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## Physiology

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Slides 

Lec No:2

Subject: Cortical Motor Function

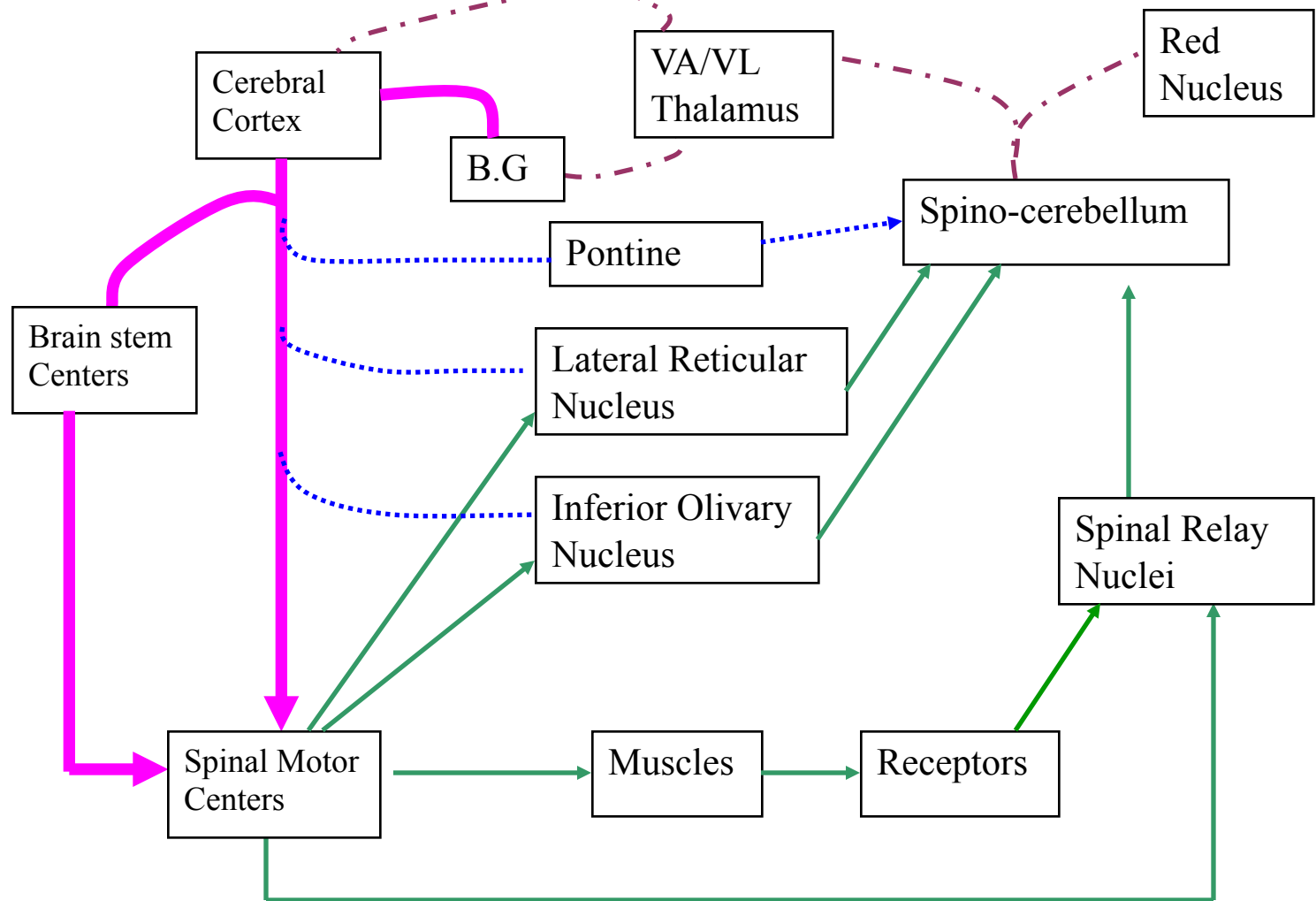
Doctor: Faisal Mohammed

# Cortical Control of Motor Function

Faisal I. Mohammed, MD, PhD

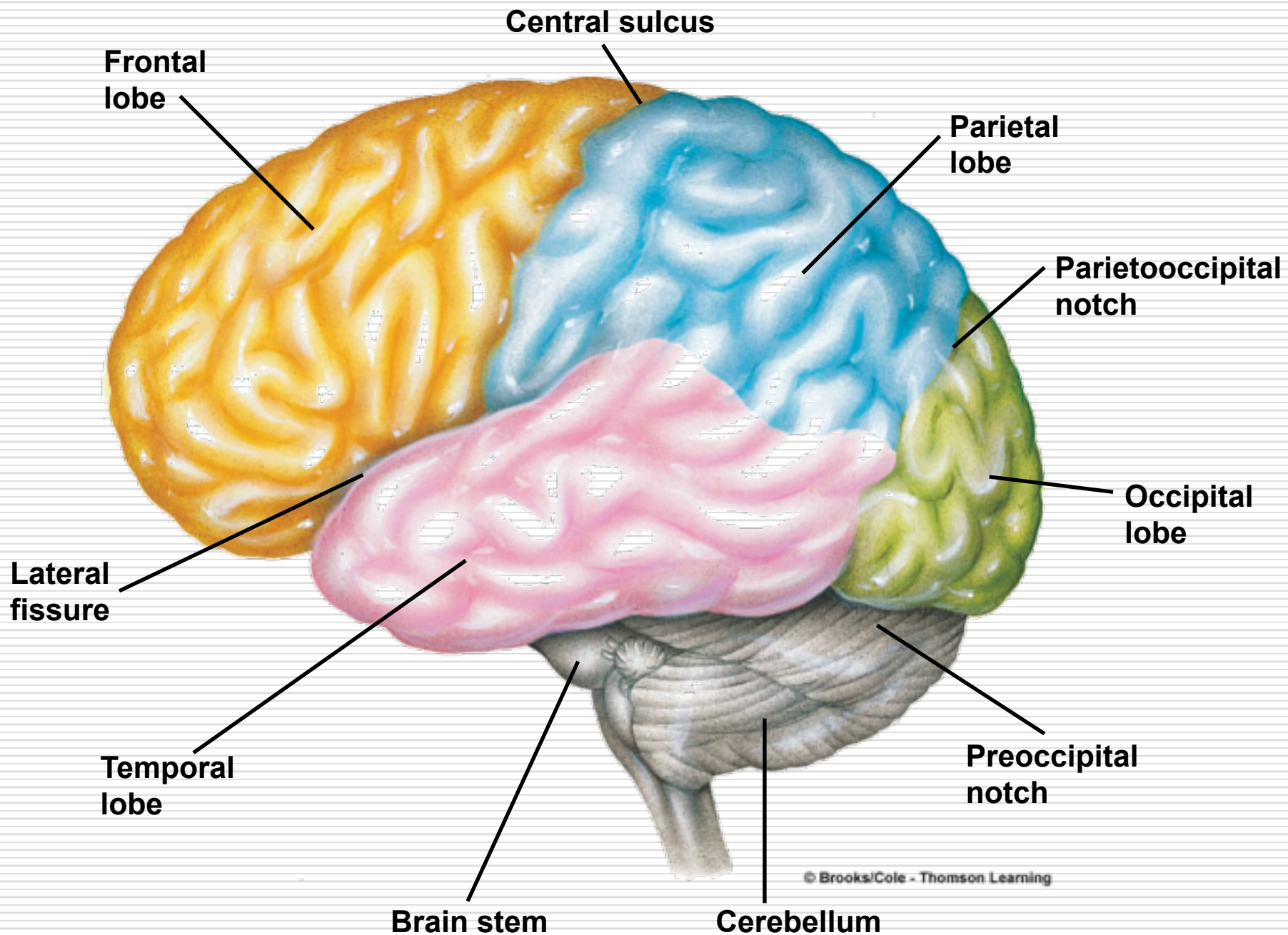
# Objectives

- Recognize cerebral cortical motor areas
- Delineate the cortical control of the corticospinal pathways
- Interpret some of the cortical abnormalities

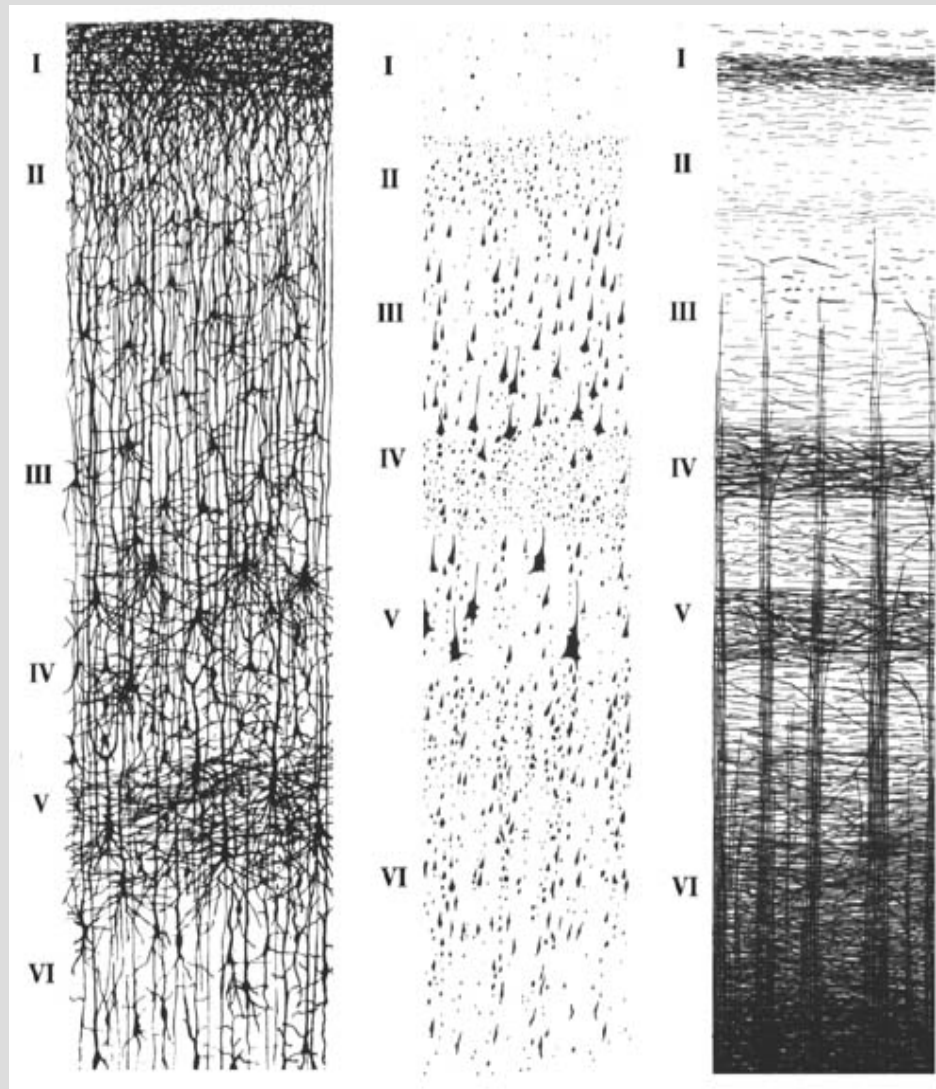


-  Motor Command
-  Feed Back
-  Command Monitor
-  Corrective Command

**Motor System**







Golgi

Nissl

Weigert

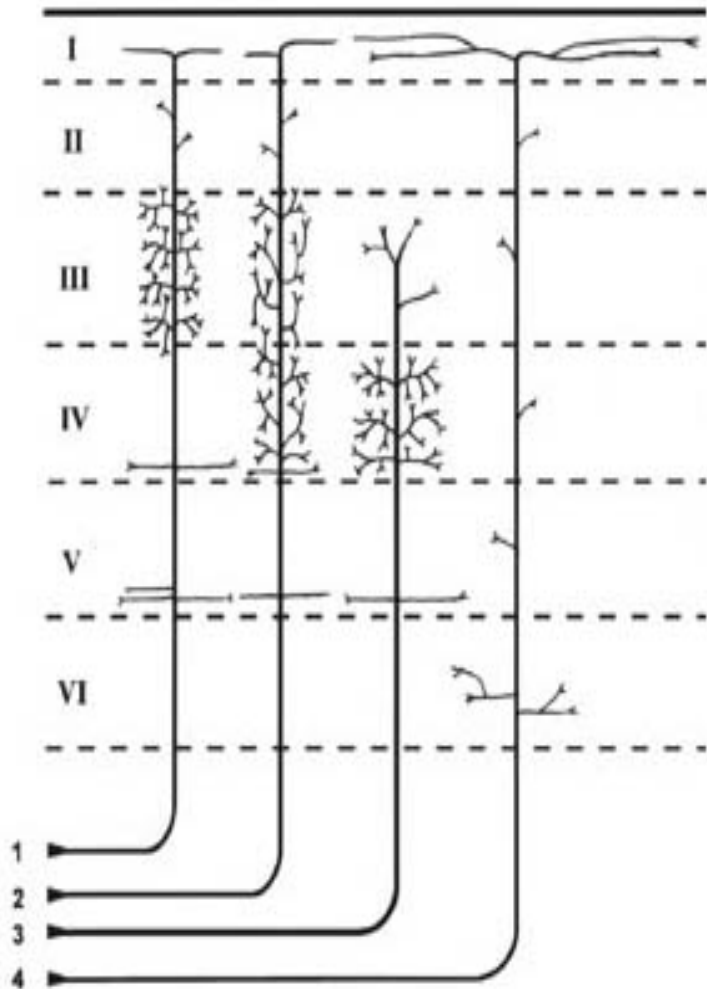
- I. Molecular Layer
- II. External Granular Layer
- III. External Pyramidal Layer
- IV. Internal Granular Layer
- V. Internal Pyramidal Layer  
Giant pyramidal cell of Betz
- VI. Polymorphic Layer

# Cortical Afferent Fiber

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1. corticocortical fiber
  - association fiber
  - commissural fiber
2. thalamocortical fiber - specific and non-specific
3. extrathalamic subcortical fiber

# Cortical Afferent Fiber



1. association fiber
2. commissural fiber
3. specific  
thalamocortical fiber
4. non-specific  
thalamocortical fiber



# Cortical Efferent Fiber

## 1. Corticofugal Fiber - Projection Fiber

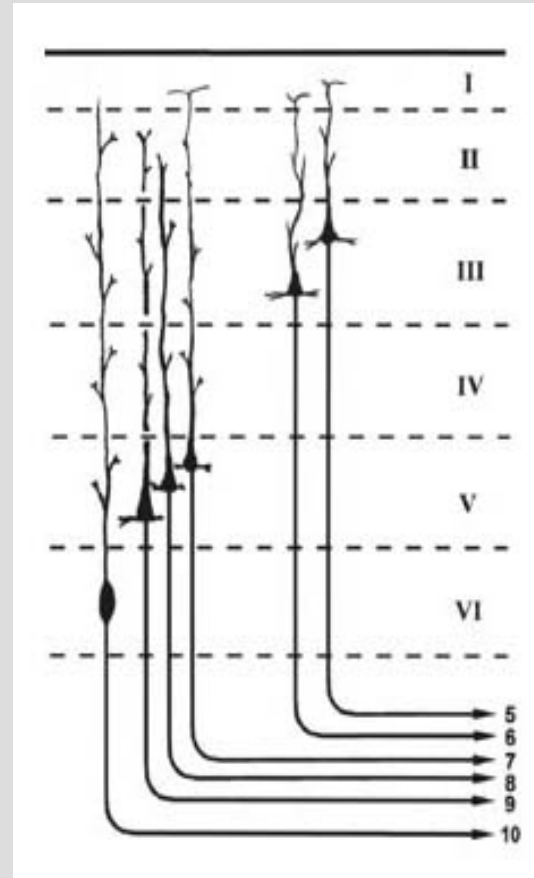
- corticostriate fiber
- corticothalamic fiber
- corticorubral fiber
- corticotectal fiber
- corticopontine fiber
- cortico-olivary fiber
- corticobulbar fiber
- corticospinal fiber

## 2. Corticocortical Fiber

- Association fiber
- Commissural fiber

# Cortical Efferent Fiber

- 5. association fiber
- 6. commissural fiber
- 7. corticostriate fiber
- 8. corticorubral fiber
- corticopontine fiber
- corticobulbar fiber
- 9. corticospinal fiber
- corticotectal fiber
- 10. corticothalamic fiber

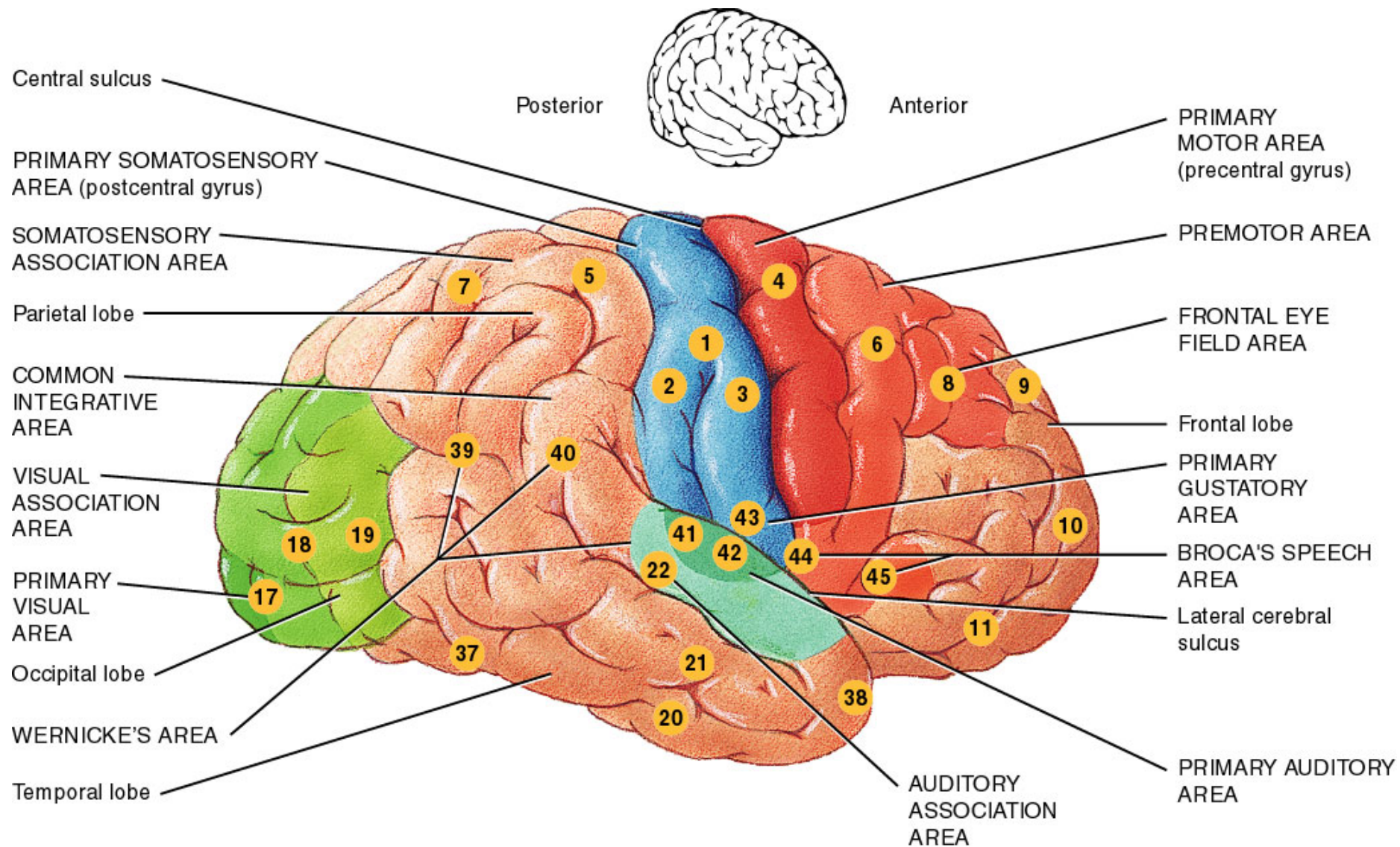


# Motor Cortex

- Divided into 3 sub areas
  - primary motor cortex
    - unequal topographic representation
    - fine motor movement elicited by stimulation
  - premotor area
    - topographical organization similar to primary motor cortex
    - stimulation results in movement of muscle groups to perform a specific task
    - works in concert with other motor areas

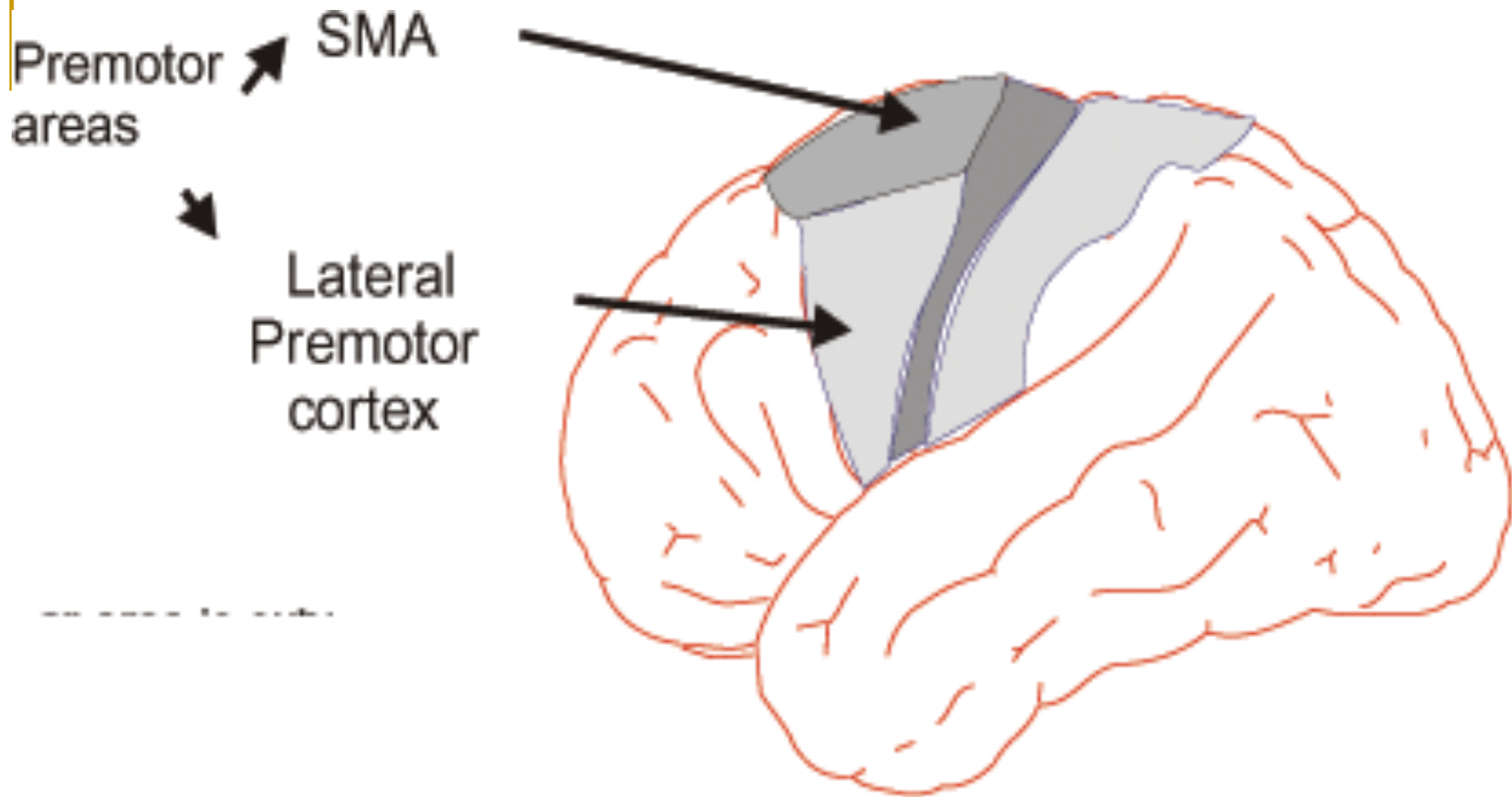
# Motor Cortex (Cont.)

- ❑ supplemental motor area
  - topographically organized
  - simulation often elicits bilateral movements.
  - functions in concert with premotor area to provide attitudinal, fixation or positional movement for the body
  - it provides the background for fine motor control of the arms and hands by premotor and primary motor cortex



Lateral view of right cerebral hemisphere

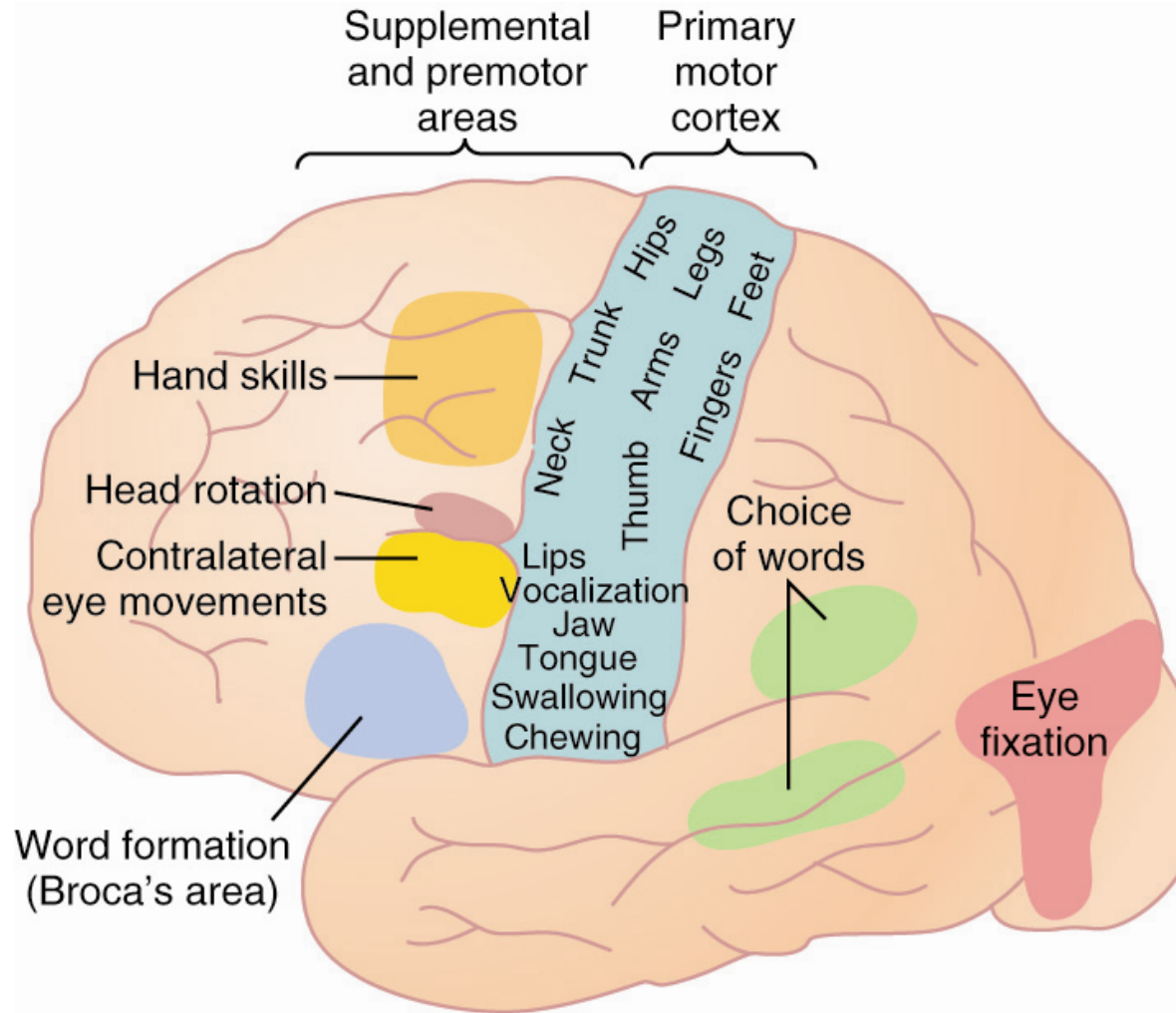
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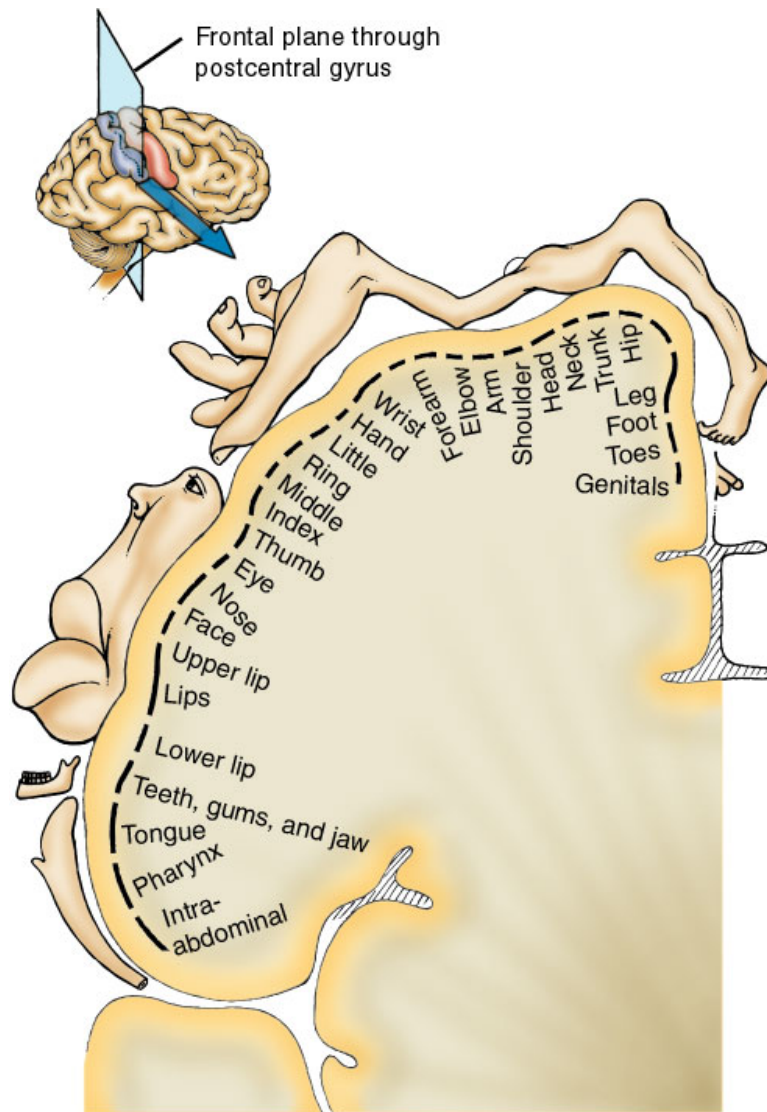


- Premotor area composed of supplementary motor area and lateral Premotor area

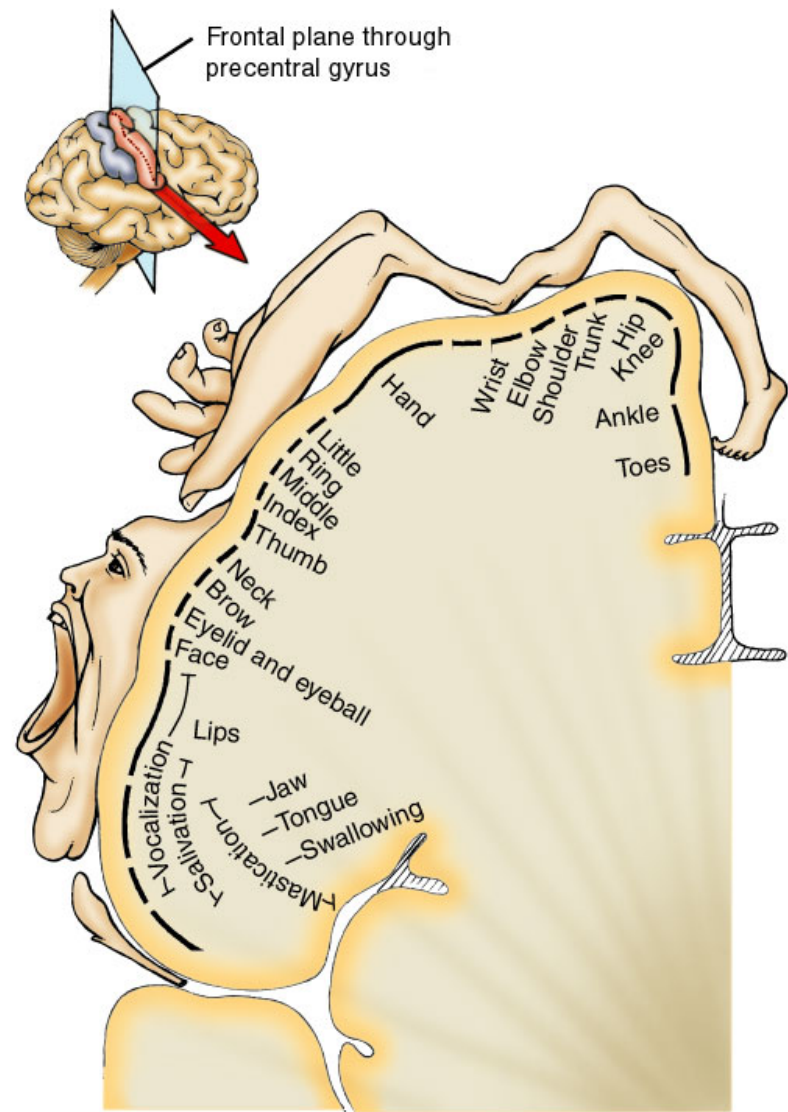


# Motor Areas of the Cortex



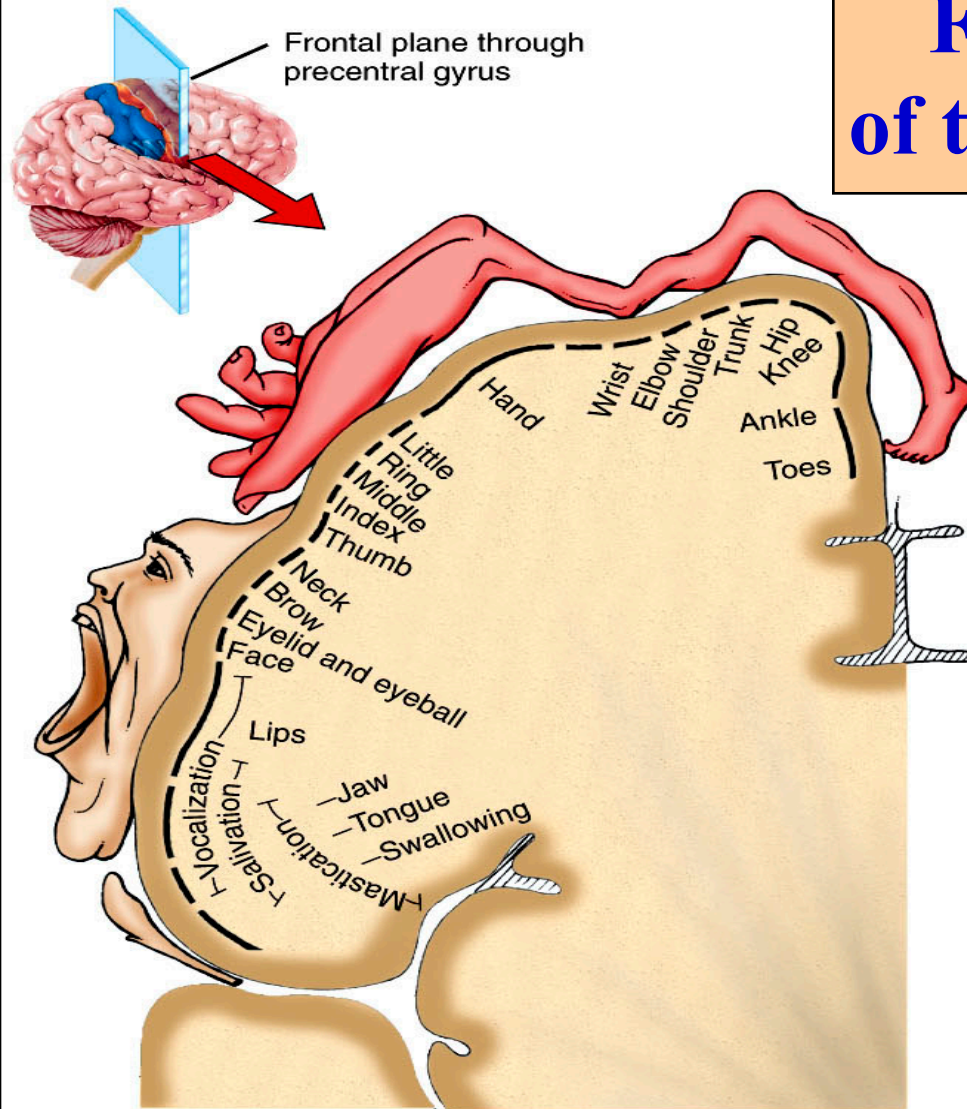


(a) Frontal section of primary somatosensory area in right cerebral hemisphere



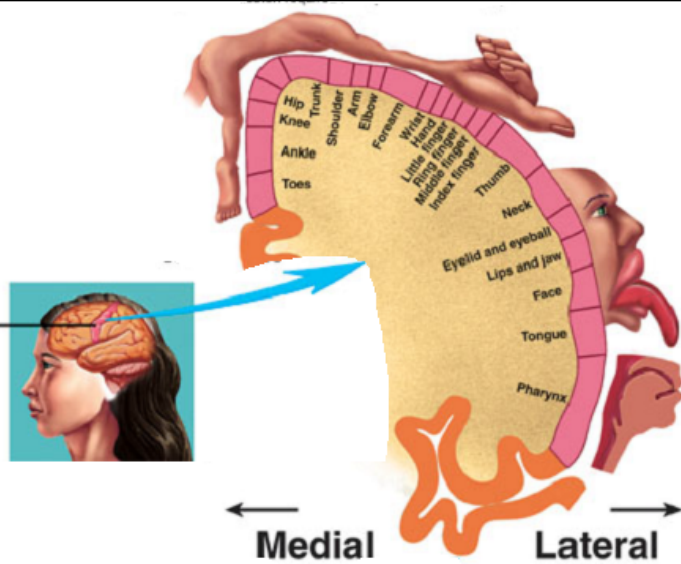
(b) Frontal section of primary motor area in right cerebral hemisphere

# Functional organization of the primary Motor Cortex



(b) Frontal section of primary motor area in right cerebral hemisphere

- ❖ Located in the precentral gyrus of the frontal lobe.
- ❖ More cortical area is devoted to those muscles involved in skilled, complex or delicate movements, that have more motor units i.e the cortical representation is proportional to the No of motor units



## Characteristics of the PMC:

1, It has predominant influence on the opposite side of the body (except some portions of the face)

2. It is organized in a homunculus pattern with inversed order

3. The degree of representation is proportional to the discreteness (number of motor unit) of movement required of the respective part of the body. (Face and fingers have large representative)

4. Stimulation of a certain part of PMC can cause very specific muscle contractions but not coordinate movement.



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- Projects directly

- to the spinal cord to regulate movement

- Via the *Corticospinal Tract*

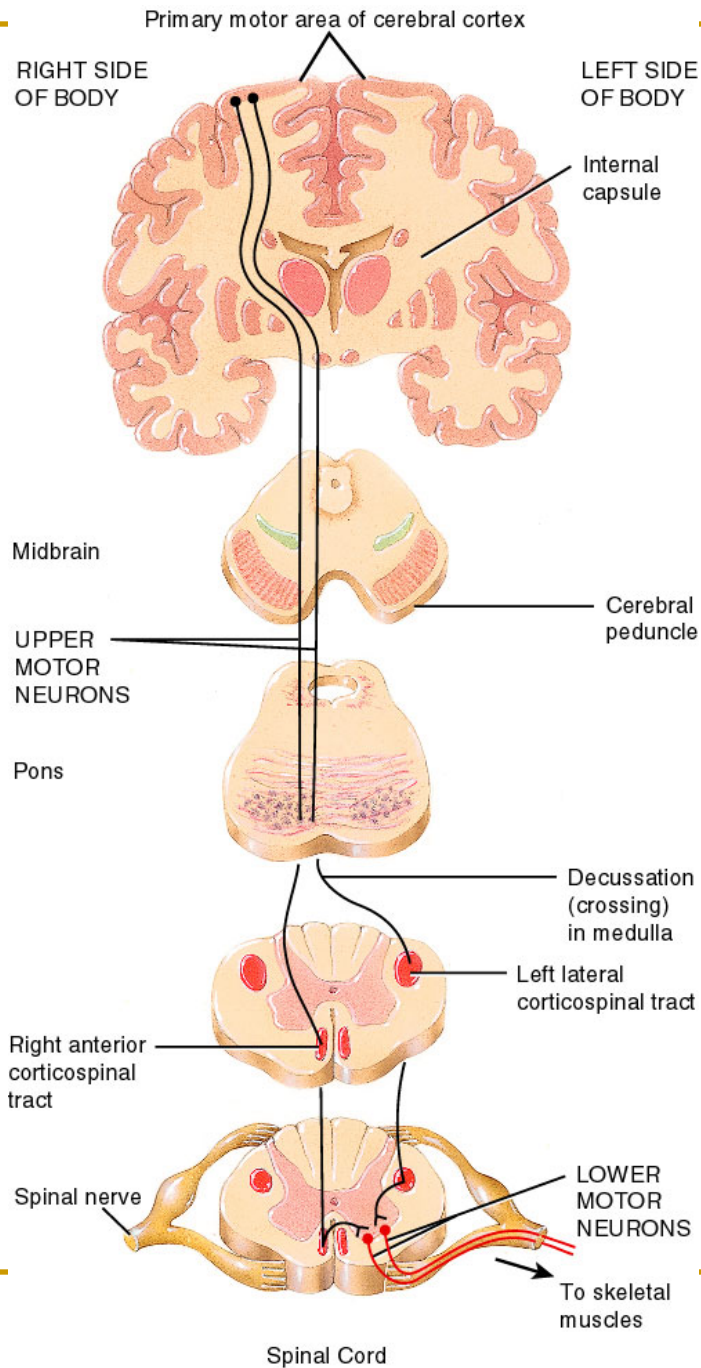
- The pyramidal system

- Projects indirectly

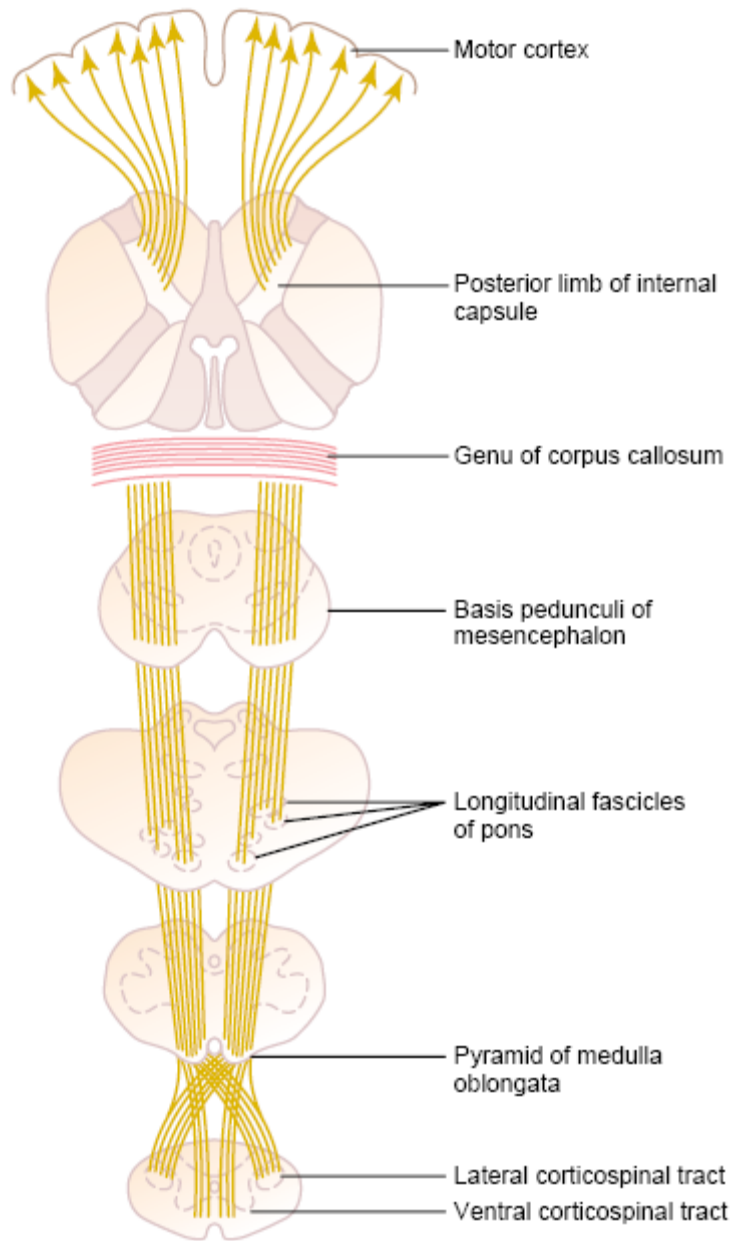
- Via the Brain stem to regulate movement

- extrapyramidal system

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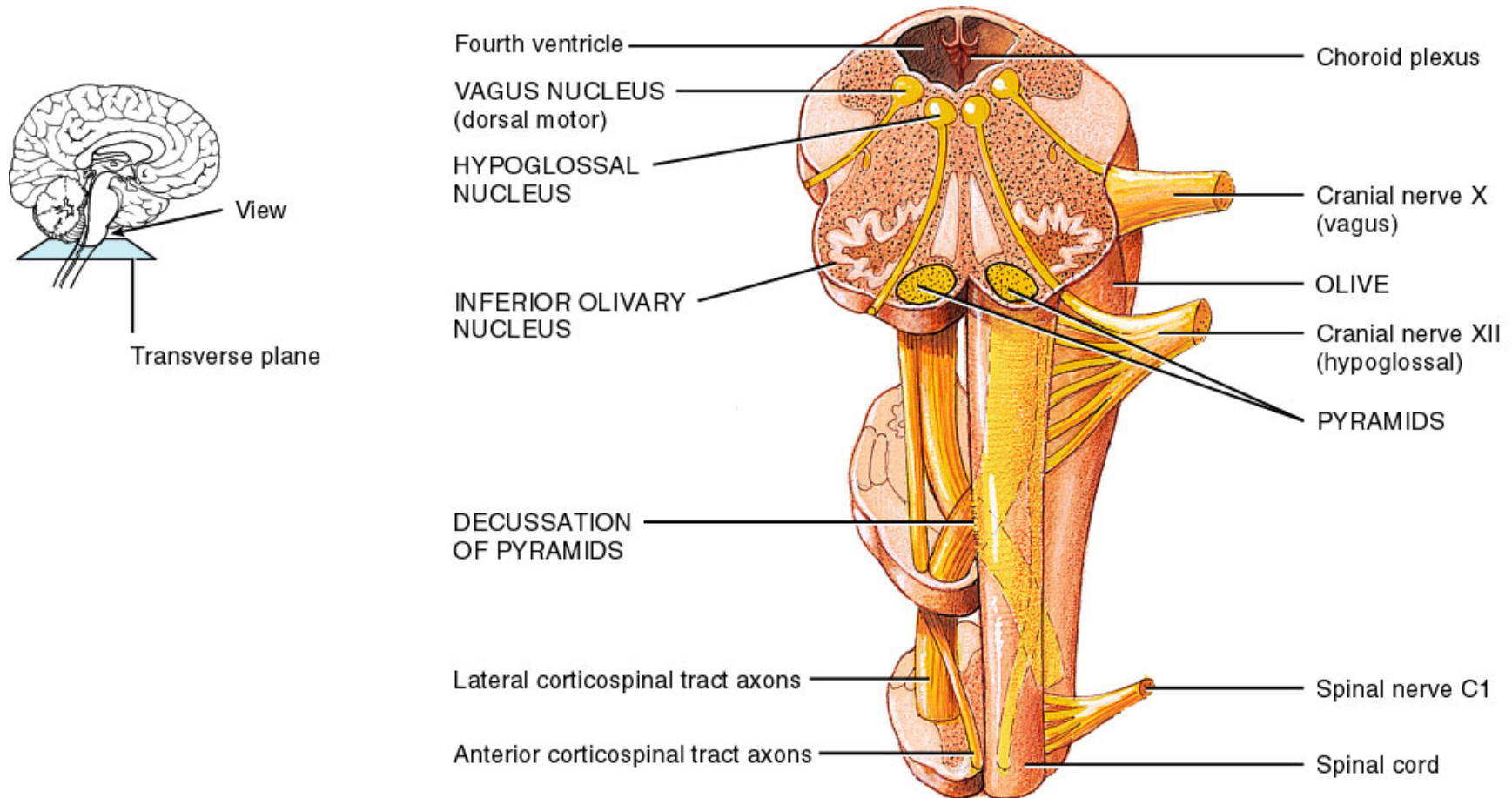


## Corticospinal pathways

**Figure 55-4**

Pyramidal tract. (Modified from Ranson SW, Clark SL: *Anatomy of the Nervous System*. Philadelphia: WB Saunders, 1959.)

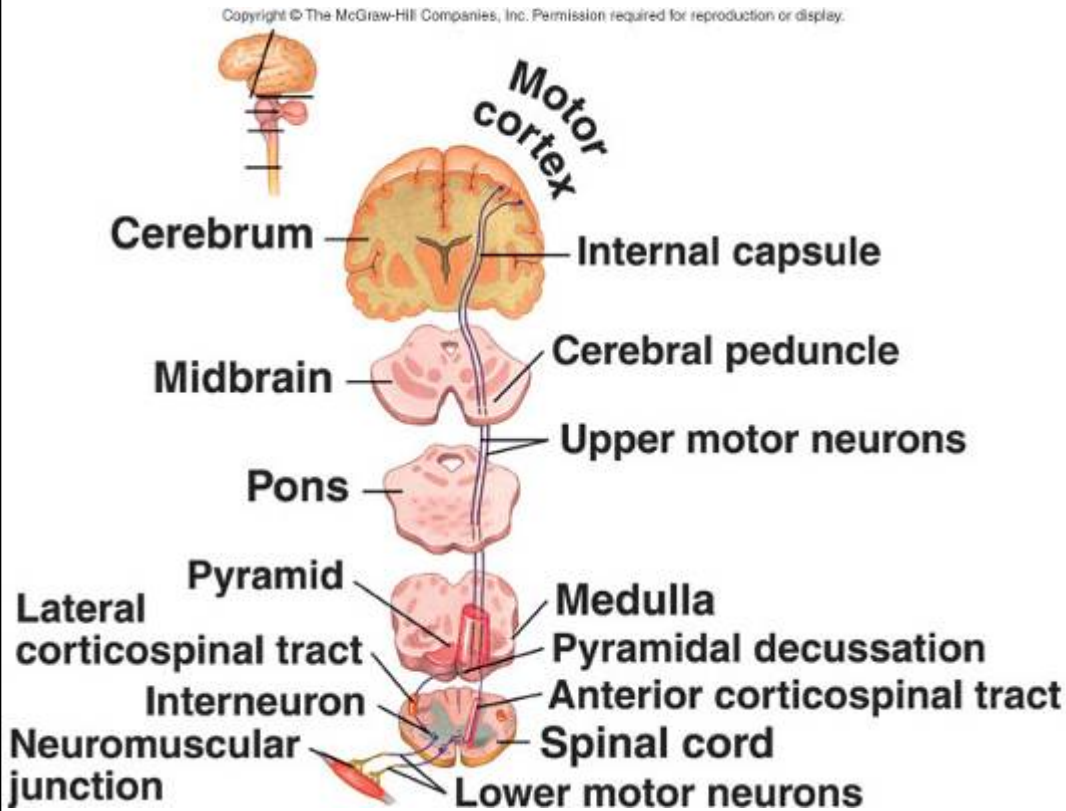
# Medulla Oblongata



Transverse section and anterior surface of medulla oblongata

# Descending Spinal Pathways

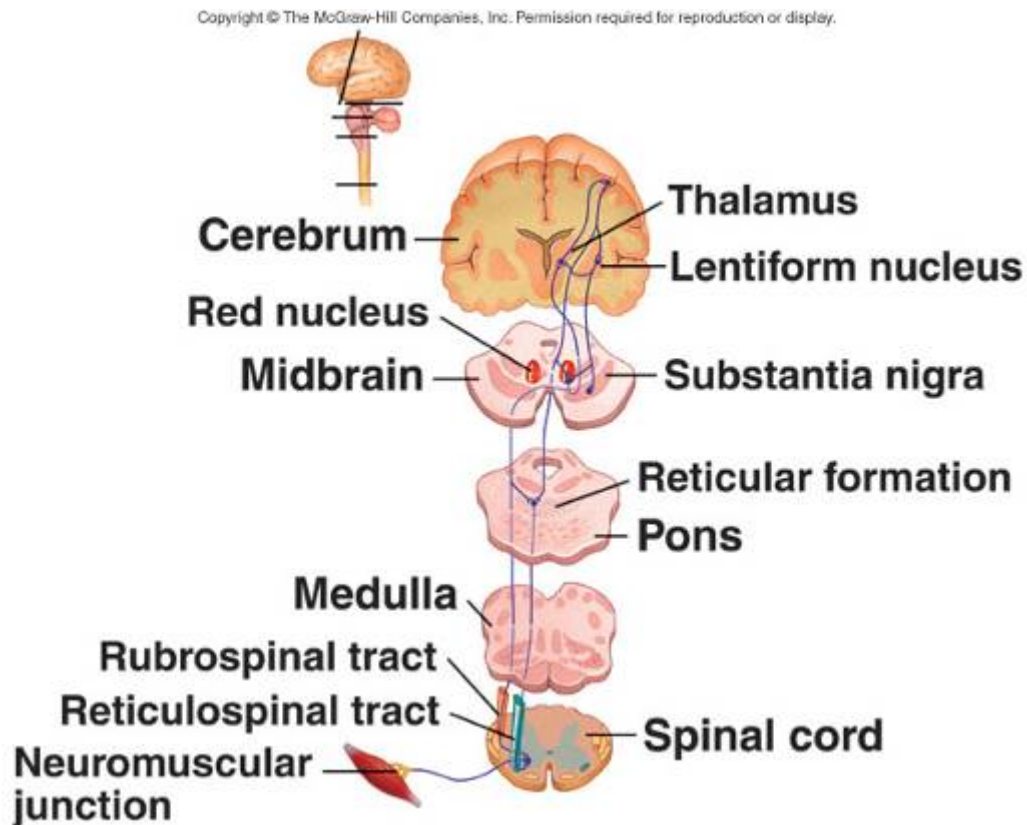
## pyramidal system



- Direct
  - Control muscle tone and conscious skilled movements
  - Direct synapse of upper motor neurons of cerebral cortex with lower motor neurons in brainstem or spinal cord

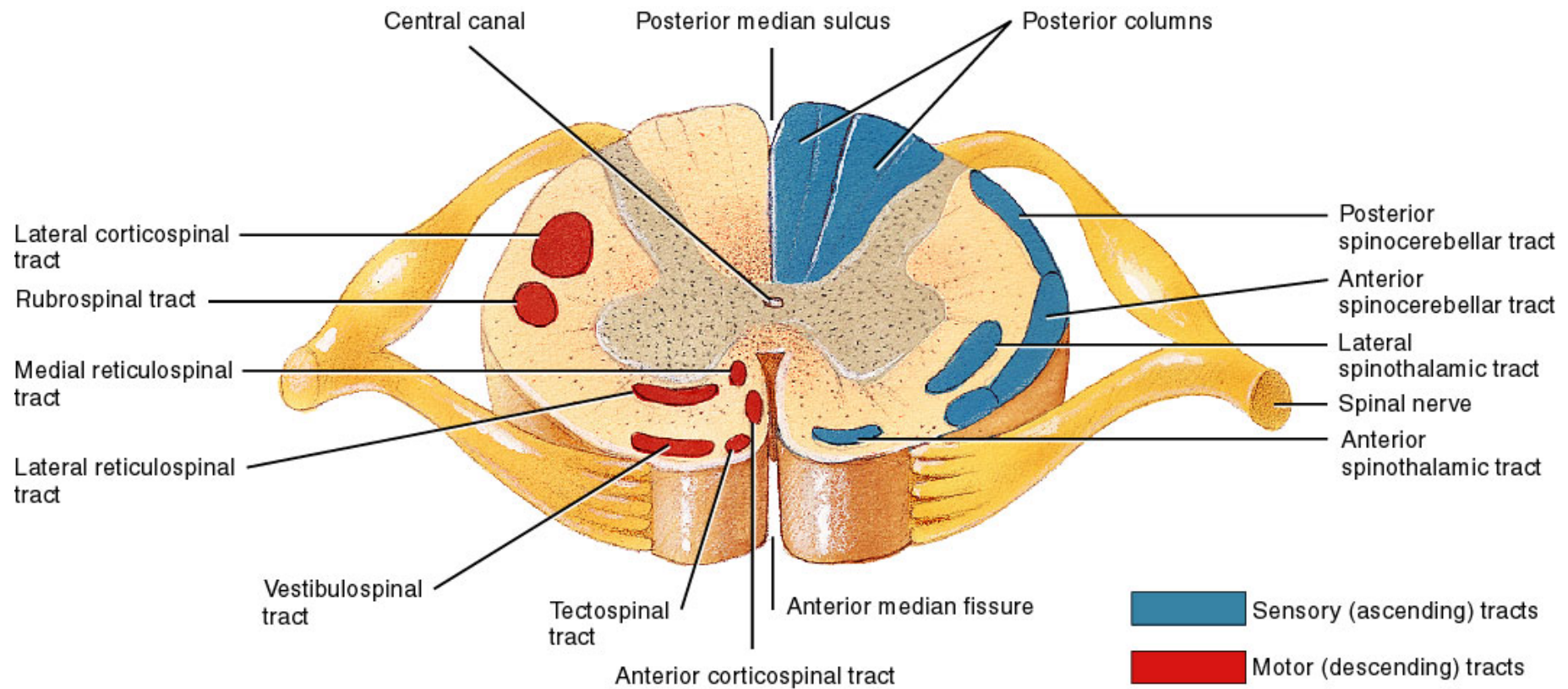
# Descending Spinal Pathways

## extrapyramidal system



- Indirect
- coordination of head & eye movements,
- coordinated function of trunk & extremity musculature to maintaining posture and balance
- Synapse in some intermediate nucleus rather than directly with lower motor neurons

# Spinal cord

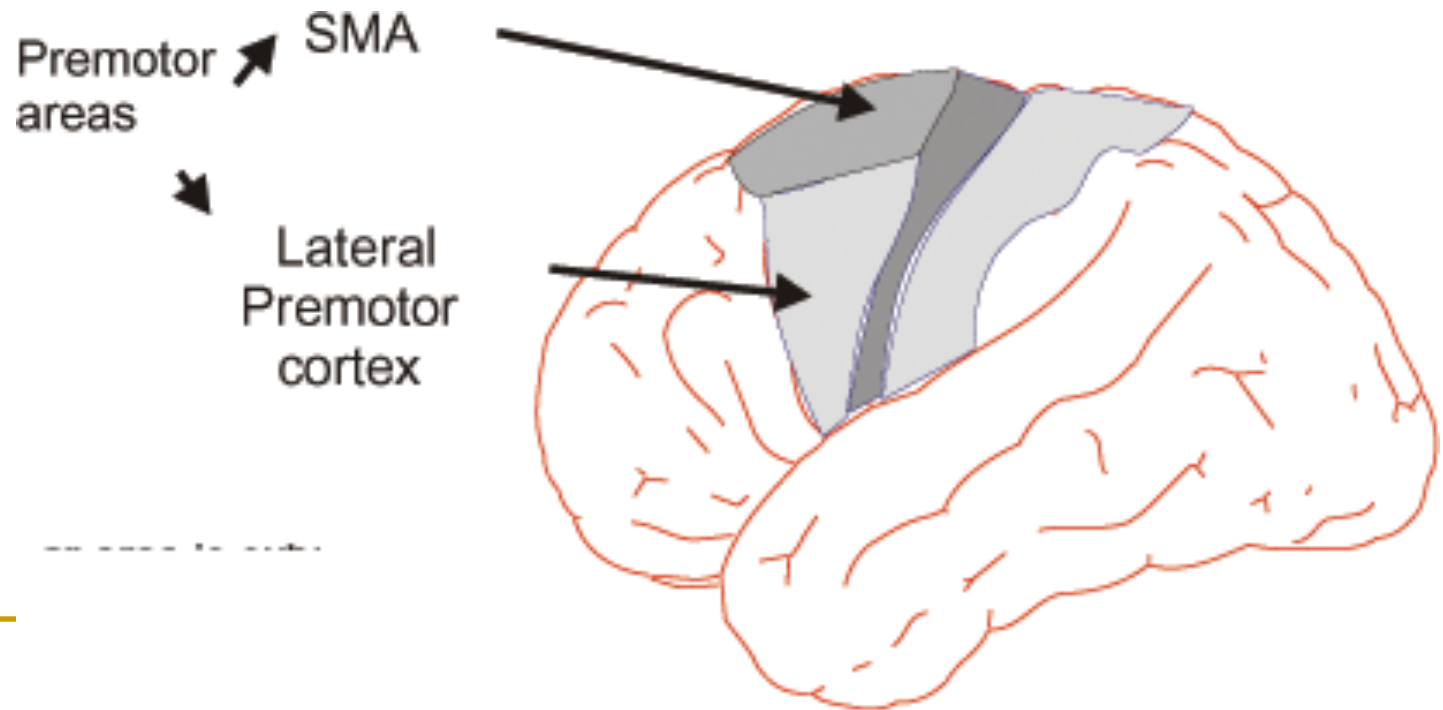


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# Premotor Areas

- Receive information from parietal and prefrontal areas
- Project to primary motor cortex and spinal cord
- For planning and coordination of complex planned movements





# Transmission of Cortical Motor Signals

- Direct pathway
  - corticospinal tract
  - for discrete detailed movement
- Indirect pathway
  - signals to basal ganglia, cerebellum, and brainstem nuclei

# Corticospinal Fibers

- 34,000 Betz cell fibers, make up only about 3% of the total number of fibers
- 97% of the 1 million fibers are small diameter fibers
  - conduct background tonic signals
  - feedback signals from the cortex to control intensity of the various sensory signals to the brain

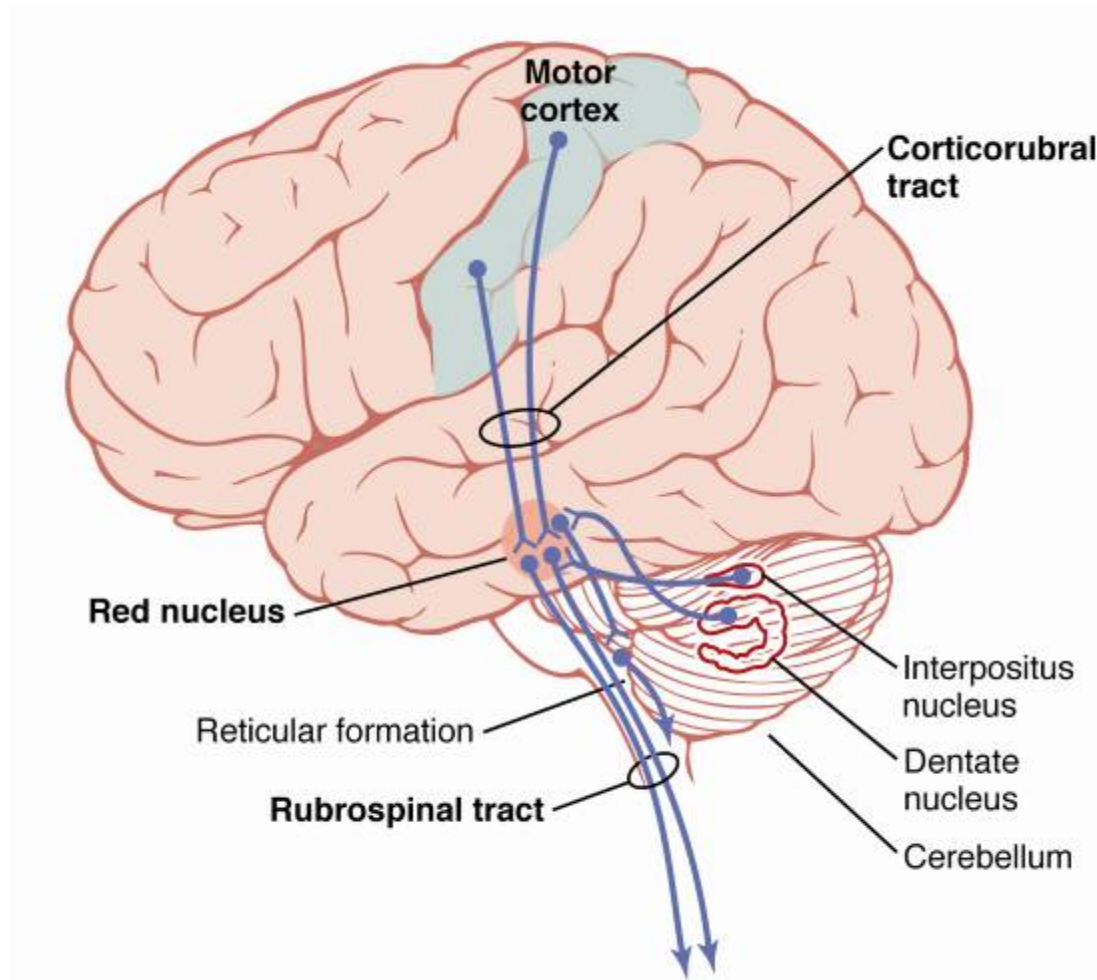
# Other Pathways from the Motor Cortex

- Betz collaterals back to cortex sharpen the boundaries of the excitatory signal
- Fibers to caudate nucleus and putamen of the basal ganglia
- Fibers to the red nucleus, which then sends axons to the cord in the rubrospinal tract
- Reticular substance, vestibular nuclei and pons then to the cerebellum
- Therefore the basal ganglia, brain stem and cerebellum receive a large number of signals from the cortex.

# Excitation of Spinal Motor Neurons

- Motor neurons in cortex reside in layer V.
- Excitation of 50-100 giant pyramidal cells is needed to cause muscle contraction.
- Most corticospinal fibers synapse with interneurons.
- Some corticospinal and rubrospinal neurons synapse directly with alpha motor neurons in the spinal cord especially in the cervical enlargement.
- These motor neurons innervate muscles of the fingers and hand.

# Other Motor Pathways



# Incoming Sensory Pathways to Motor Cortex

- subcortical fibers from adjacent areas of the cortex especially from somatic sensory areas of parietal cortex and visual and auditory cortex.
  - subcortical fibers from opposite hemisphere which pass through *corpus callosum*.
  - somatic sensory fibers from ventrobasal complex of the thalamus (i.e. cutaneous and proprioceptive fibers).
-



## Incoming Sensory Pathways to Motor Cortex (Cont.)

- ventrolateral and ventroanterior nuclei of thalamus for coordination of function between motor cortex, basal ganglia, and cerebellum.
  - fibers from the intralaminar nuclei of thalamus (control level of excitability of the motor cortex), some of these may be pain fibers
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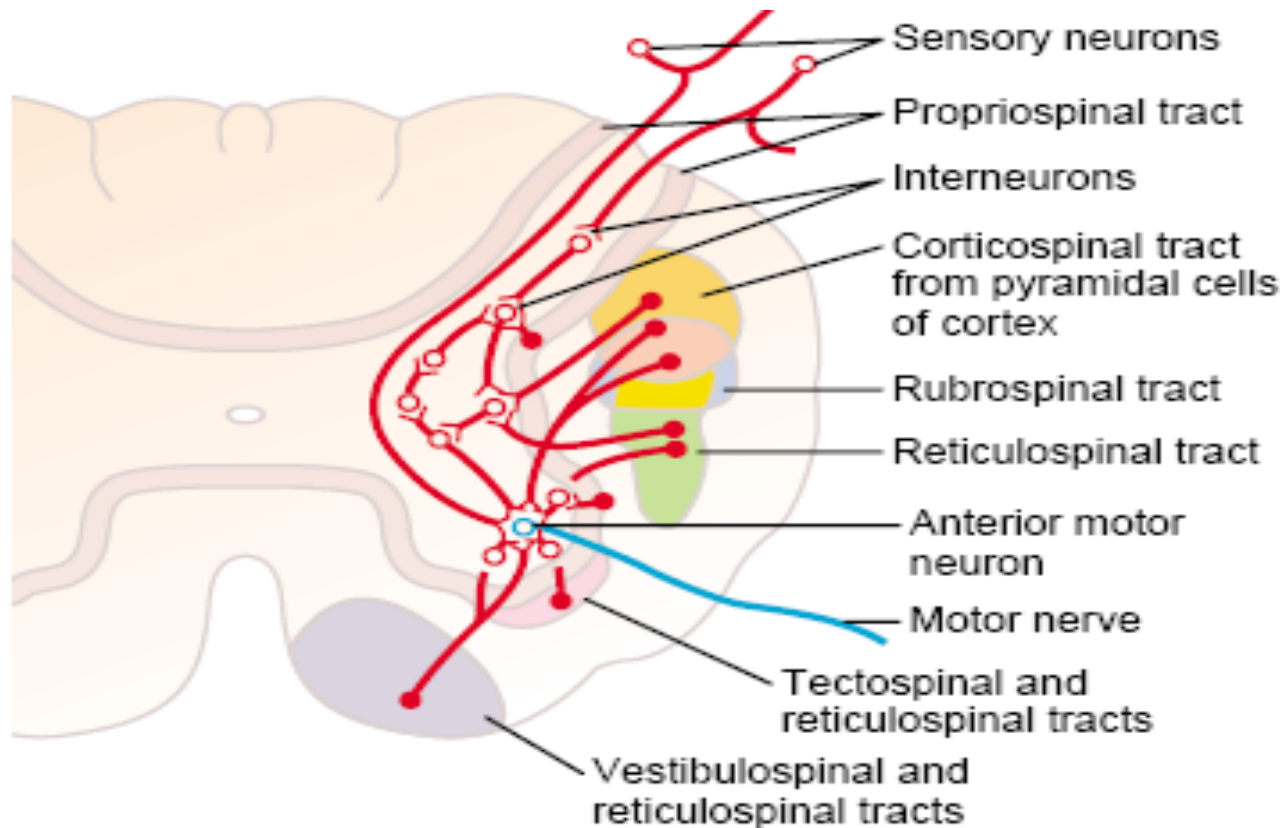
# Red Nucleus and the Rubrospinal Tract

- substantial input from primary motor cortex
- primary motor cortex fibers synapse in the lower portion of the nucleus called the magnocellular portion which contains large neurons similar to Betz cells
- magnocellular portion gives rise to rubrospinal tract
- magnocellular portion has somatotopic organization similar to primary motor cortex

# Red Nucleus and the Rubrospinal Tract

- stimulation of red nucleus causes relatively fine motor movement but not as discrete as primary motor cortex
- accessory route for transmission of discrete signals from the motor cortex

# Final Common Pathway



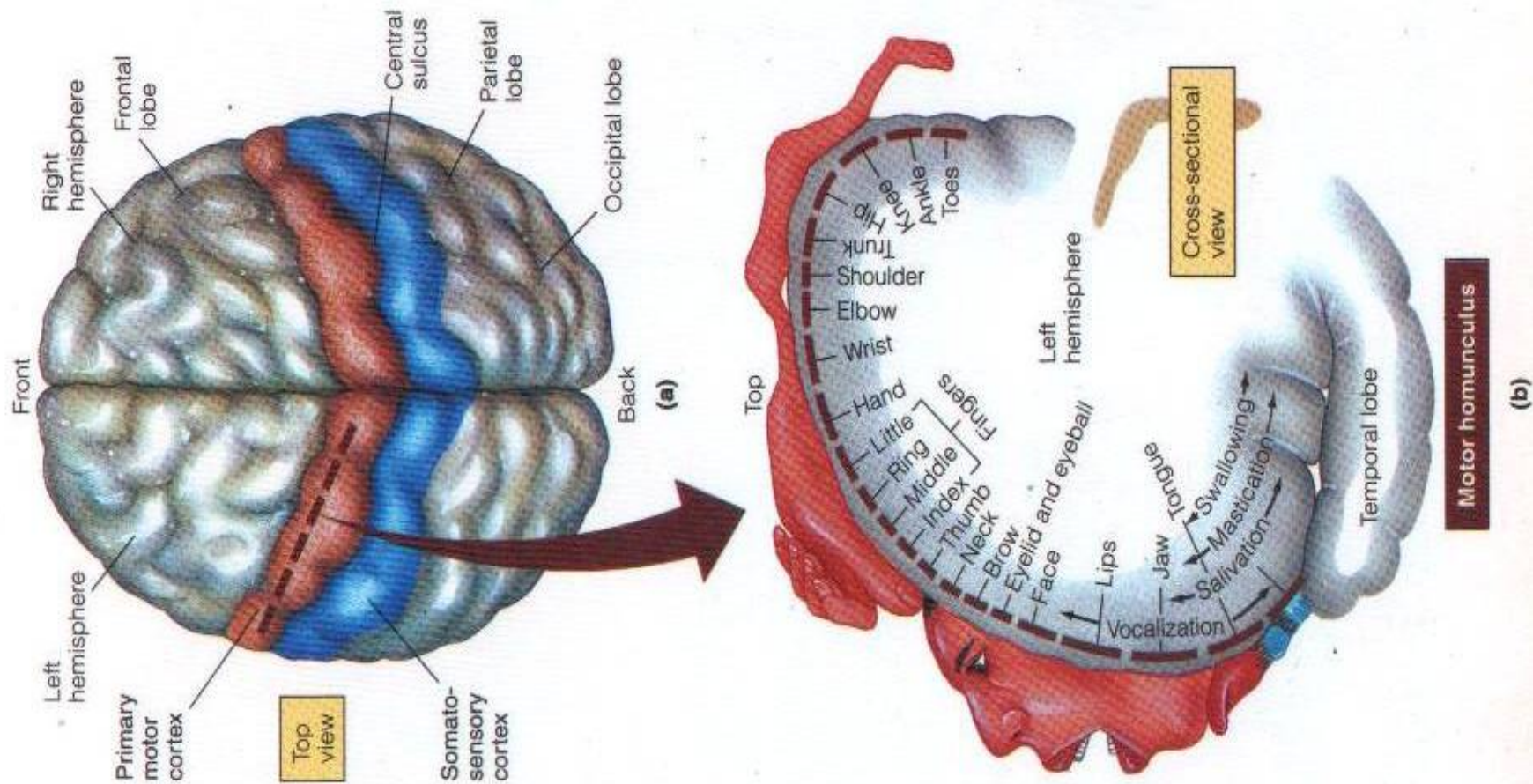
**Figure 55-6**

Convergence of different motor control pathways on the anterior motor neurons.

# Lesions of the Motor Cortex

- Primary motor cortex - loss of voluntary control of discrete movement of the distal segments of the limbs.

# Somatotopic Map of the Primary Motor Cortex

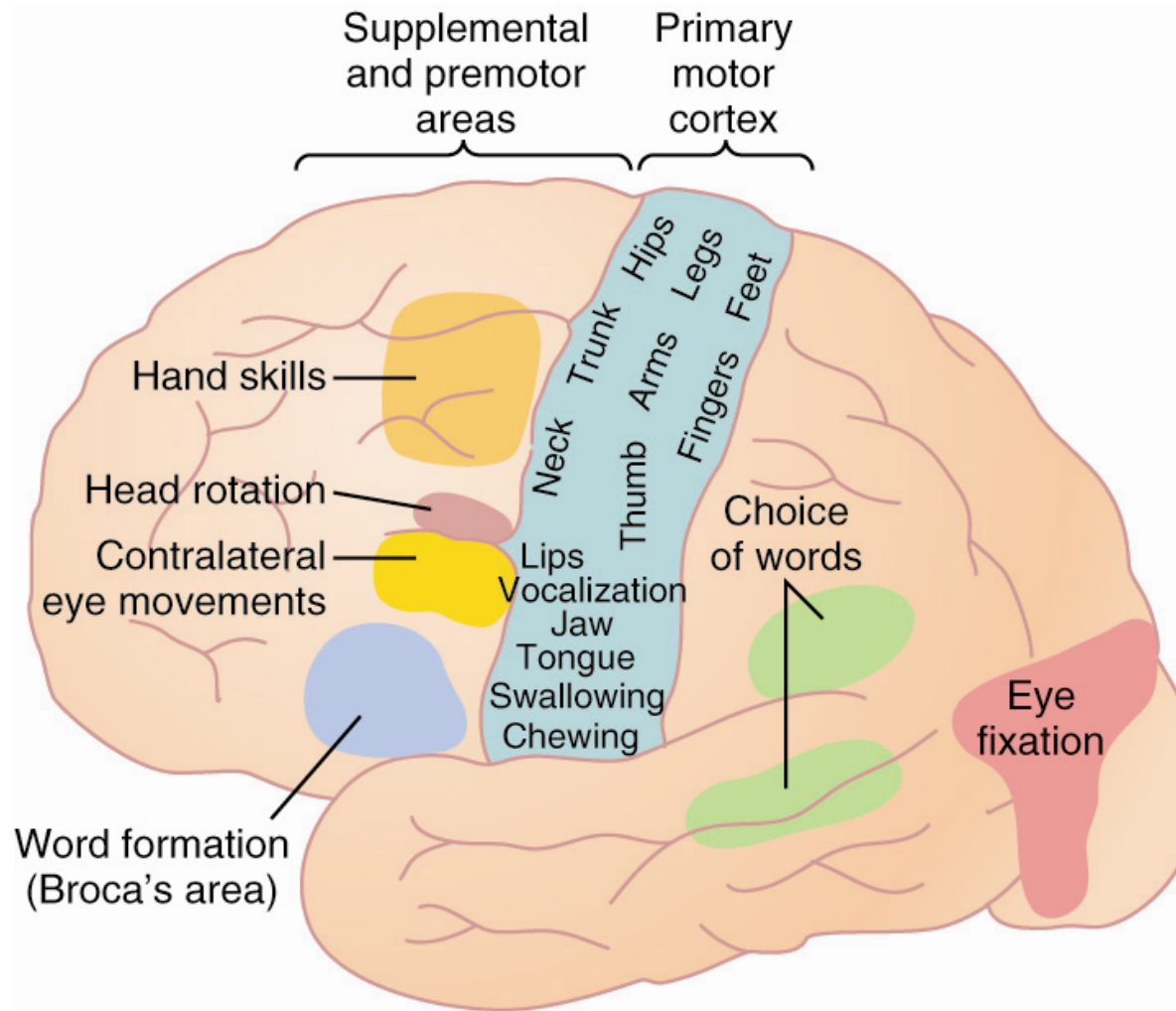




# Specialized Areas of the Motor Cortex

- Broca's area
  - ❑ damage causes decreased speech capability
  - ❑ closely associated area controls appropriate respiratory function for speech
- eye fixation and head rotation area
  - ❑ for coordinated head and eye movements
- hand skills area
  - ❑ damage causes *motor apraxia* the inability to perform fine hand movements

# Motor Areas of the Cortex





THANK YOU