

Chapter 8: Control of Movement

General Principles of Motor Behavior

Skeletal Muscle Anatomy and Physiology

Proprioception and Reflexes

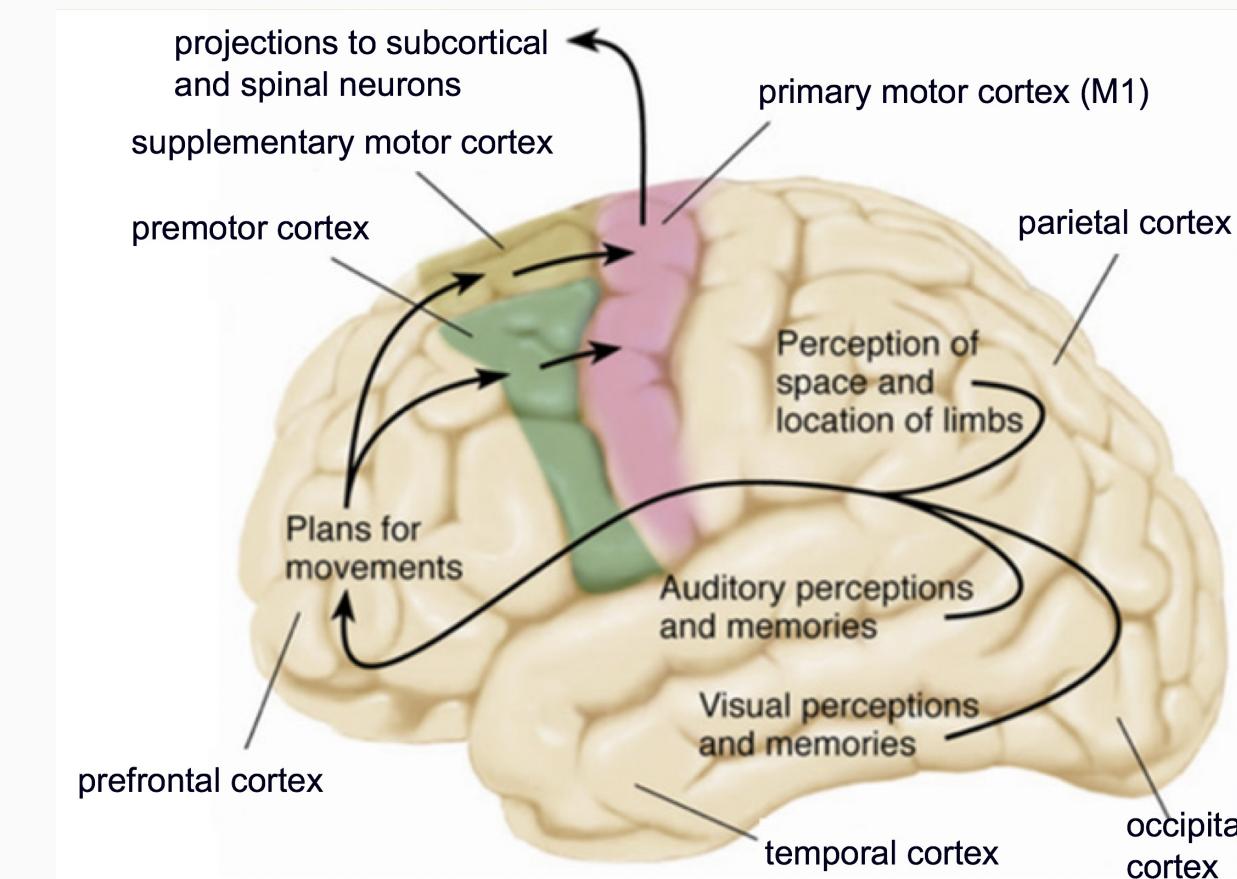
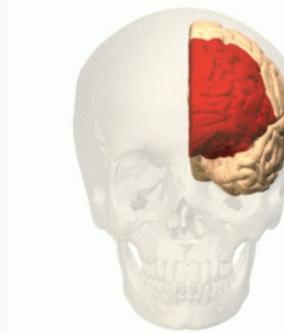
Control of Movement by the Brain

Movement Disorders

Control of Movement by the Brain

Prefrontal Cortex.

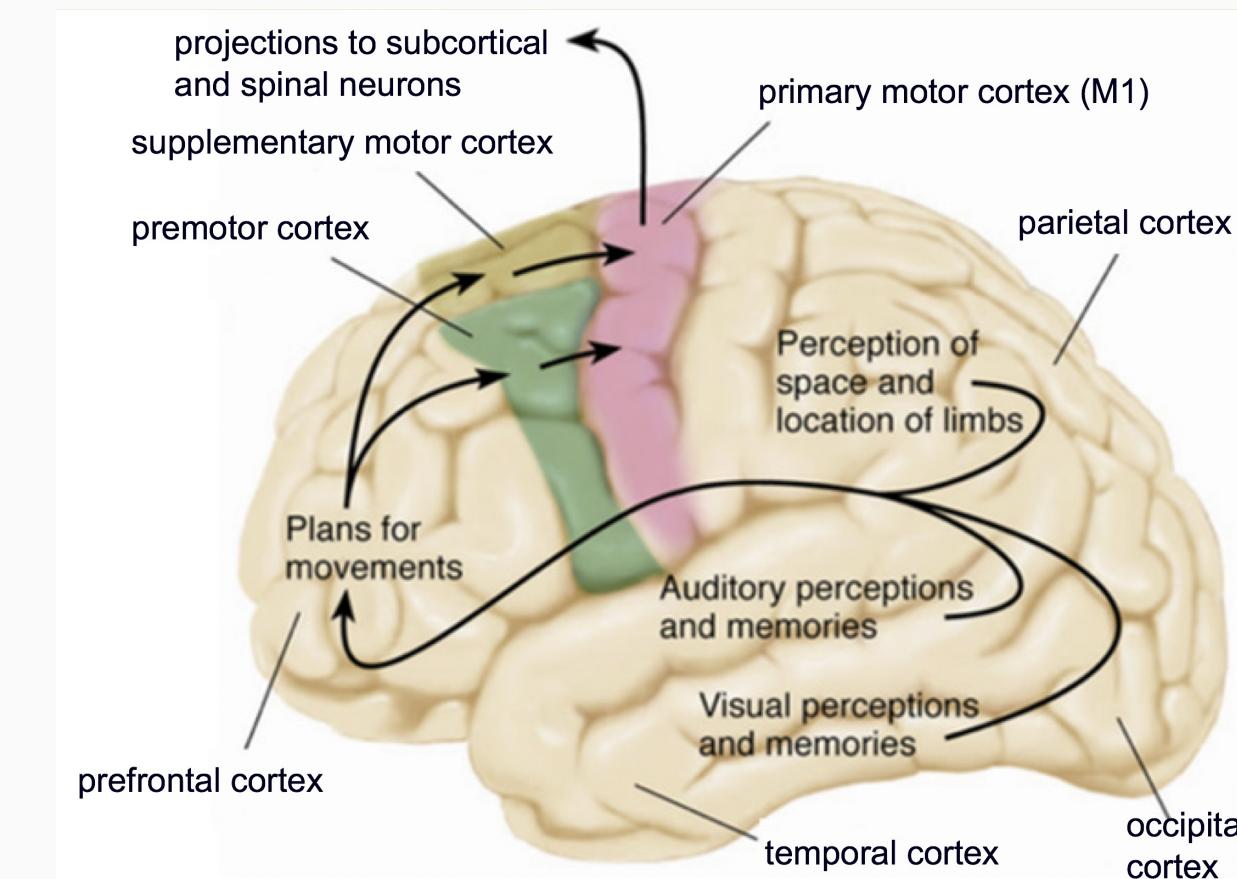
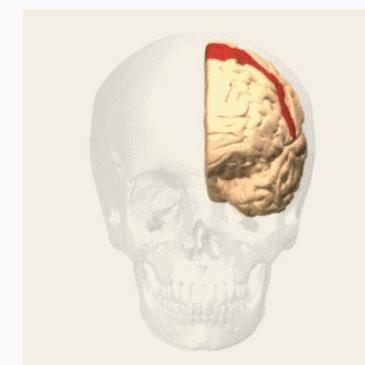
- rostral to premotor cortex & supplementary motor area
- sensory inputs from temporal and parietal lobes
- important for organizing movement plans



Control of Movement by the Brain

Premotor Cortex and Supplementary Motor Area.

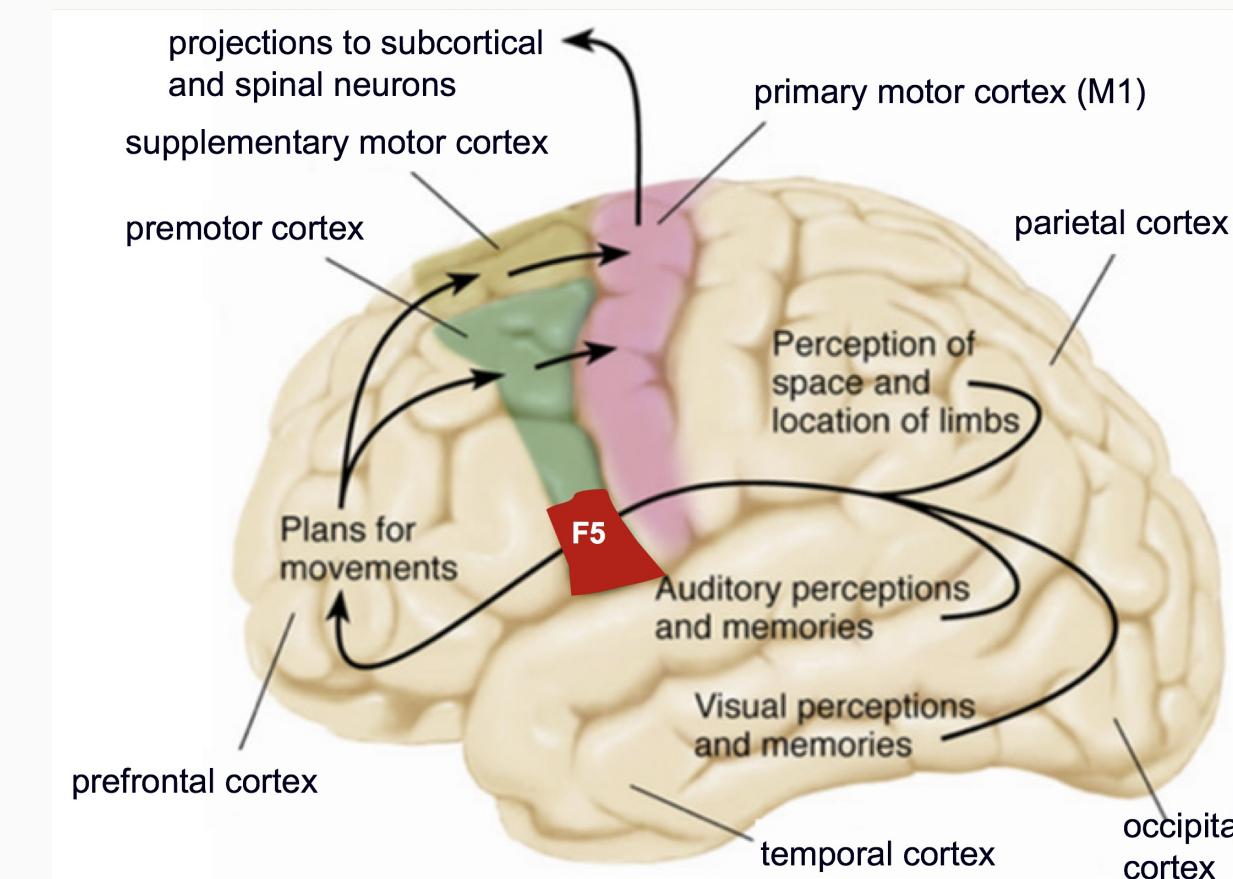
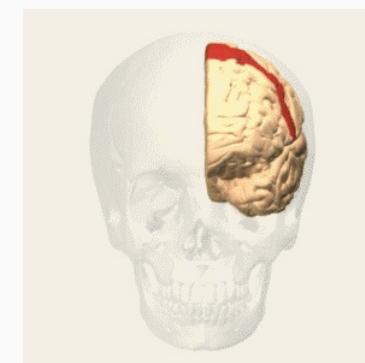
- input from prefrontal, parietal & temporal cortices
- output to primary motor cortex
- important in planning
 - complex, sequenced behaviors



Control of Movement by the Brain

Premotor Cortex and Supplementary Motor Area.

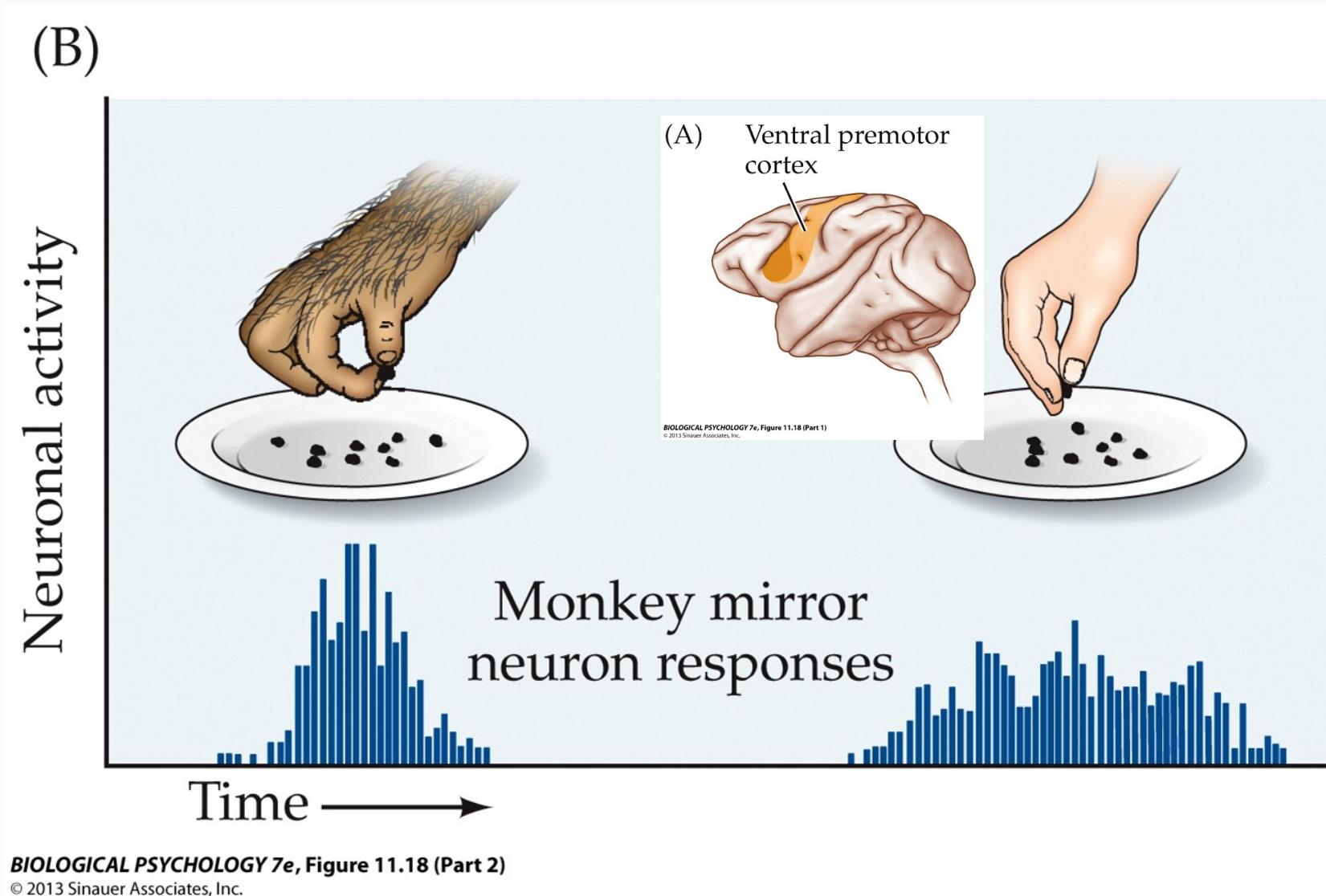
- SMA lesion impairs initiation and sequencing of behavior
- premotor cortex lesion
 - stance, gait, limb coordination
 - fine motor function



Control of Movement by the Brain

Ventral Premotor Cortex.

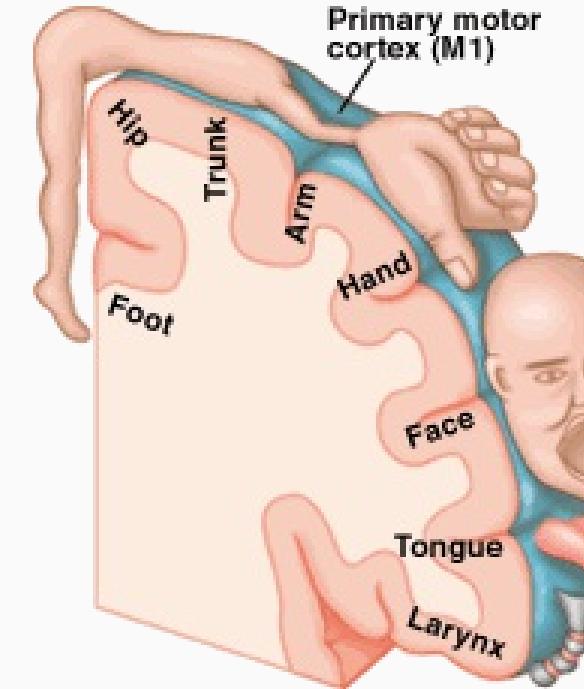
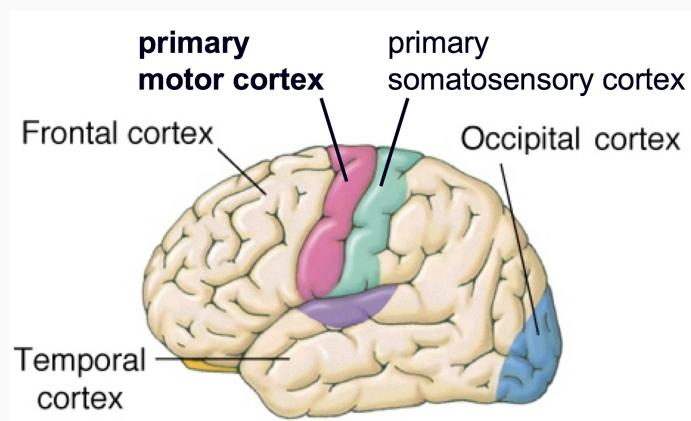
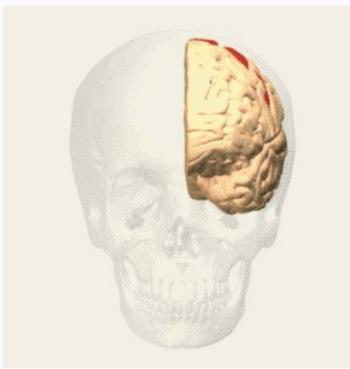
- mirror neurons



Control of Movement by the Brain

Primary Motor Cortex (M1).

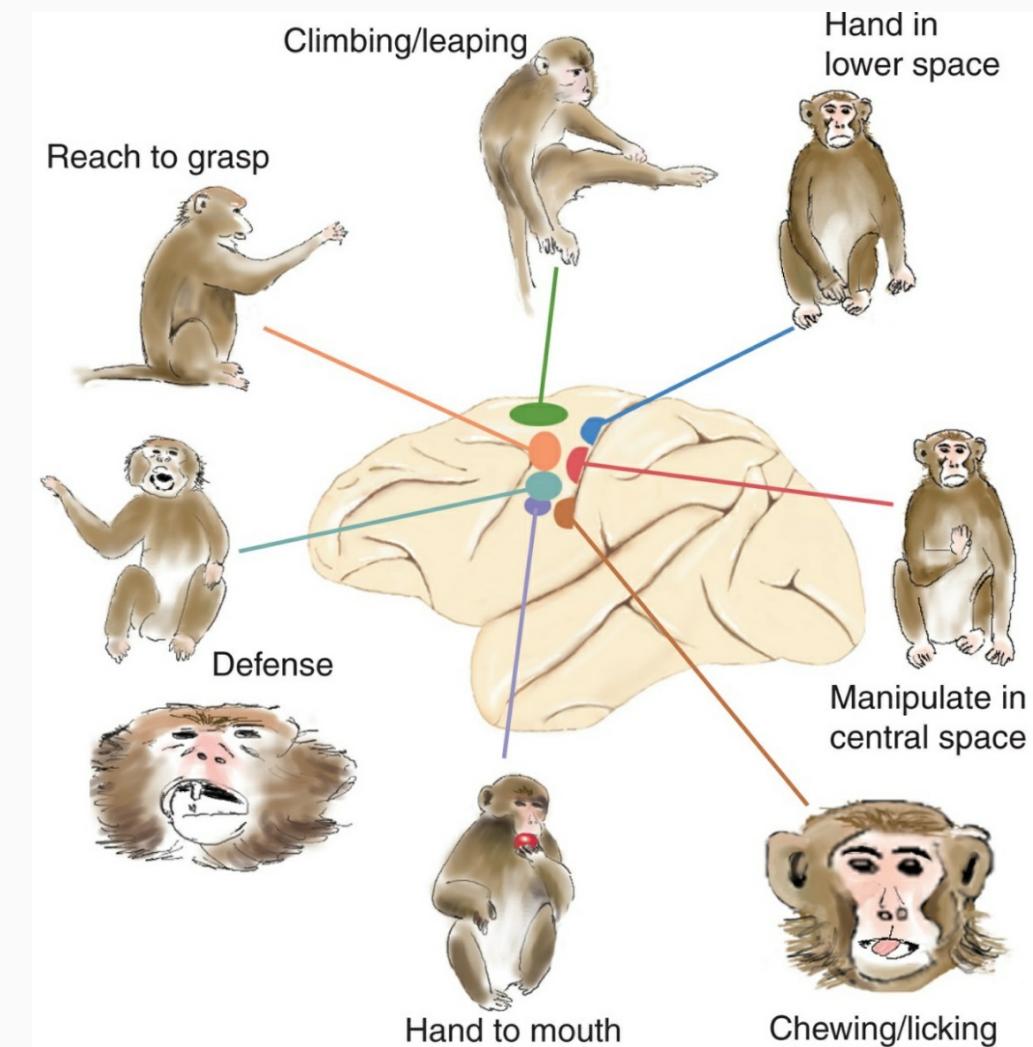
- precentral gyrus, rostral to central fissure



Control of Movement by the Brain

Primary Motor Cortex.

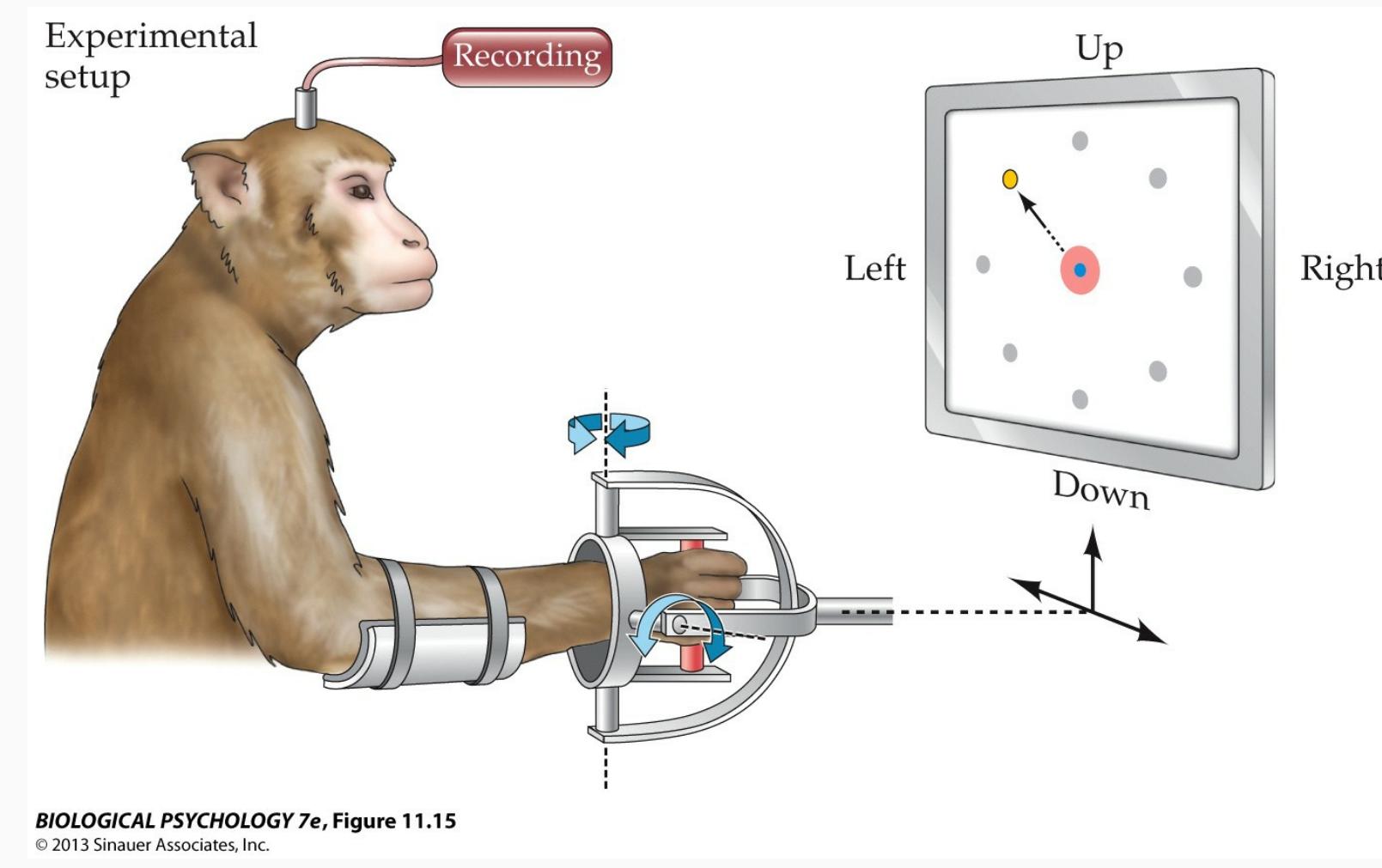
- brief stimulation caused brief jerky movement
- prolonged stimulation caused complex movement



Control of Movement by the Brain

Primary Motor Cortex.

- about $\frac{1}{3}$ of M1 cells encode single muscle movement
- other M1 cells encode complex functions like direction



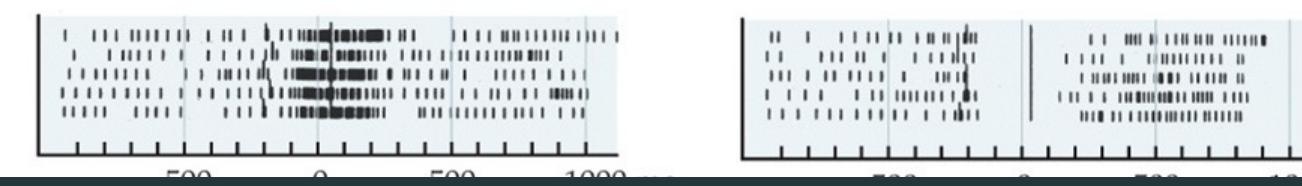
Control of Movement by the Brain

Primary Motor Cortex.

- about $\frac{1}{3}$ of M1 cells encode
 - single muscle movement
- other M1 cells encode complex functions
 - movement direction

Target appears ↑

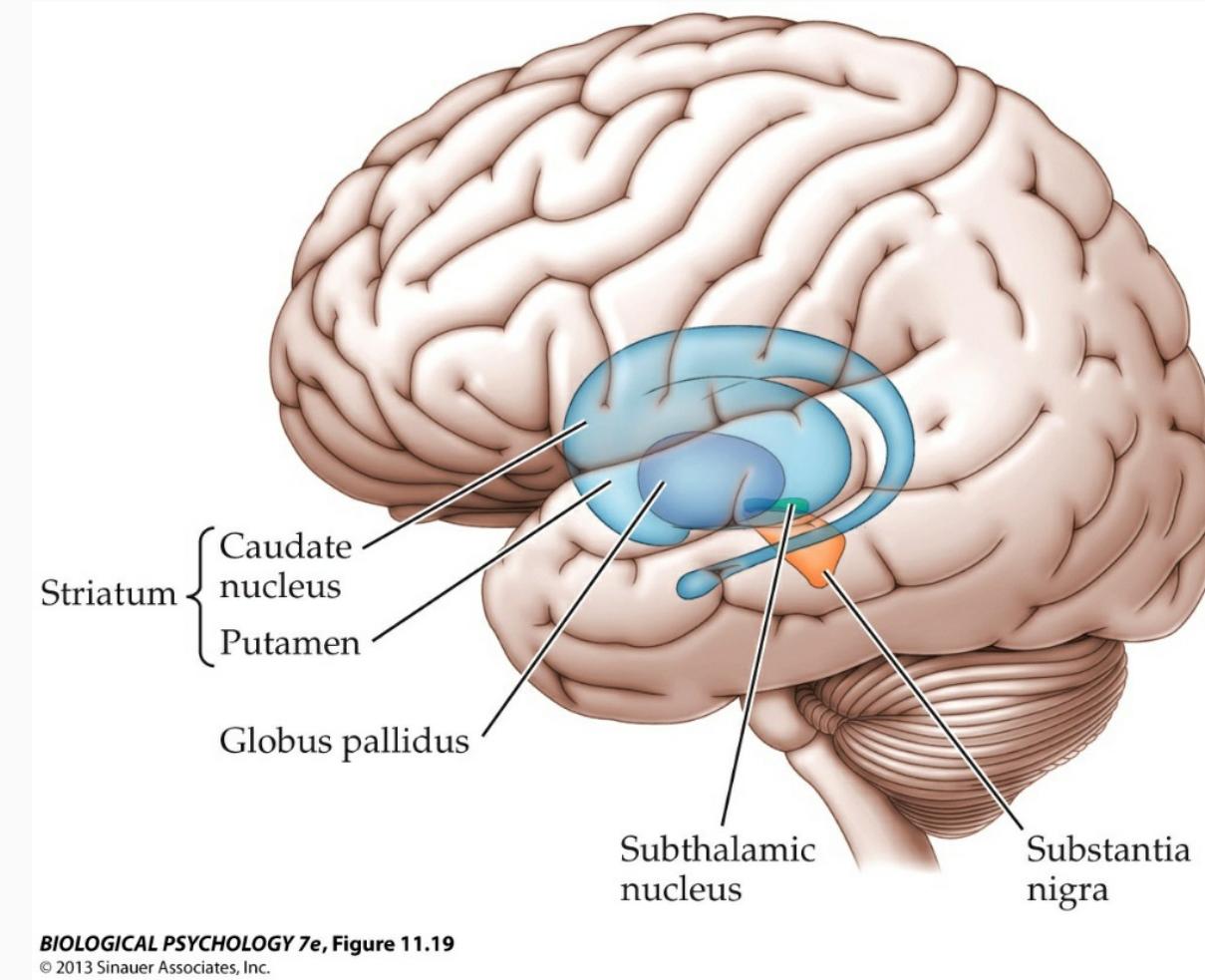
Movement begins



Control of Movement by the Brain

Basal Ganglia.

- interconnected subcortical ganglia
 - in diencephalon and mesencephalon
- activity of neurons correlate with movement
 - and (CPu)
 - (STN)
 - (GPi, GPe)
 - (SNpc, SNpr)

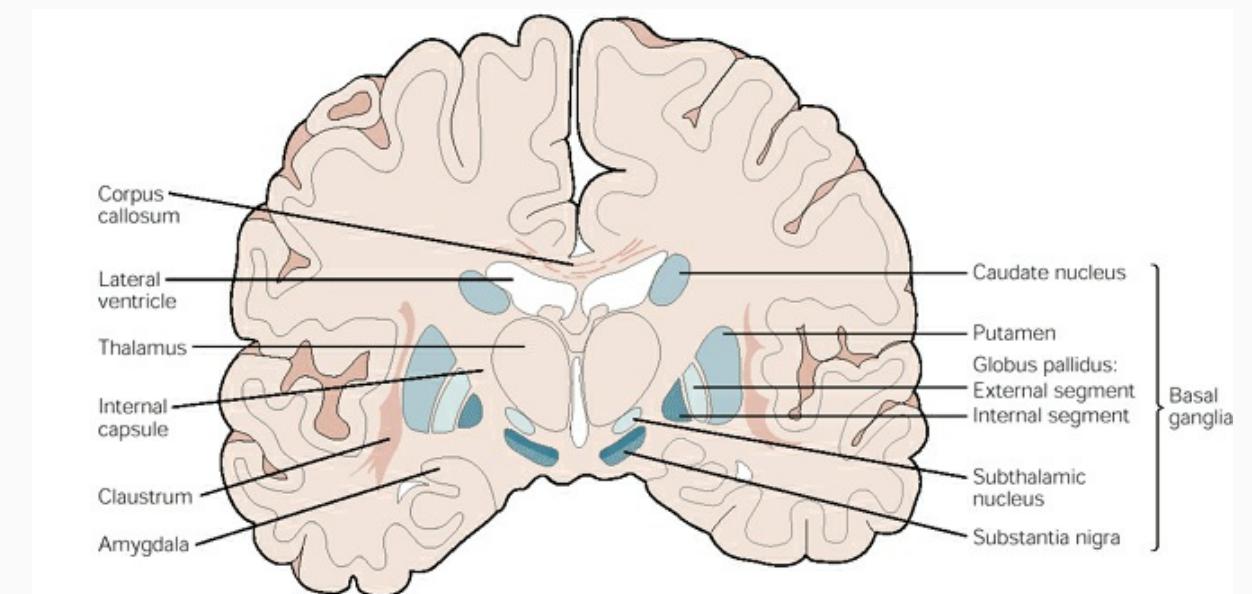


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Control of Movement by the Brain

Basal Ganglia.

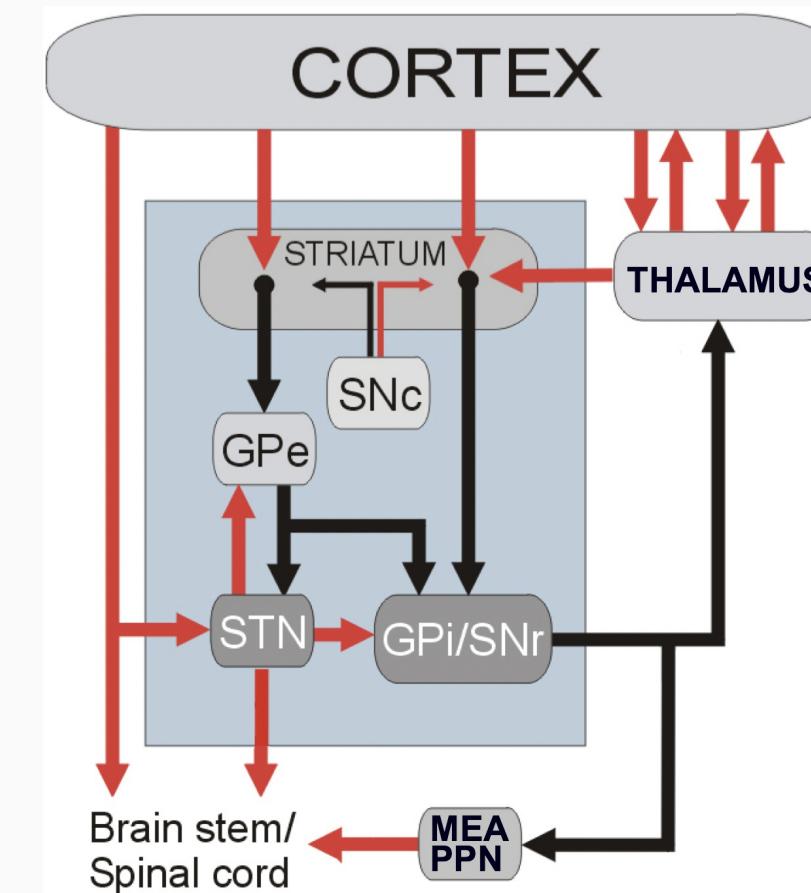
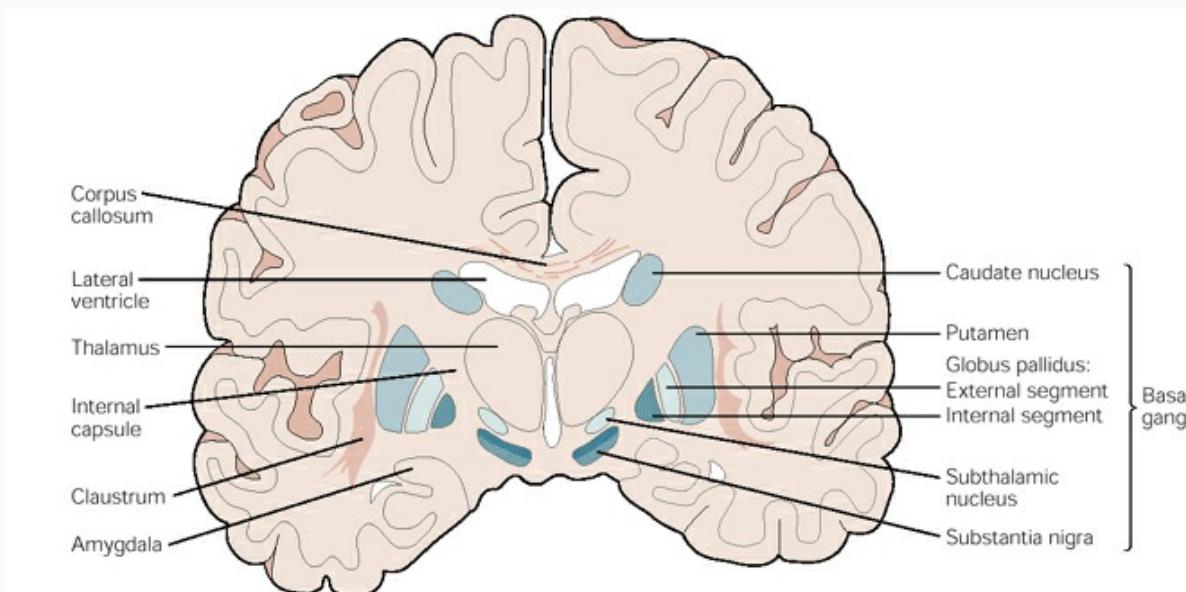
- extensive cortical inputs, many thalamic inputs
- focused inhibitory output to thalamus and brainstem
- organizing and production of movement
- inhibits excess motor activity



Control of Movement by the Brain

Basal Ganglia.

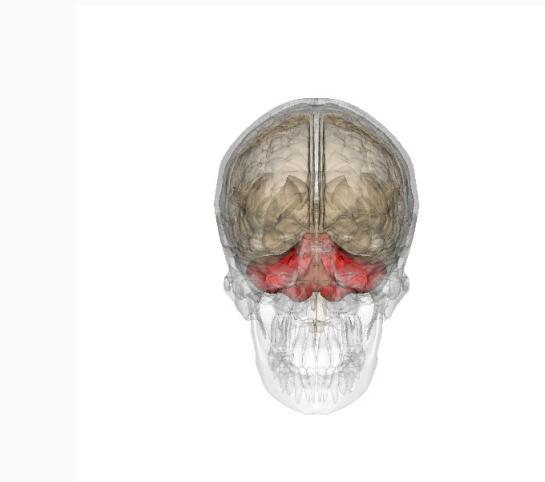
- **indirect pathway**
 - cortex → caudate → Gpe → Gpi/SNr
- **direct pathway**
 - cortex → caudate → GPi/SNr
- **hyperdirect pathway**
 - cortex → STN → Gpe and GPi/SNr



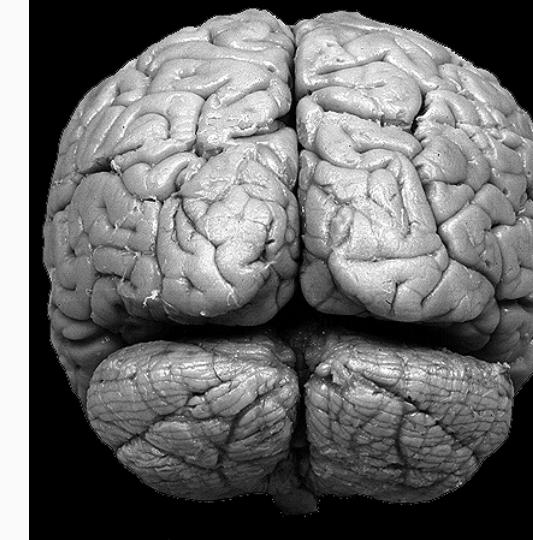
Control of Movement by the Brain

Cerebellum.

- about 50 billion neurons (vs. 22 billion in neocortex)
- 2 hemispheres, cerebellar cortex, deep cerebellar nuclei
- cerebellar inputs provide joint angles, muscle loads, etc.
- cerebellar outputs influence motor systems
- cerebellum also implicated in non-motor functions
 - (attention, executive control, language, working memory, learning, pain, emotion, motivated behavior, addiction)



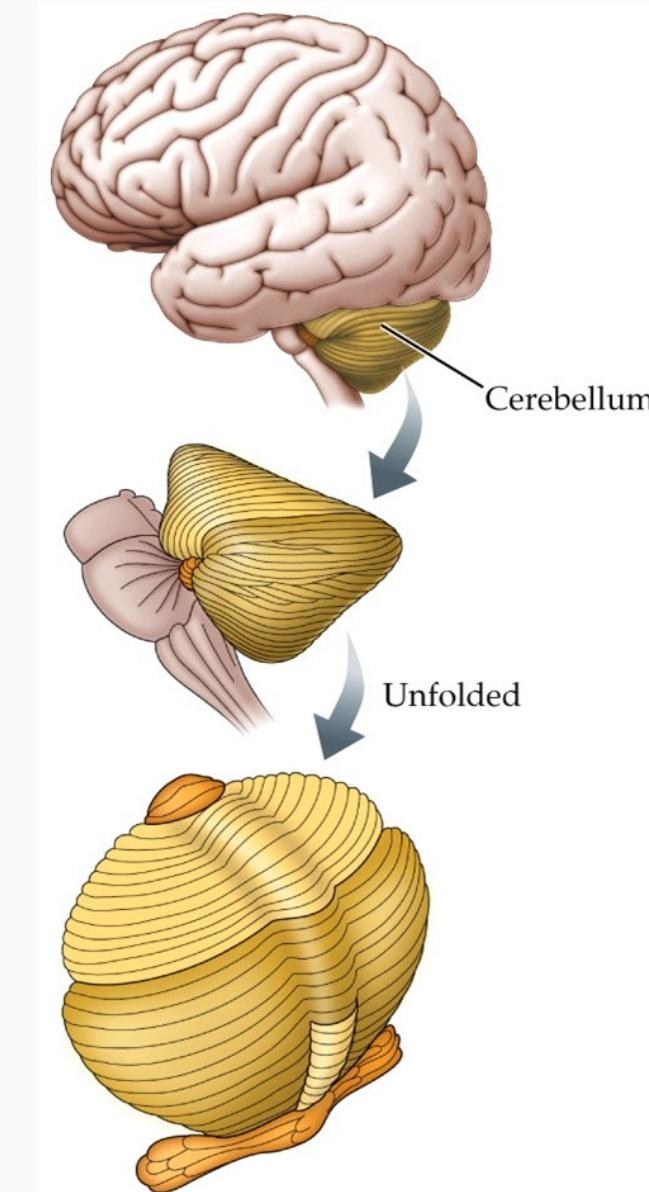
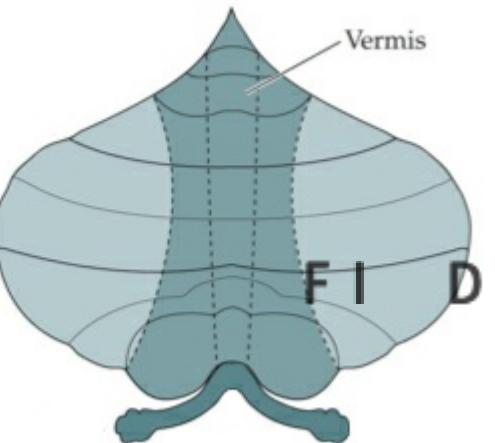
Cerebellum



Control of Movement by the Brain

Cerebellum.

- **medial cerebellum** (vermis)
- receives vestibular/auditory/visual/somatosensory input
- outputs to:
 - fastigial nucleus → vestibular nucleus
 - fastigial nucleus → reticular formation
 - controls trunk and proximal limbs (posture, gait, and balance)

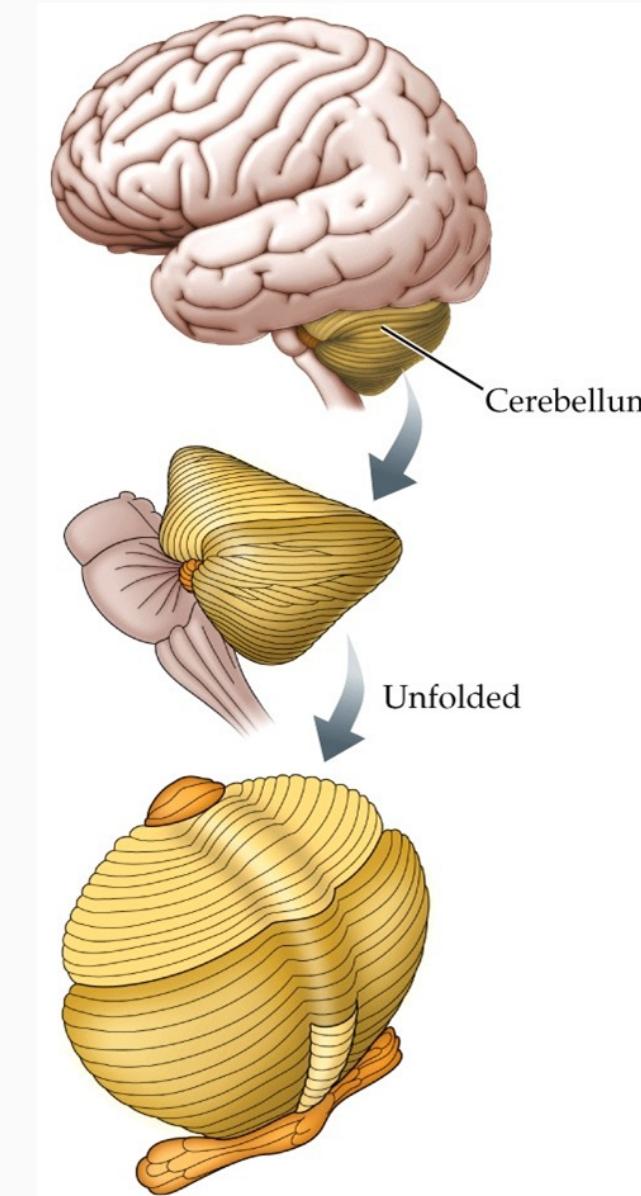
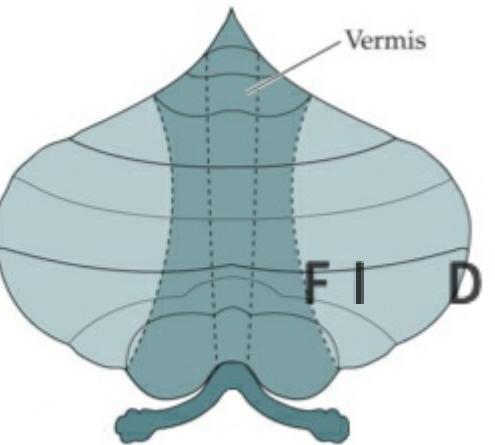


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Control of Movement by the Brain

Cerebellum.

- **intermediate cerebellum**
- input from motor cortex and somatosensory spinal cord
- outputs to interpositus nucleus
- interpositus nucleus → red nucleus
- interpositus nucleus → thalamus → motor cortex
- controls proximal limb movements

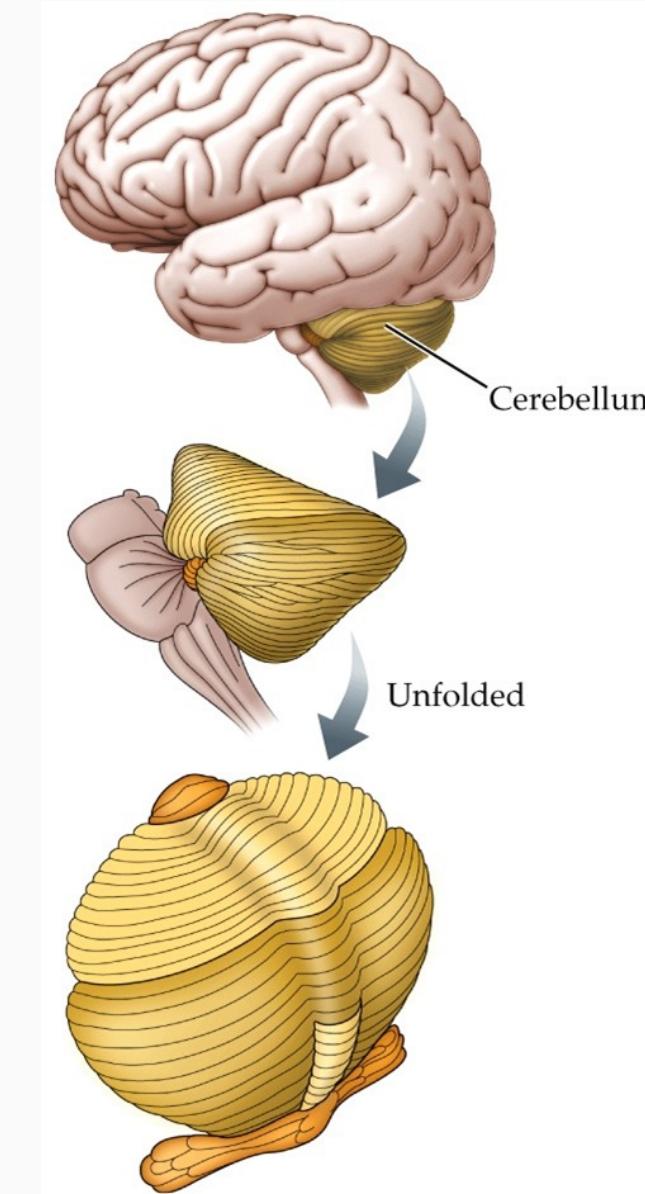
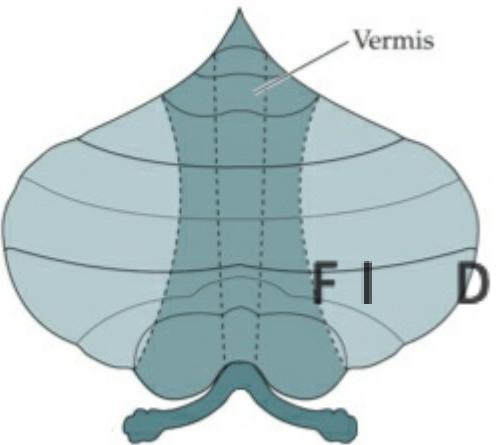


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Control of Movement by the Brain

Cerebellum.

- **lateral cerebellum**
- input from motor cortex and somatosensory spinal cord
- outputs to dentate nucleus
- dentate nucleus → red nucleus
- dentate nucleus → thalamus → motor cortex
- controls independent and rapid, skilled limb movements (ballistic movements)



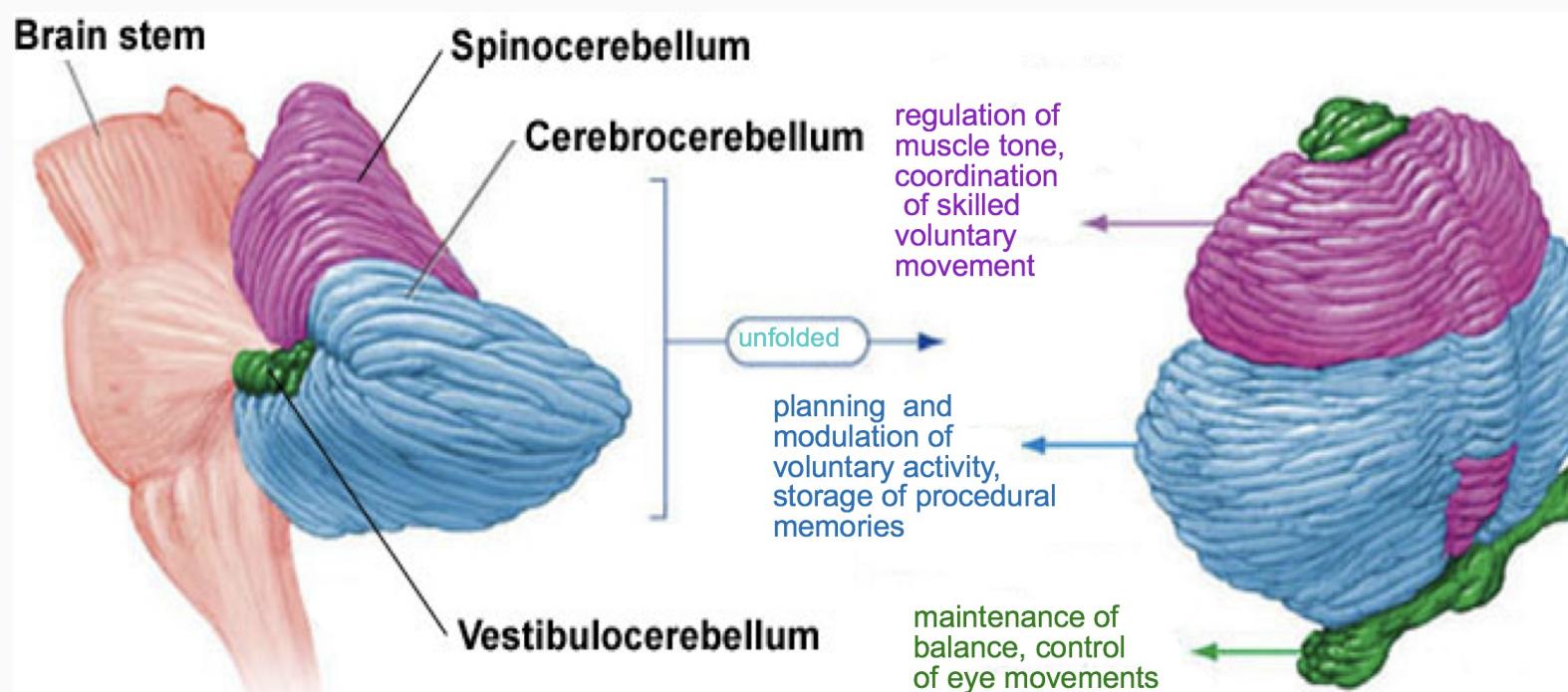
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Control of Movement by the Brain

Cerebellum.

- **floculonodular lobe** (aka *vestibulocerebellum*)
 - balance, eye movements
- **posterior lobe** (aka *cerebrocerebellum*)
 - voluntary activity, procedural memory

- **anterior lobe** (aka *spinocerebellum*)
 - gait, coordination, skilled movements, regulation of muscle tone, coordination of skilled voluntary movement planning and modulation of voluntary activity, storage of procedural memories maintenance of balance, control of eye movements



Control of Movement by the Brain

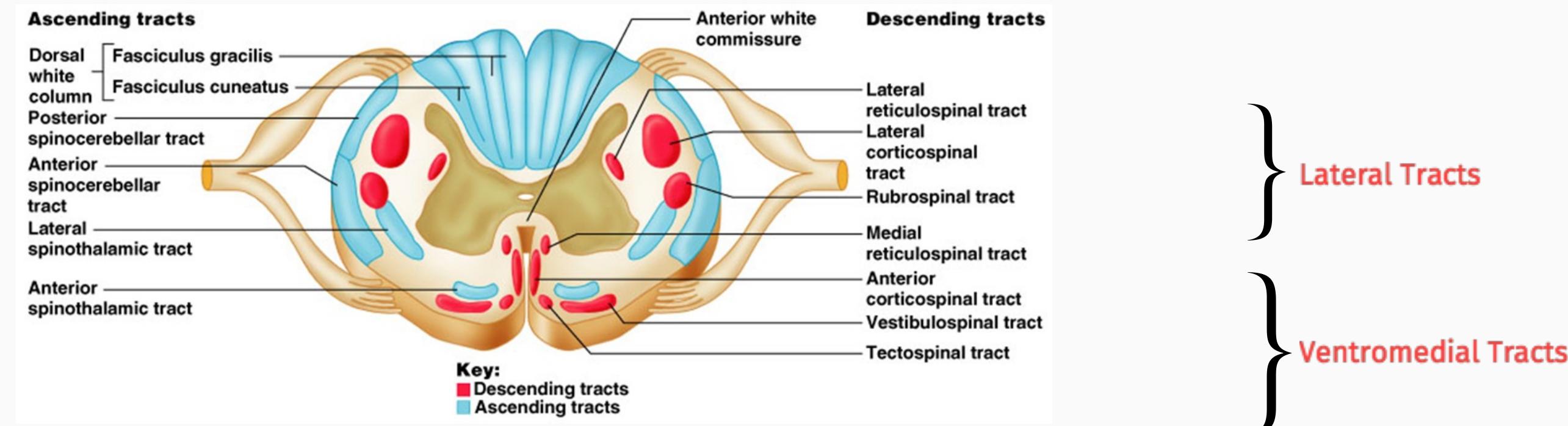
Descending Projections.

- **Lateral Tracts:**

- inputs from M1, and from nuclei that receive M1 inputs
- mostly control of distal portions of limbs

- **Ventromedial Tracts:**

- inputs from midbrain/brainstem nuclei and from M1
- mostly control of trunk and proximal portions of limbs



Control of Movement by the Brain

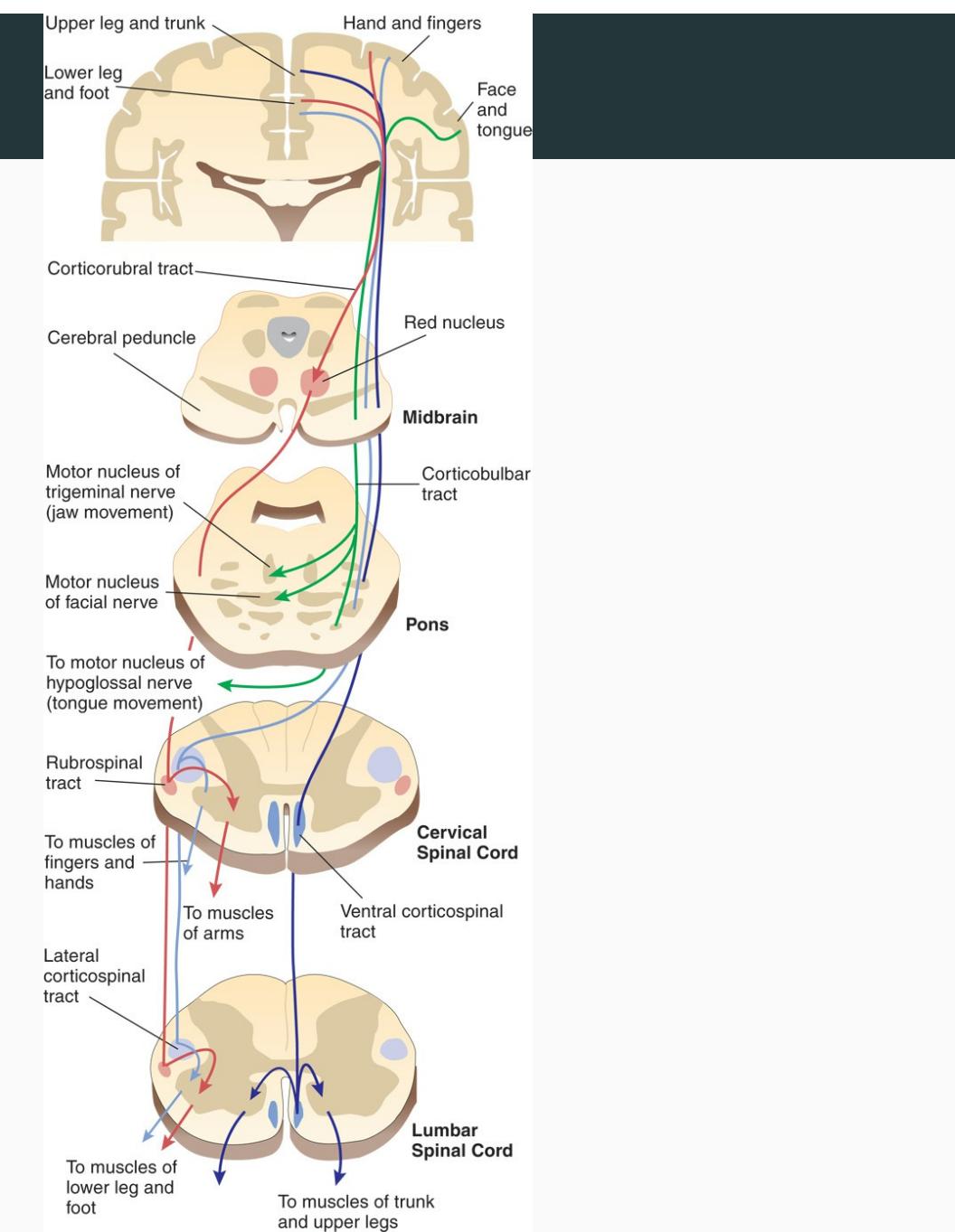
Descending Projections - Lateral Tracts.

1) **lateral corticospinal** (pyramidal) tract

- originate in finger, hand, arm regions of M1
- terminate in spinal cord
- controls fingers, hands, arms
- grasping and manipulating objects

2) **corticorubral-rubrospinal** tract

- originate in M1 and red nucleus
- terminate in spinal cord
- controls hands (not fingers), feet, distal portions of limbs
- independent limb movements

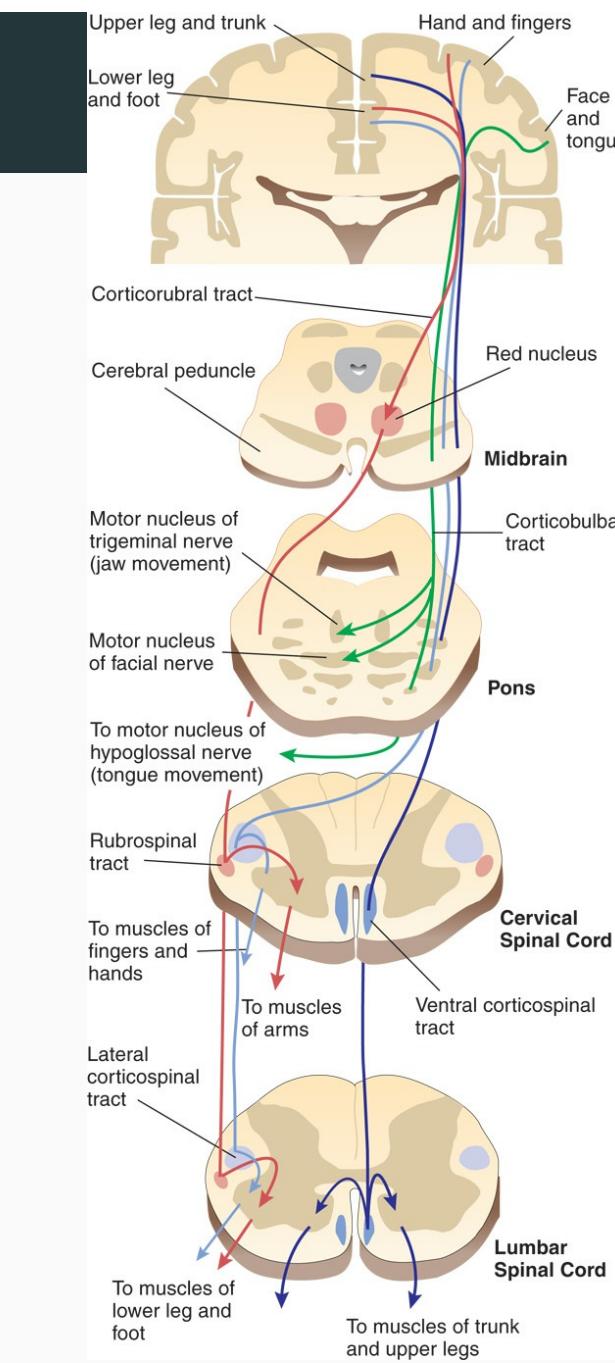


Control of Movement by the Brain

Descending Projections - Lateral Tracts.

3) corticobulbar tract

- originate in face region of M1
- terminate in cranial nuclei
- control face and tongue movements



Control of Movement by the Brain

Descending Projections - Ventromedial Tracts.

1) **tectospinal tract**

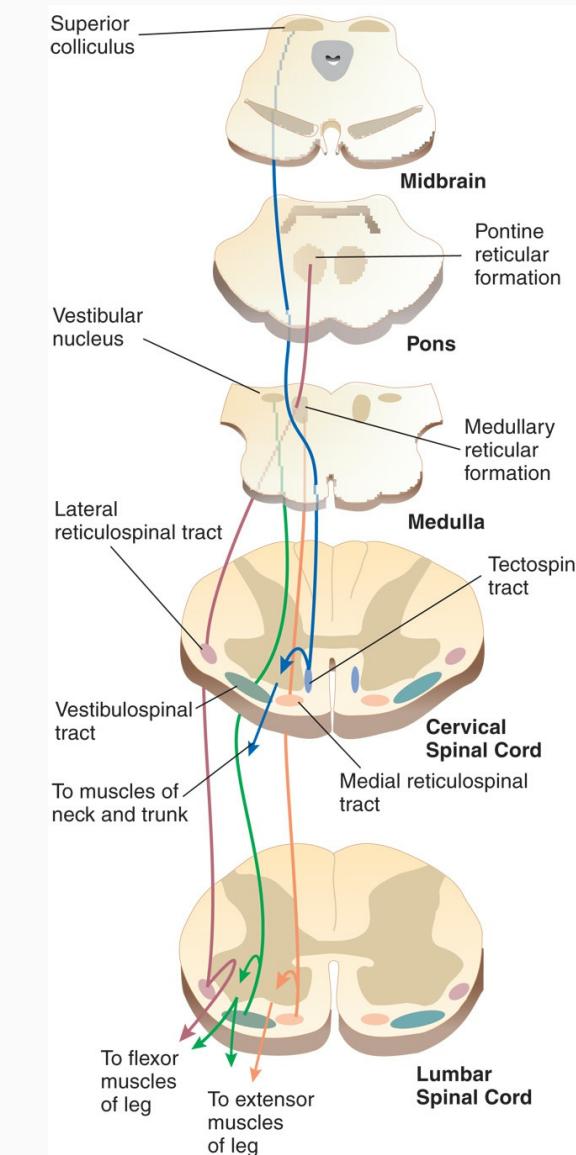
- originate in superior colliculus
- controls neck and trunk
- coordinates with eye movements

2) **vestibulospinal tract**

- originate in brainstem vestibular nuclei
- terminate in spinal cord
- controls trunk and legs, posture

3) **lateral and medial reticulospinal tracts**

- originate in reticular formation
- terminate in spinal cord
- control muscles of legs
- walking



Control of Movement by the Brain

Descending Projections - Ventromedial Tracts.

4) ventral corticospinal tract

- originate in trunk and proximal leg region of M1
- terminate in spinal cord
- controls hands (not fingers), lower arms, feet, lower legs
- walking and posture

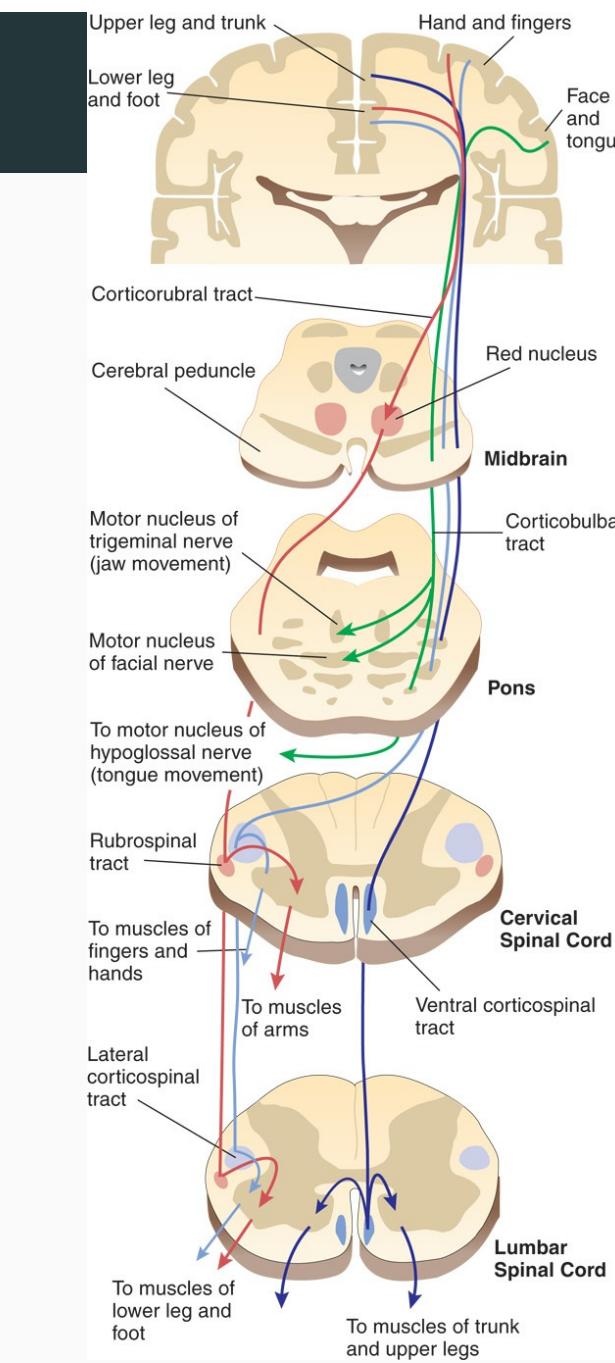


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