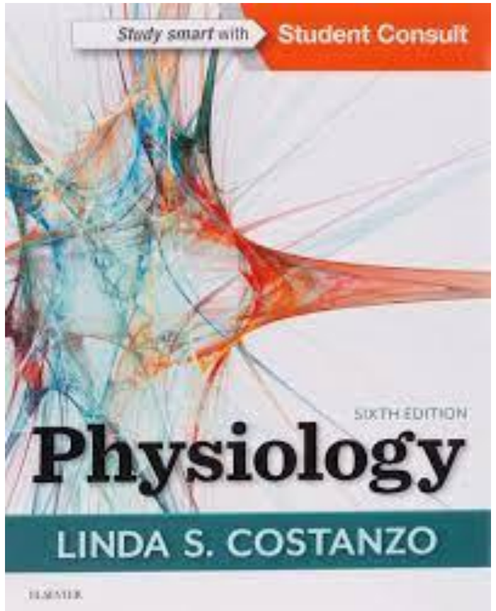
# Vestibular signals

- Signals transmitted upward in the brain stem from both the vestibular nuclei and the cerebellum via the medial longitudinal fasciculus cause corrective movements of the eyes every time the head rotates, so the eyes remain fixed on a specific visual object.

- Signals also pass upward to the cerebral cortex, terminating in a primary cortical center for equilibrium.

Thank you

# References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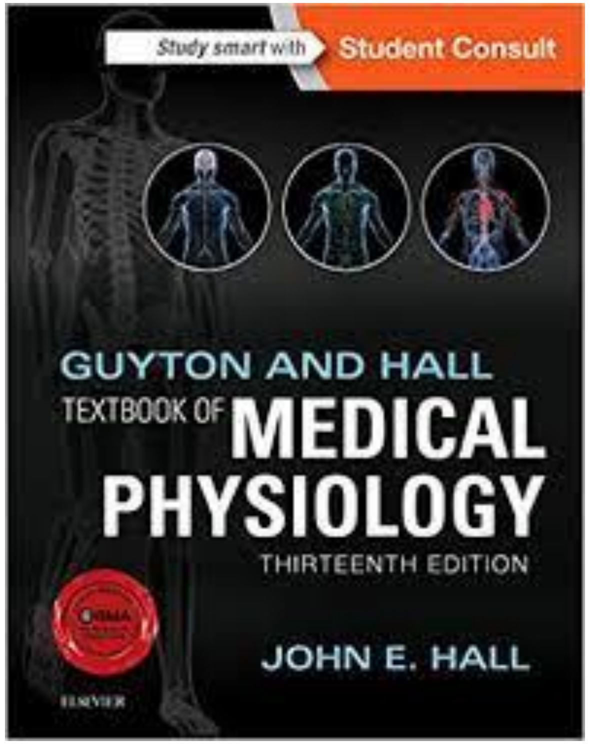
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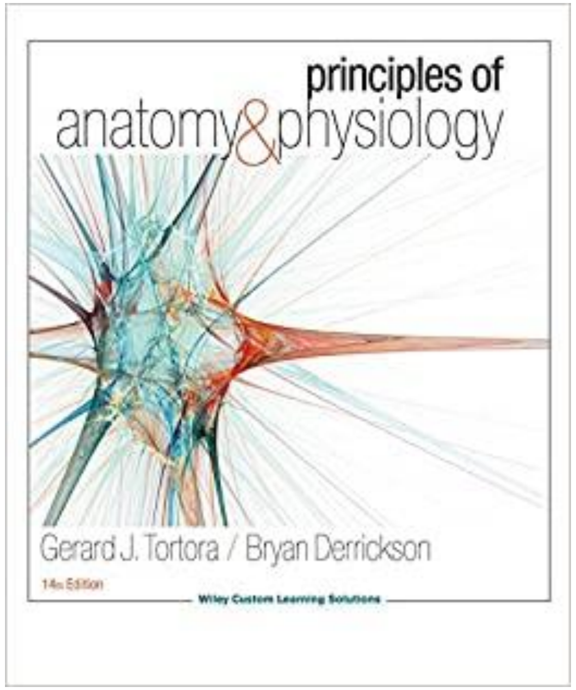
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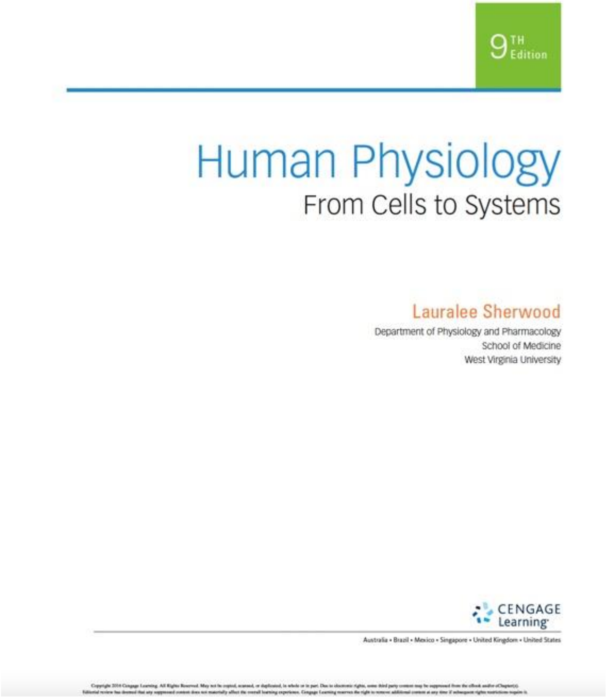
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