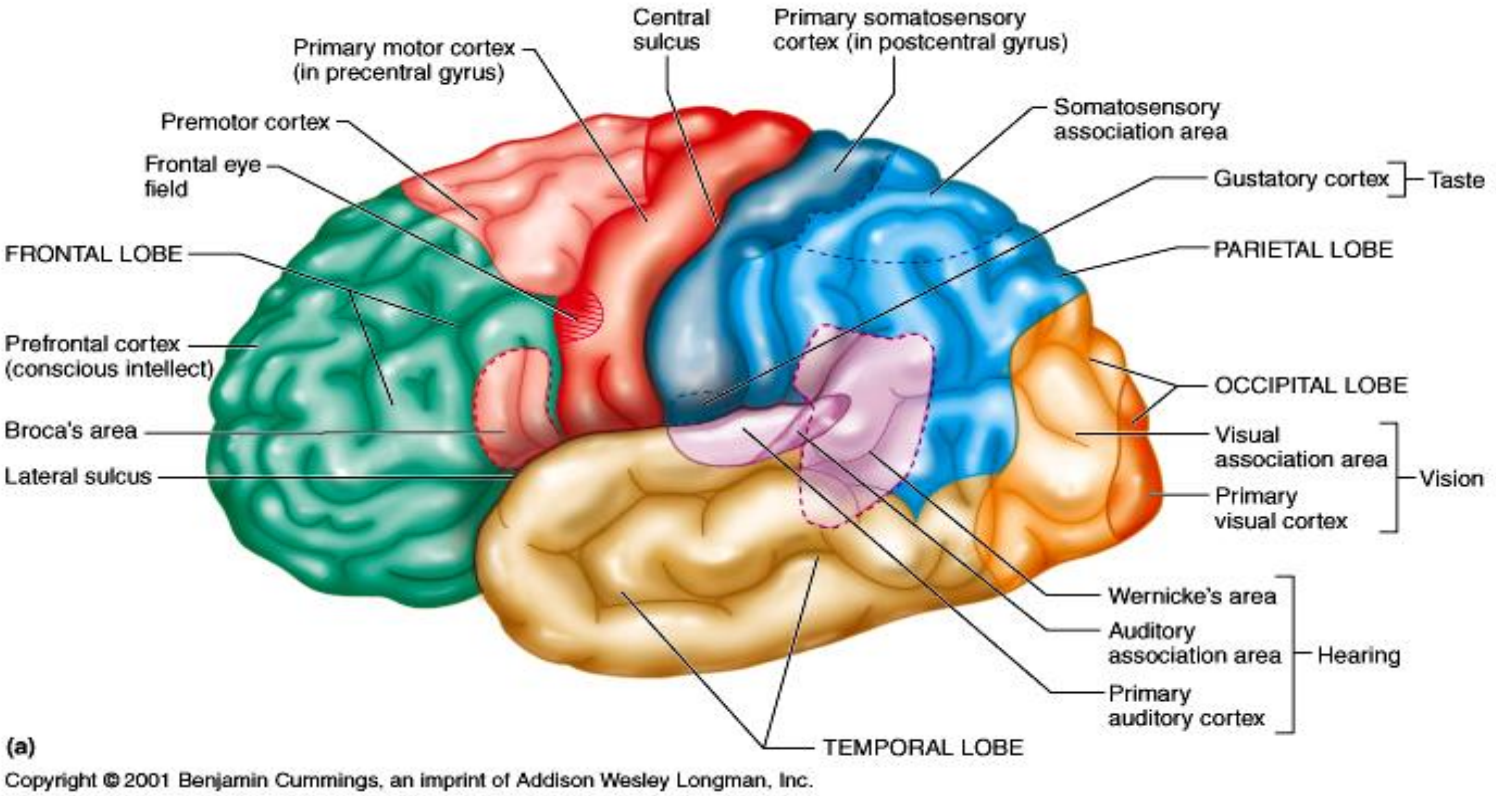
Cerebral Cortex

- Research on the structure and function of the brain reveals that there are both specialized and diffuse areas of function
- Motor and sensory areas are localized in discrete cortical areas called domains
- Many higher mental functions such as memory and language appear to have overlapping domains and are more diffusely located
- Broadmann areas are areas of localized function

Cerebral Cortex - Generalizations

- The cerebral cortex has three types of functional areas
  - Motor areas / control voluntary motor function
  - Sensory areas / provide conscious awareness of sensation
  - Association areas / act mainly to integrate diverse information for purposeful action
- Each hemisphere is chiefly concerned with the sensory and motor functions of the opposite (contralateral) side of the body

Motor Areas



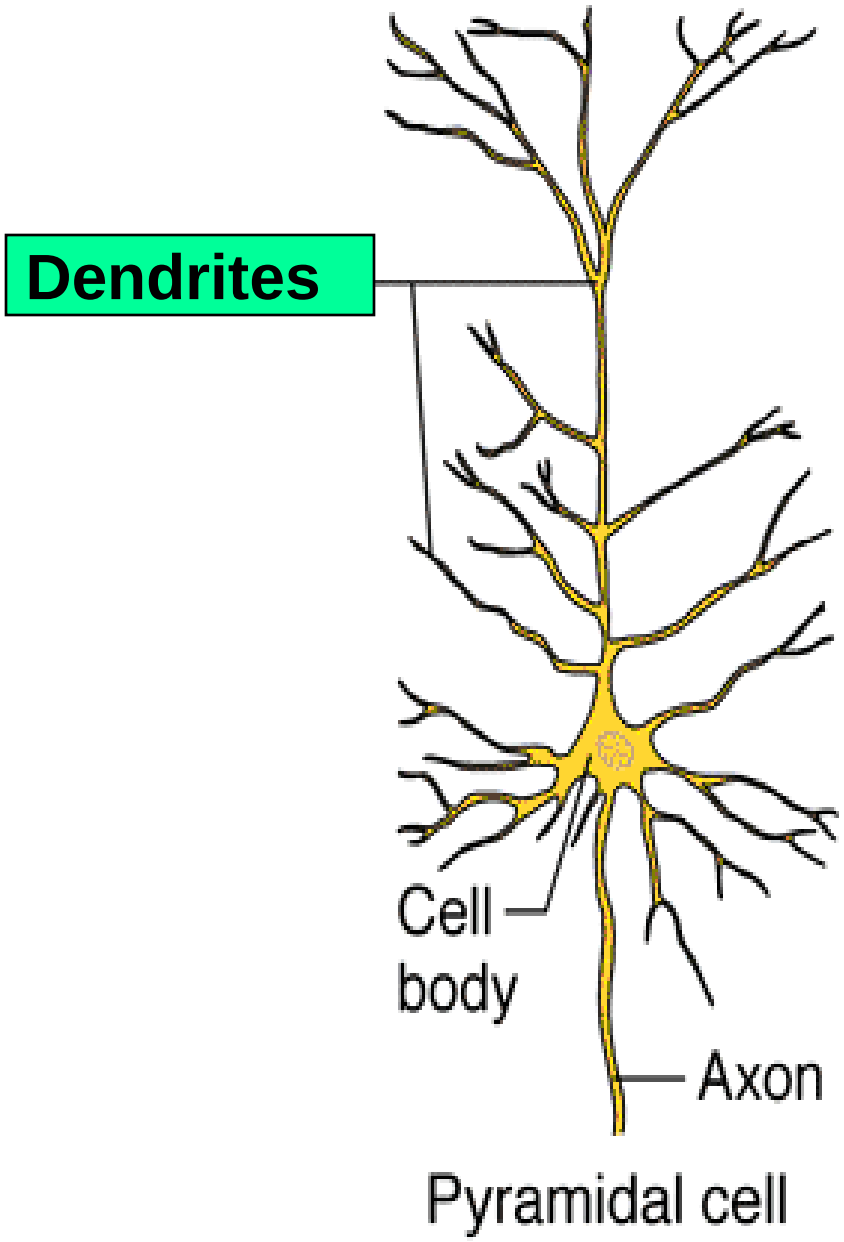
- Cortical areas controlling motor functions lie in the posterior part of the frontal lobes
- Motor areas include the primary motor cortex, the premotor cortex, Broca’s area, and the front eye field

Primary Motor Cortex

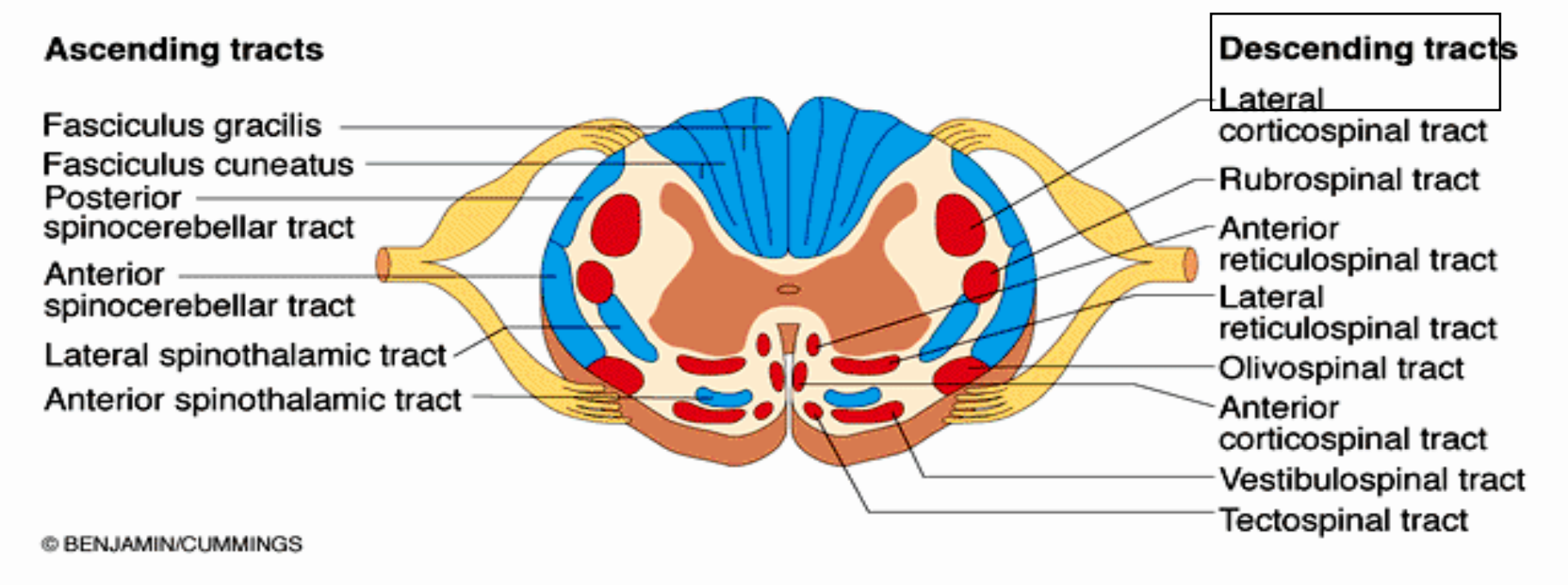
- The primary motor cortex is located in the precentral gyrus of the frontal lobe of each hemisphere
- Large neurons (pyramidal cells) in these gyri allow us to consciously control the precise or skill voluntary movements of our skeletal muscles

Pyramidal cells

- These long axons, which project to the spinal cord, form the massive voluntary motor tracts called the pyramidal, or corticospinal tracts
- All other descending motor tracts issue from brain stem nuclei and consists of chains of two, three, or more neurons



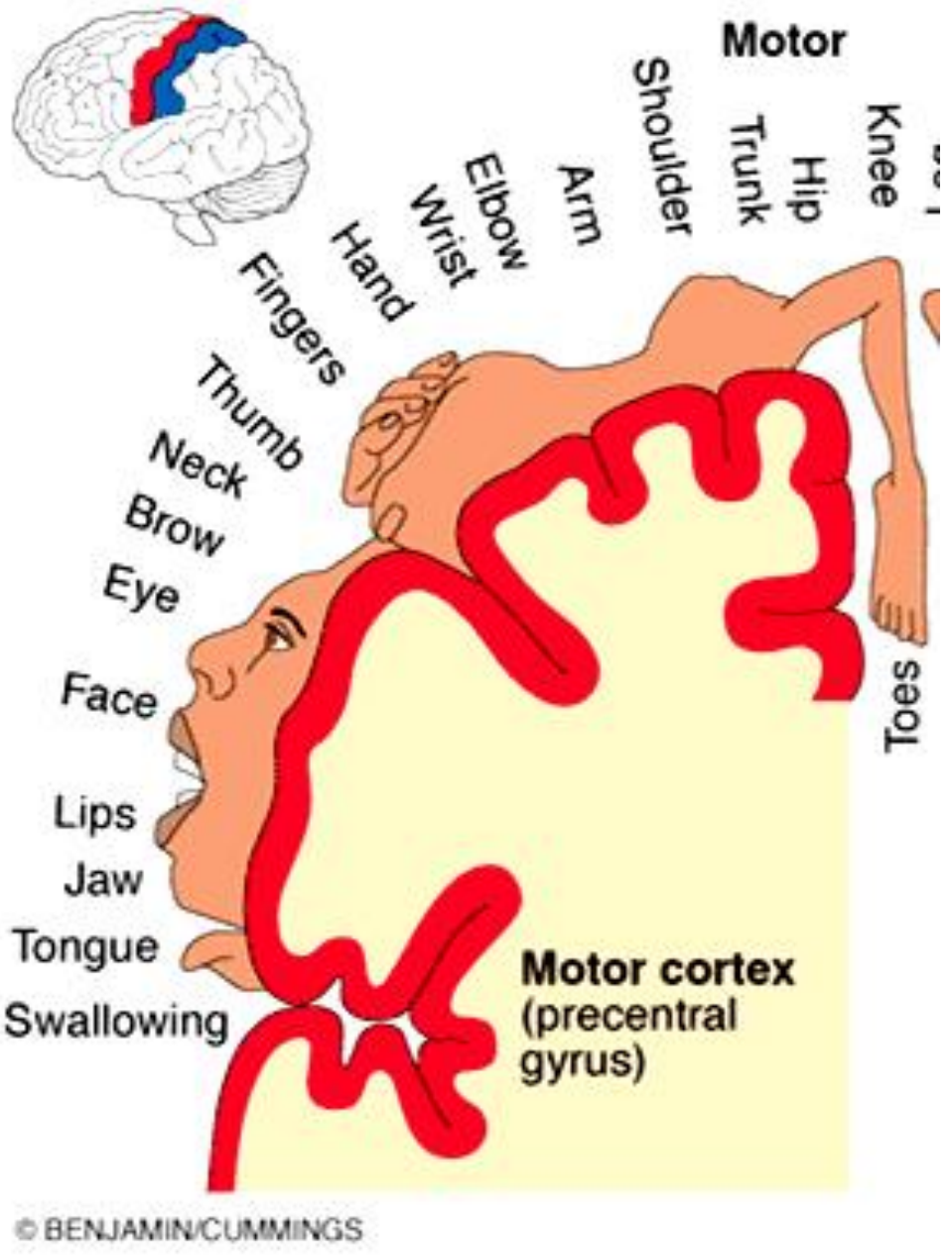
Pyramidal Tracts



- The lateral corticospinal tract consists of the long axons of the pyramidal cells located within the primary motor cortex

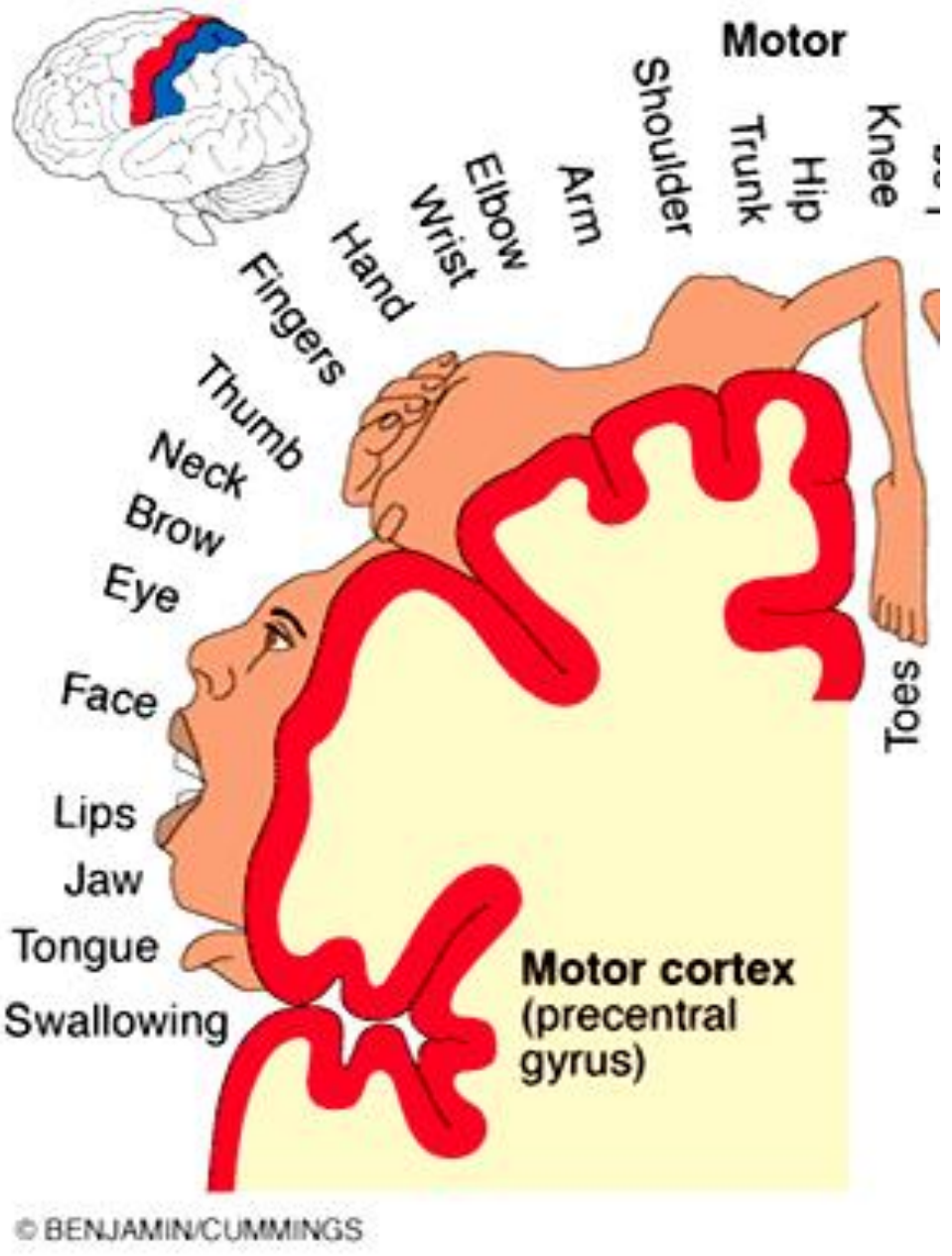
Motor Somatotopy

- Body is represented spatially in the primary motor cortex of each hemisphere
- Most of the neurons in these gyri control muscles in body areas having the most precise motor control
- The areas with the most control (face, tongue, and hands)



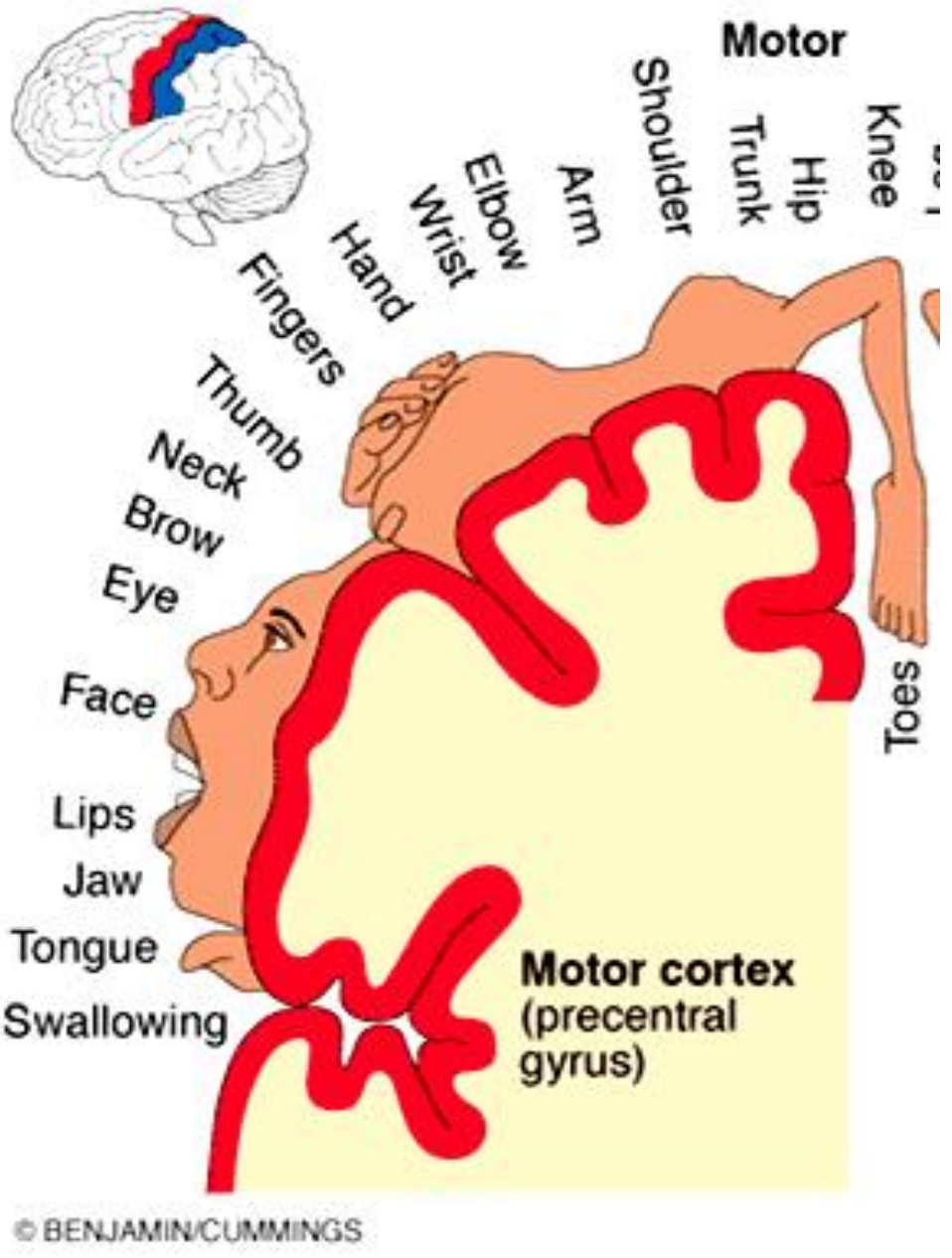
Motor Somatotopy

- Motor innervation is contralateral; left primary motor controls right side of body
- A given muscle may be controlled by several cortical neurons recruited for several specific actions



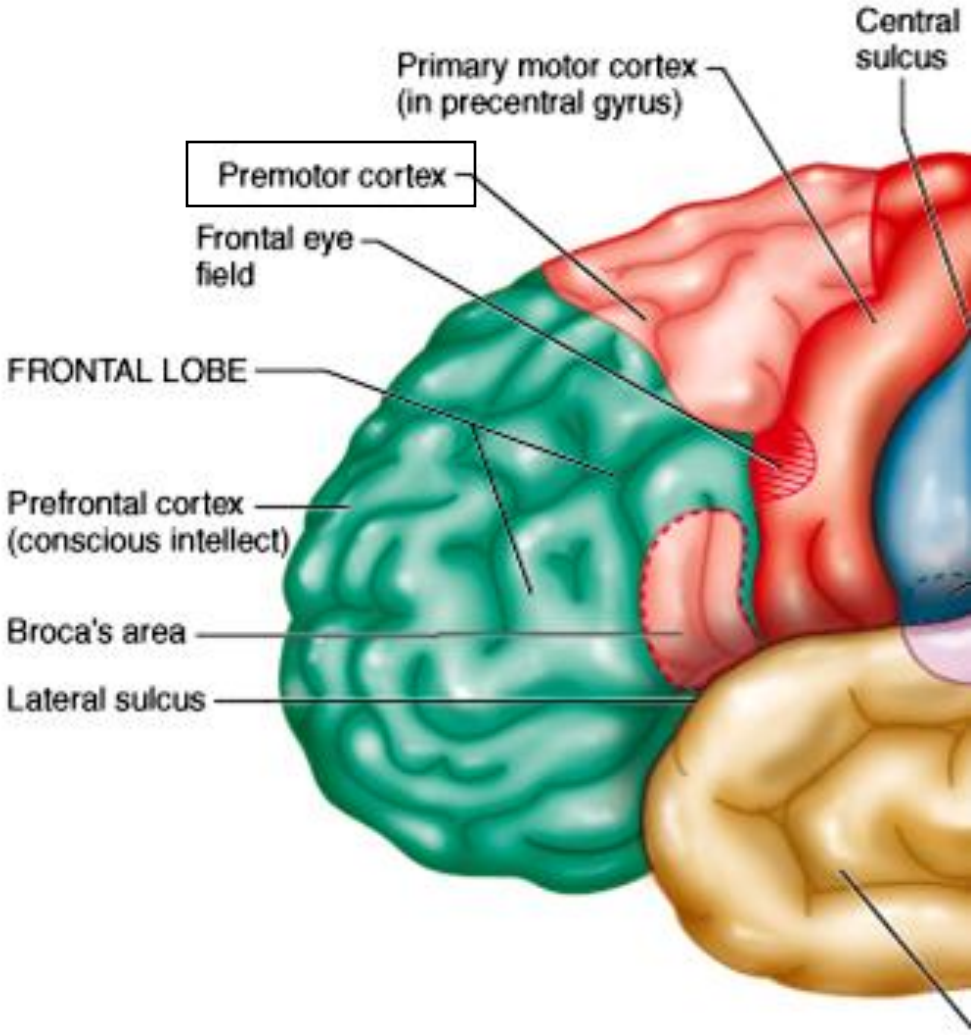
Motor Somatotopy

- Damage to the localized areas of the primary motor cortex paralyzes the muscles controlled by this area
- If the lesion is in the right hemisphere, the left side will be paralyzed
- Only voluntary control is lost as the muscles can still contract reflexively



Premotor Cortex

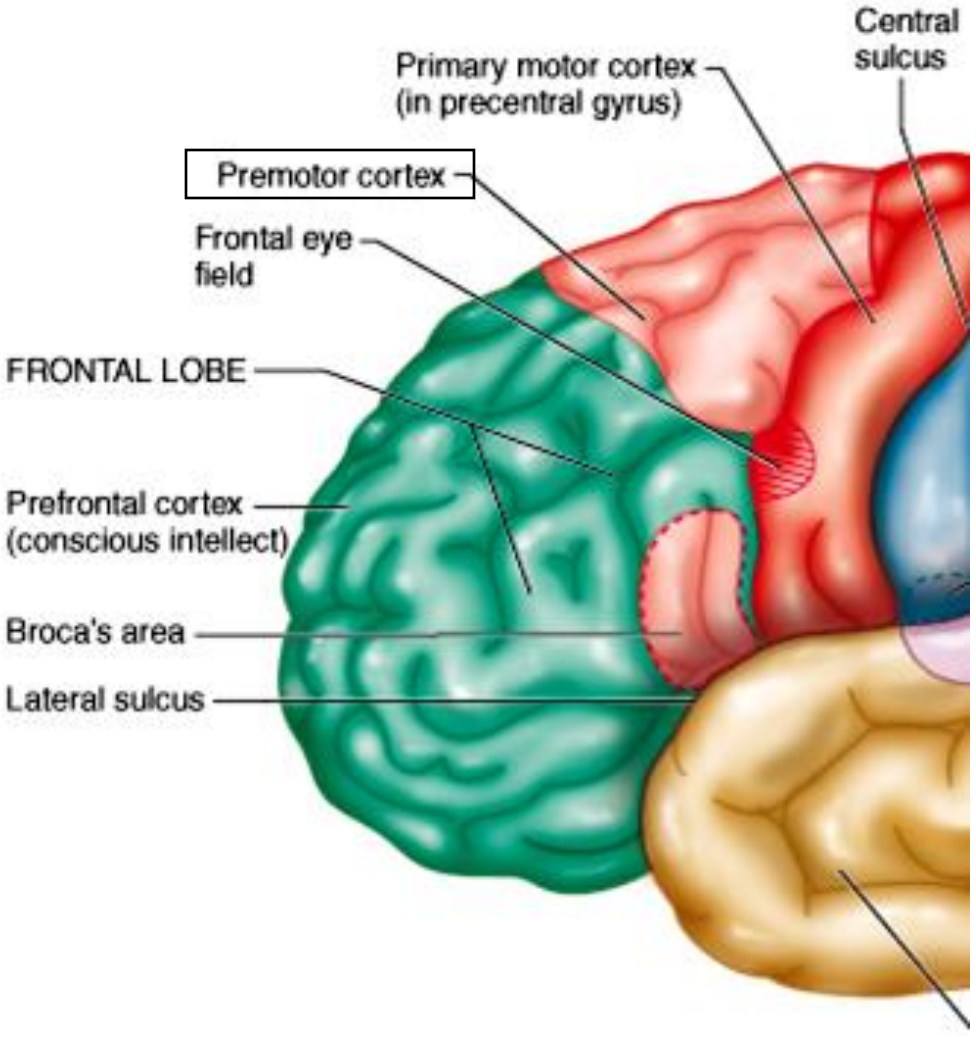
- The premotor cortex controls motor skills of repetitive or patterned nature (typing or piano)
- The premotor cortex coordinates the movement of several muscle groups to act simultaneously or sequentially



(a)

Premotor Cortex

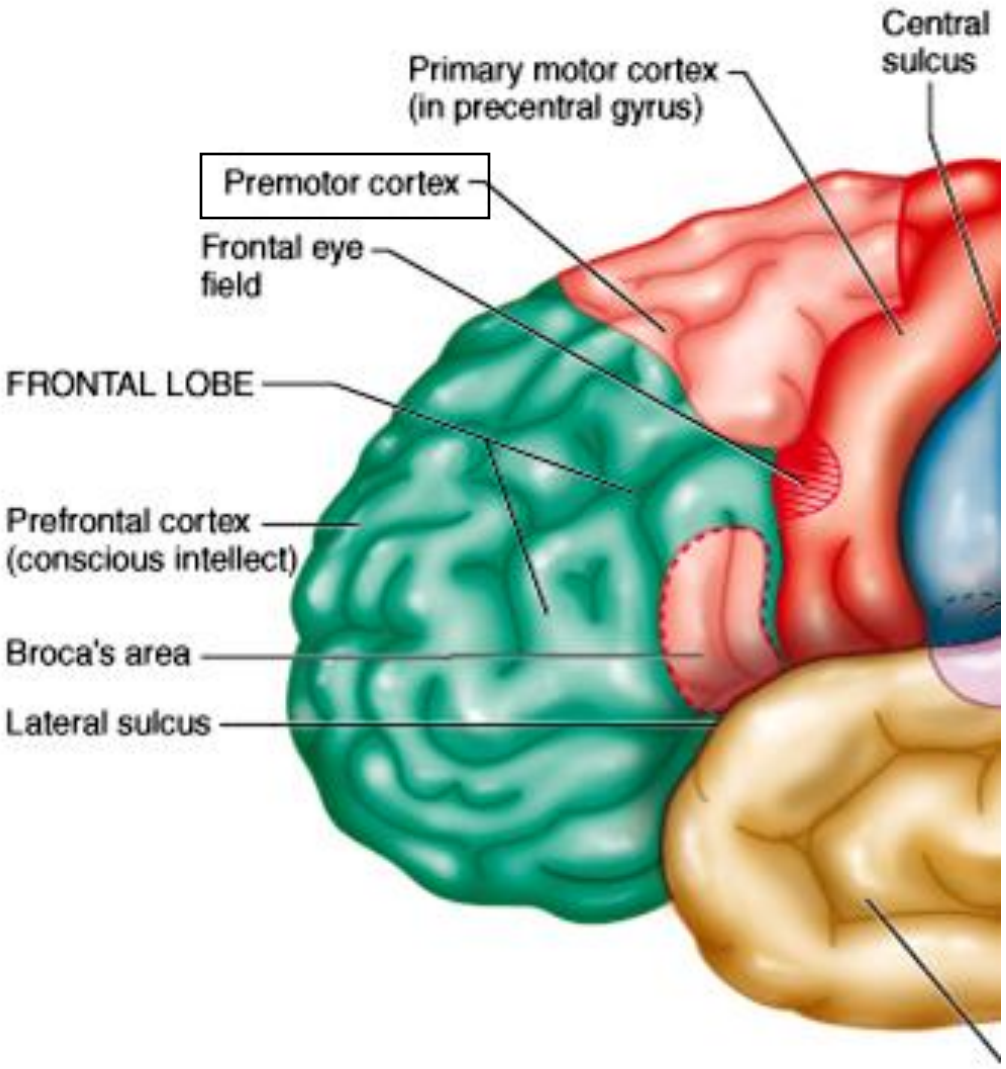
- The premotor cortex sends activating impulses to the primary motor cortex
- Also influences motor actively more directly by supplying about 15% of pyramidal tract fibers
- A memory bank of skilled motor activities



(a)

Premotor Cortex

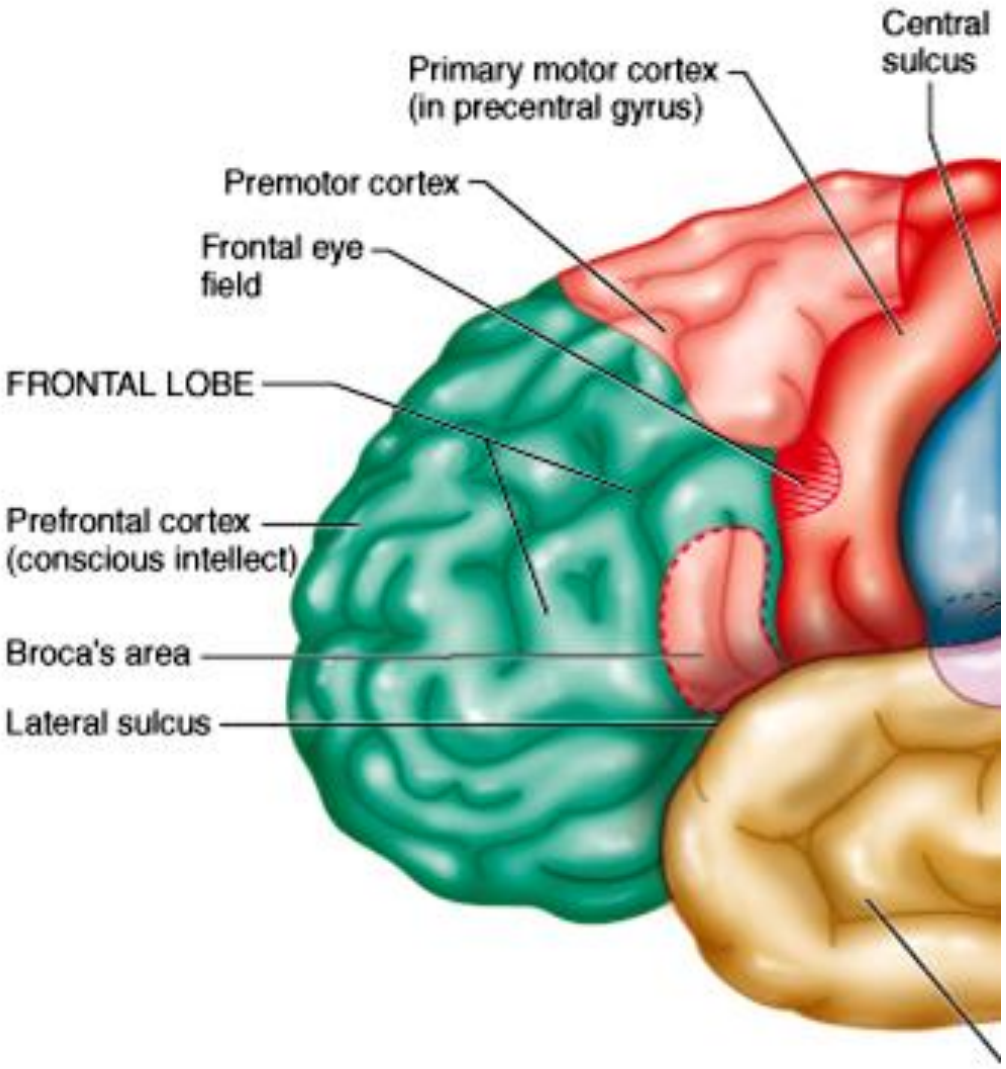
- This area appears to involved with motor planning
- It controls voluntary actions that depend on sensory feedback



(a)

Premotor Cortex

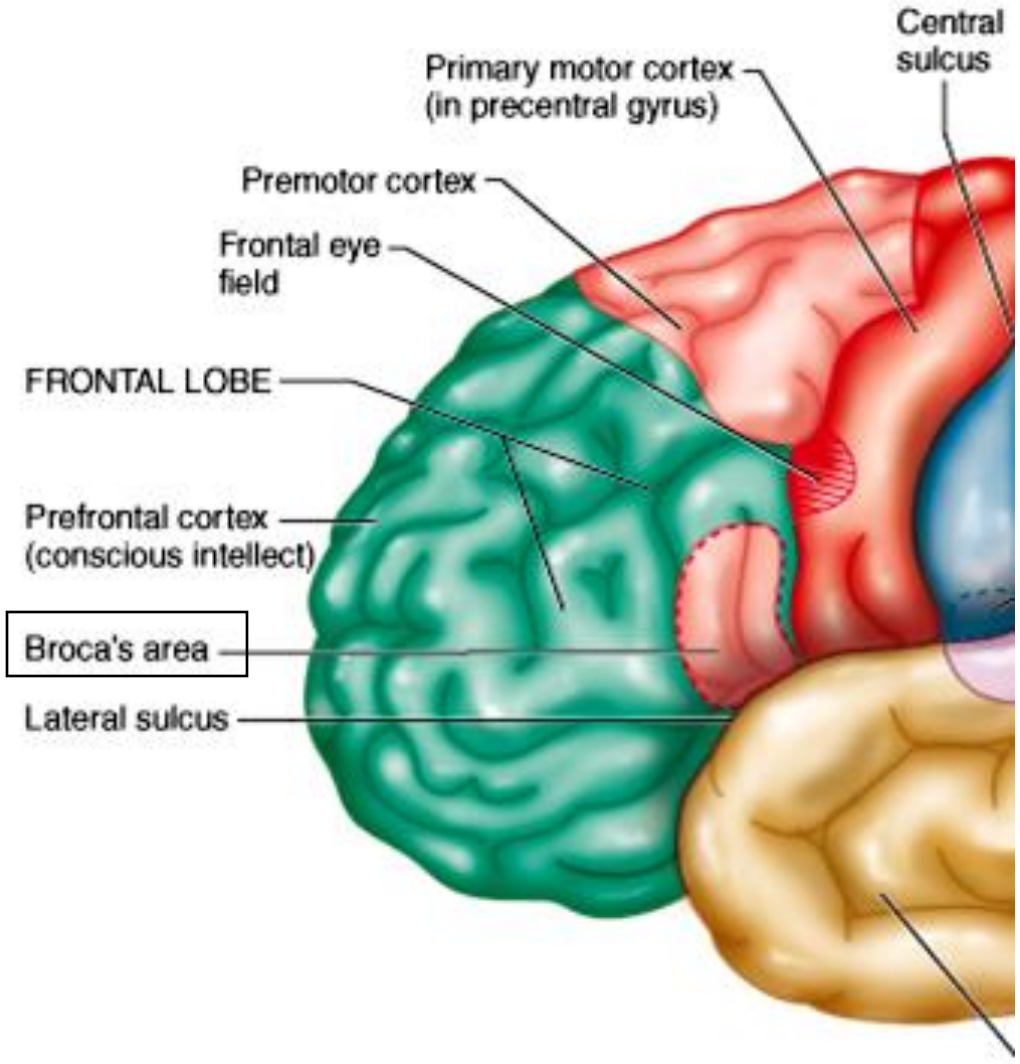
- Damage to the premotor area results in the loss of the motor skills in that region
- Muscle strength and the ability to perform the discrete individual movements are not hindered
- Neurons relearning the skill would require practice



(a)

Broca's area

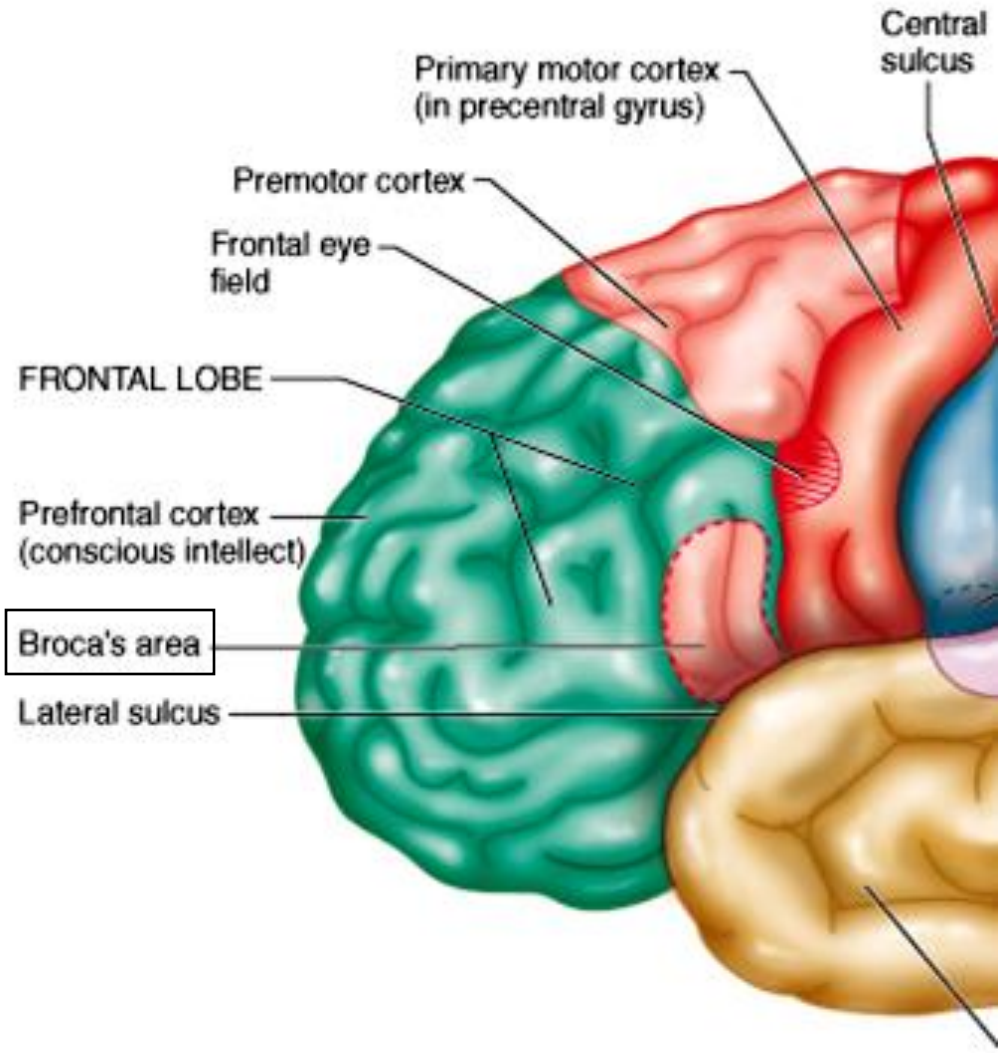
- The area has long been considered to be present in only one hemisphere (usually left)
- A special motor speech area that directs the muscles of the tongue, throat, and lips in articulating words



(a)

Broca’s area

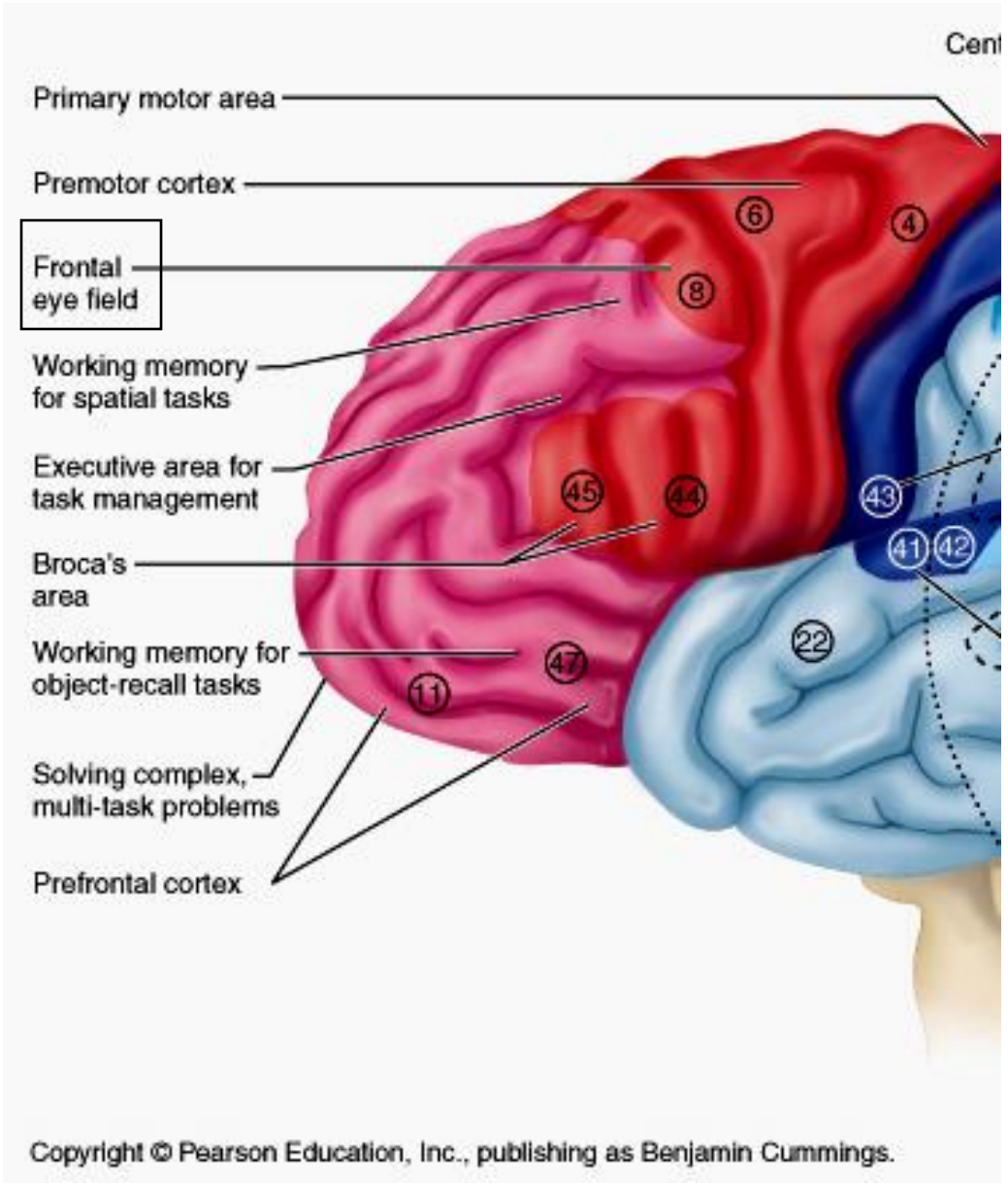
- Recent PET scans indicates that Broca’s area and a similar area in the opposite hemisphere become active as we prepare to speak
- The areas may be involved with planning speech and other voluntary motor activities



(a)

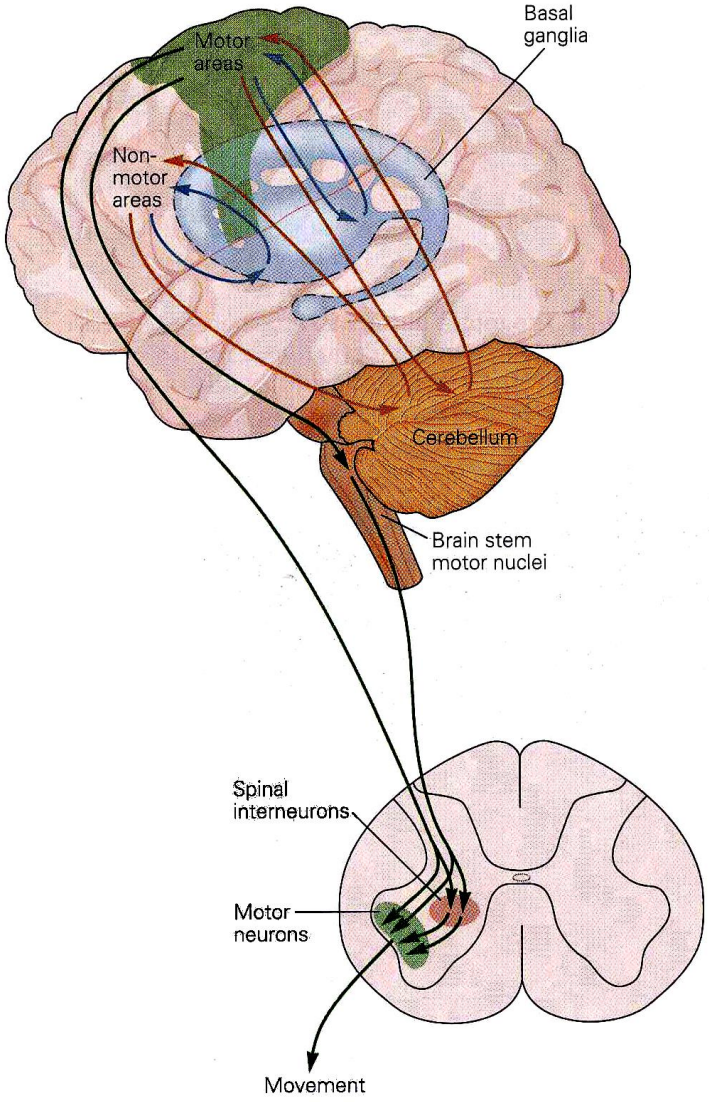
Frontal Eye Field

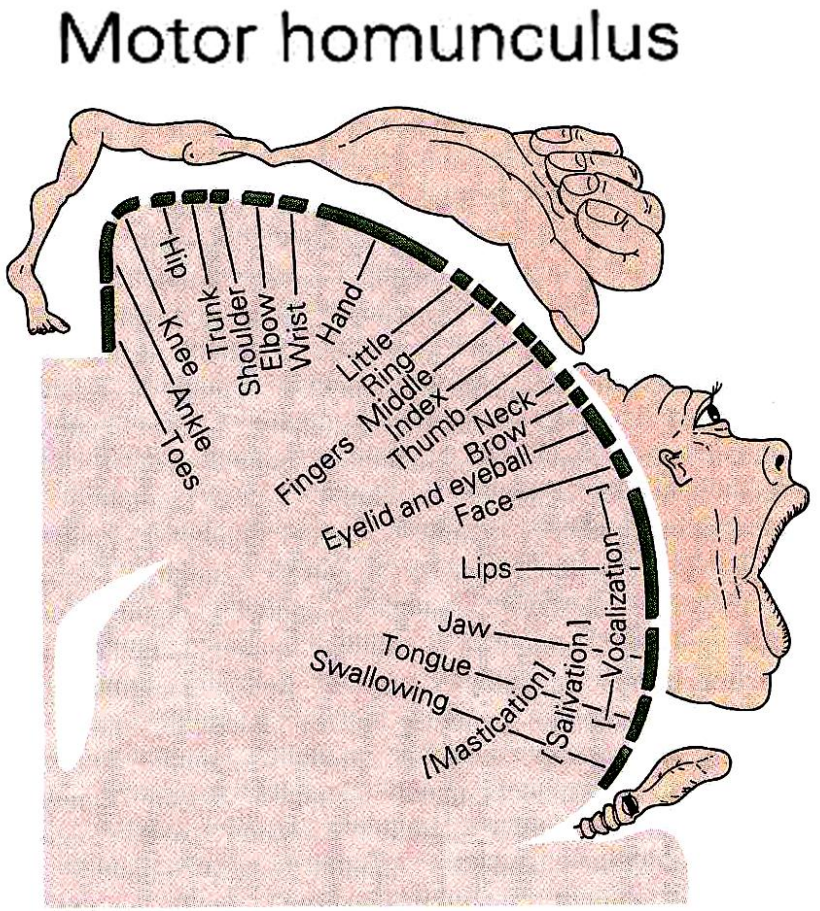
- This cortical region controls the voluntary movements of the eyes
- Engaged when we look quickly at something, as in moving our eyes to follow a moving target



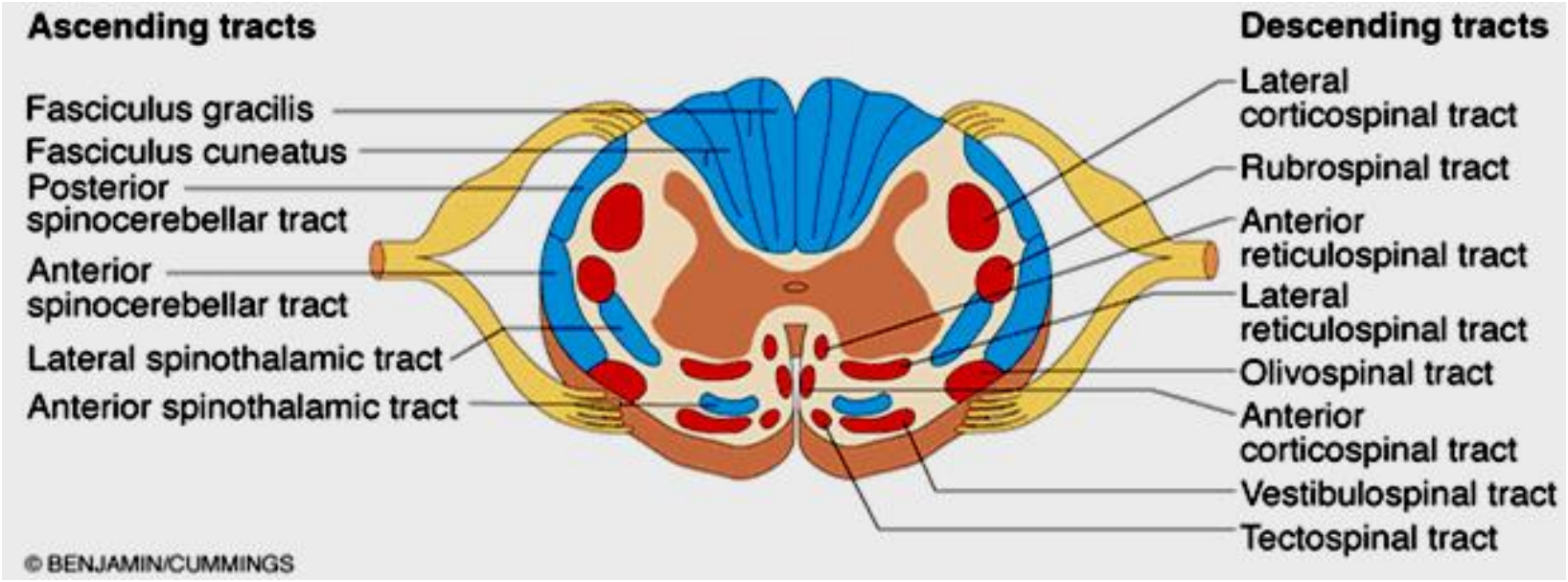
DESCENDING PATHWAYS FROM THE MOTOR CORTEX

SOME CORTICAL NEURONS PROJECT AXONS THAT SYNAPSE ON SPINAL MOTOR NEURONS





Descending (Motor) Tracts



- The pyramidal tracts are also called the direct pathways because their axons descend without synapsing from the pyramidal cells of the primary motor cortex all the way to the spinal cord

Descending (Motor) Pathways

- Descending tracts deliver efferent impulses from the brain to the spinal cord, and are divided into two groups
  - Direct pathways equivalent to the pyramidal tracts
  - Indirect pathways, essentially all others
- Motor pathways involve two neurons (upper and lower)

The Direct (Pyramidal) System

- Direct pathways originate with the pyramidal neurons in the precentral gyri
- Impulses are sent through the corticospinal tracts and synapse in the anterior horn
- Stimulation of anterior horn neurons activates skeletal muscles
- Parts of the direct pathway, called corticobulbar tracts, innervate cranial nerve nuclei
- The direct pathway regulates fast and fine (skilled) movements

The Direct (Pyramidal) System

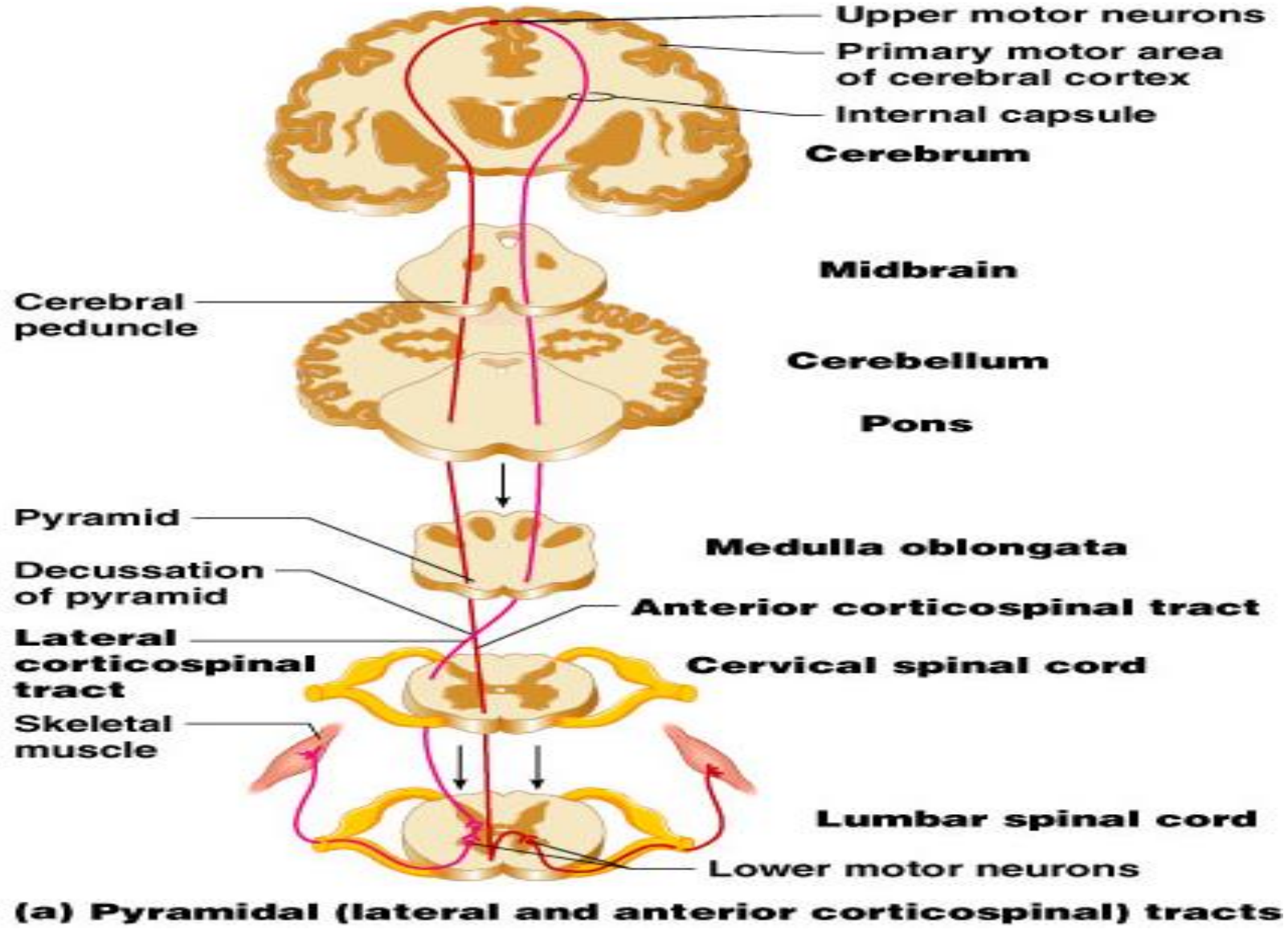
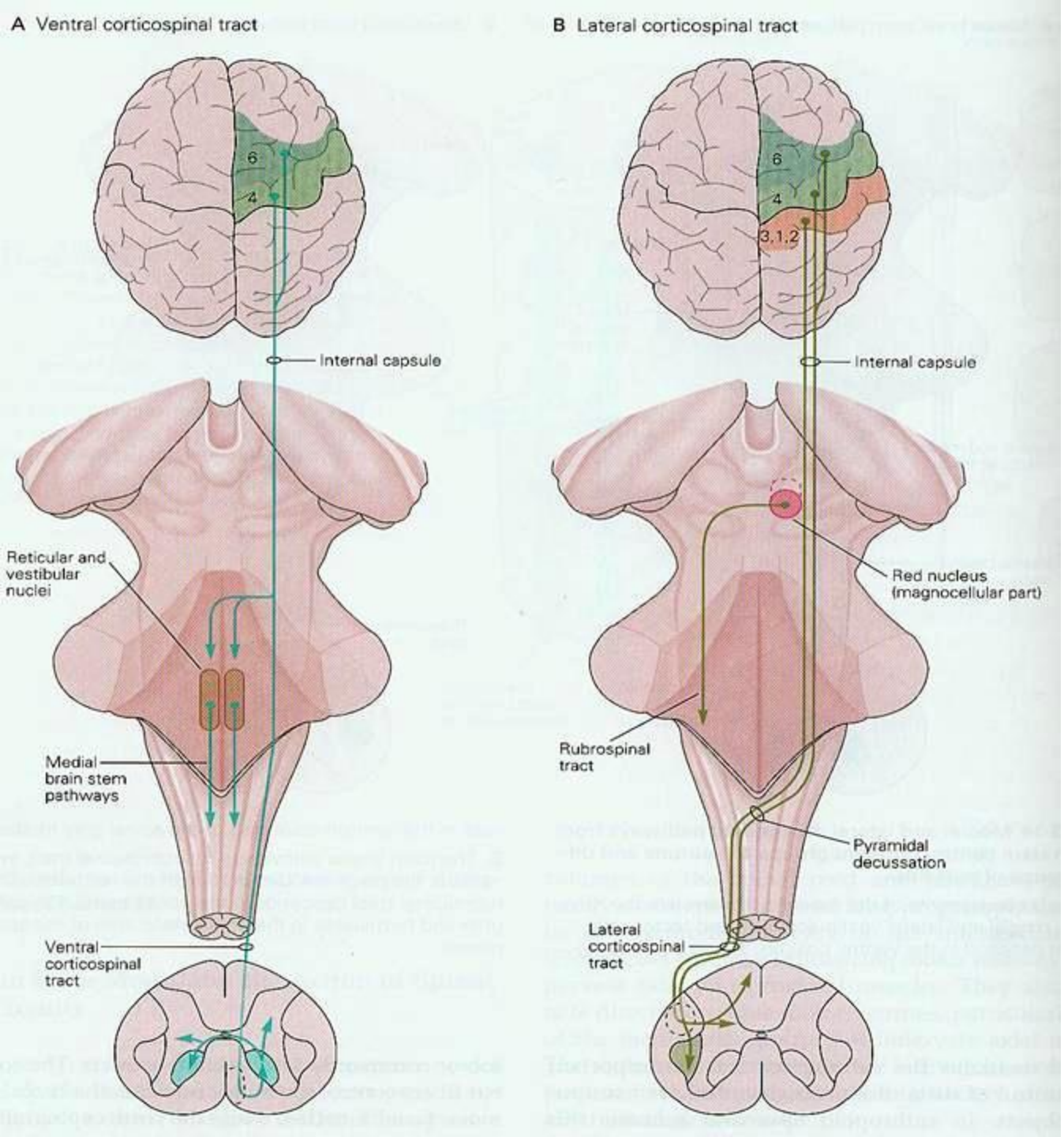
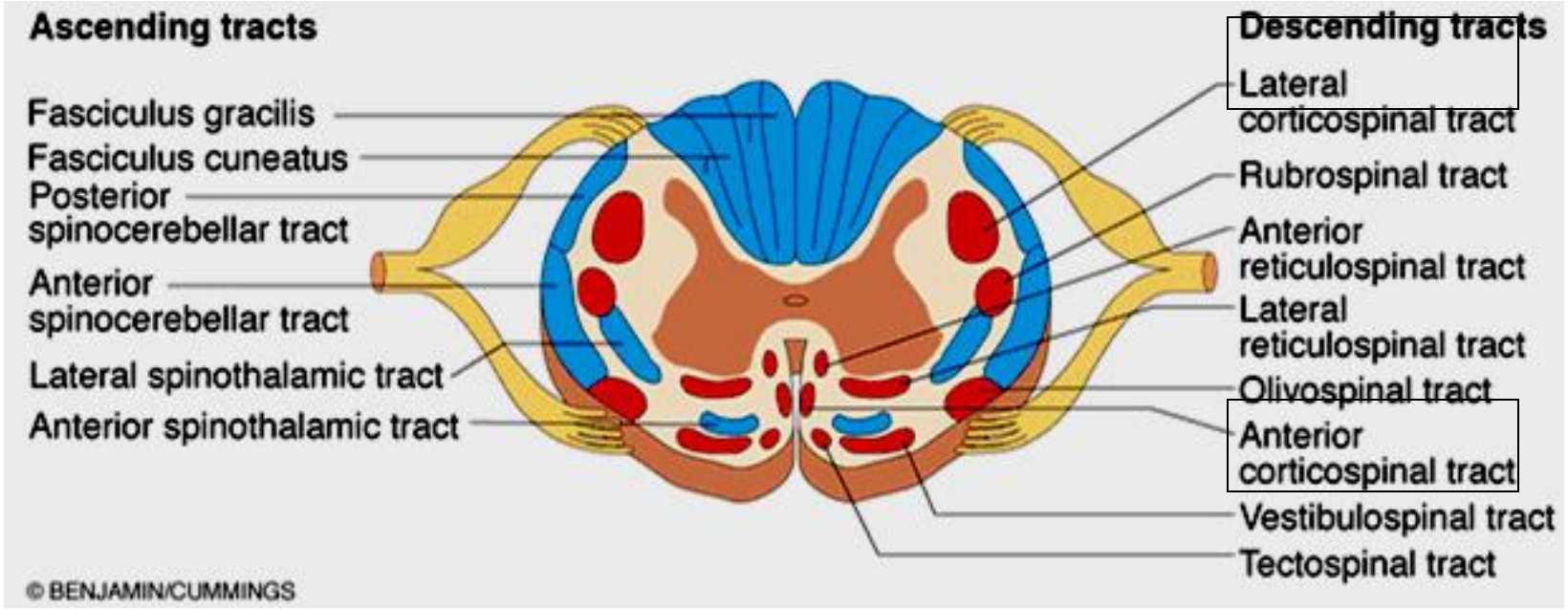


Figure 12.34a


A Ventral corticospinal tract
6
4
Internal capsule
Reticular and vestibular nuclei
Medial brain stem pathways
Ventral corticospinal tract
B Lateral corticospinal tract
6
4
3,1,2
Internal capsule
Red nucleus (magnocellular part)
Rubrospinal tract
Pyramidal decussation
Lateral corticospinal tract

Descending (Motor) Tracts



- The lateral (pyramdial) and anterior corticospinal tracts are the major motor pathways concerned with voluntary movement, particularly precise or skilled movement

Corticospinal Tract

Origin: *Cerebral Cortex*

Brodmann Area 4 (Primary Motor Area, M I)
Brodmann Area 6 (Premotor Area, PM)
Brodmann Area 3,1,2 (Primary Somesthetic Area, S I)
Brodmann Area 5 (Anterior Portion of Sup. Parietal Lobule)

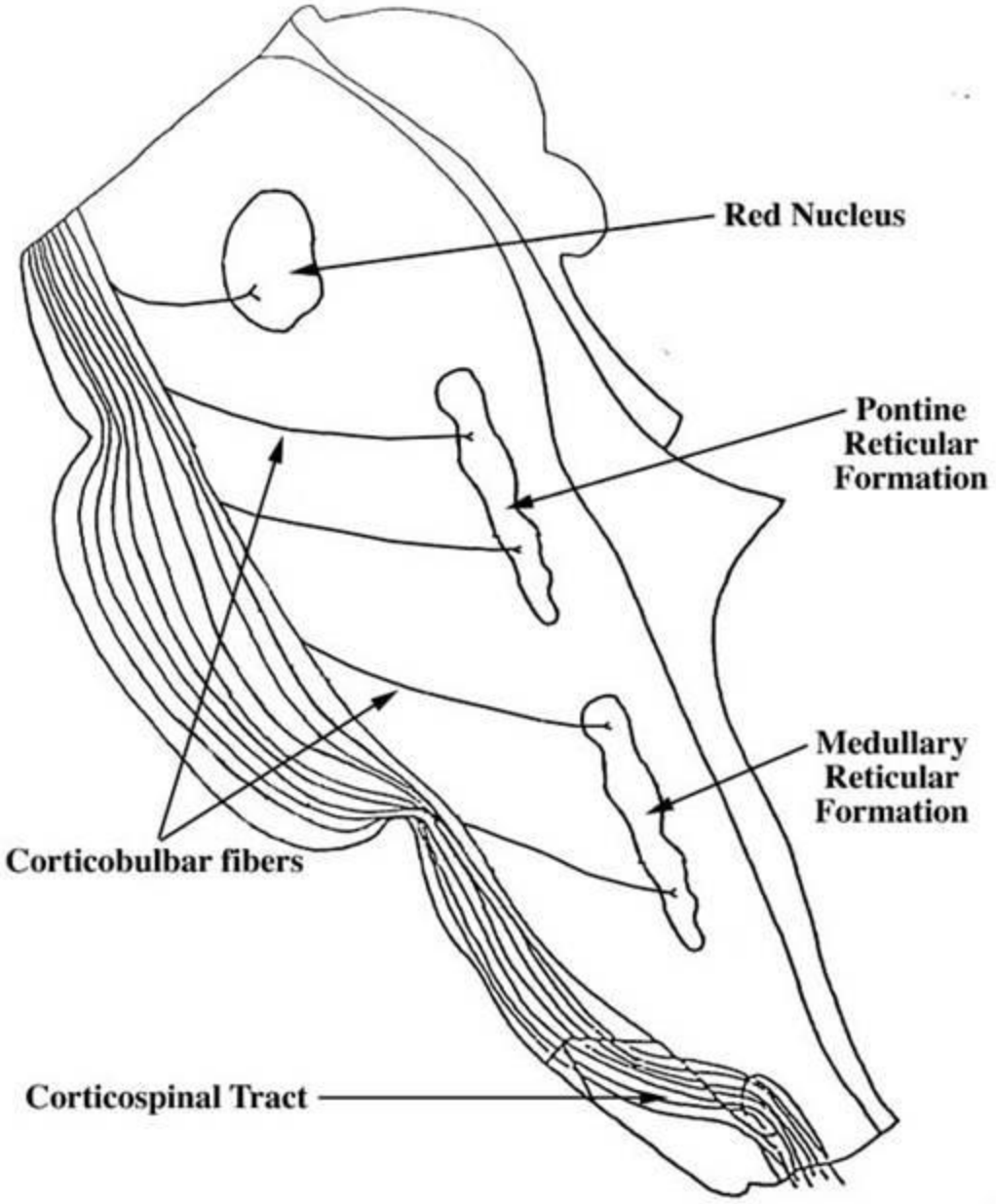
Corona Radiata
Internal Capsule, Posterior Limb
Crus Cerebri, Middle Portion
Longitudinal Pontine Fiber
Pyramid - pyramidal decussation
Corticospinal Tracts:

- *Lateral (crossed) - 85%*
- *Anterior (Not crossed) - 15%*

Termination: *Spinal Gray (Rexed IV-IX)*

Corticobulbar tract

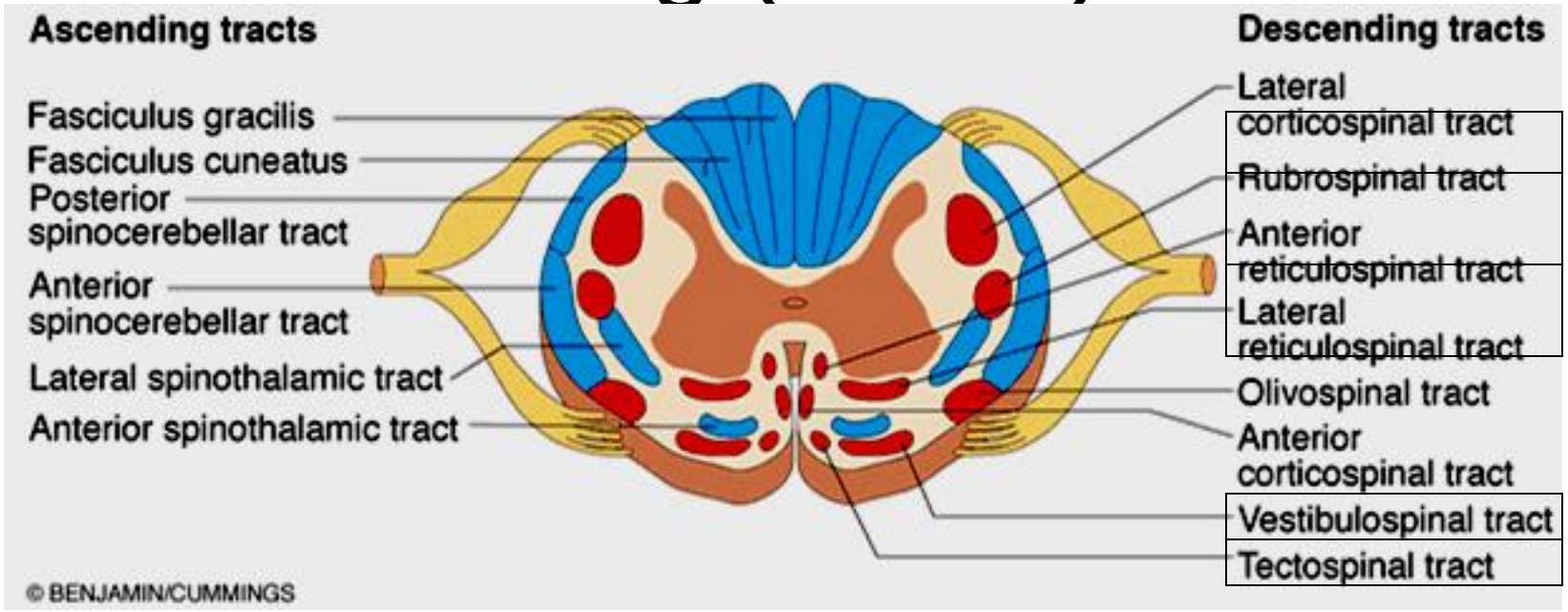
- Cortical projections to red nucleus and reticular formation
- Cortical projections from frontal eye fields to gaze centers
- Corticonuclear projections to V, VII, IX-X, and XII



Bilateral – 5, 7 (upper face), ambiguus

Contralateral – 7 (lower face); 12

Descending (Motor) Tracts

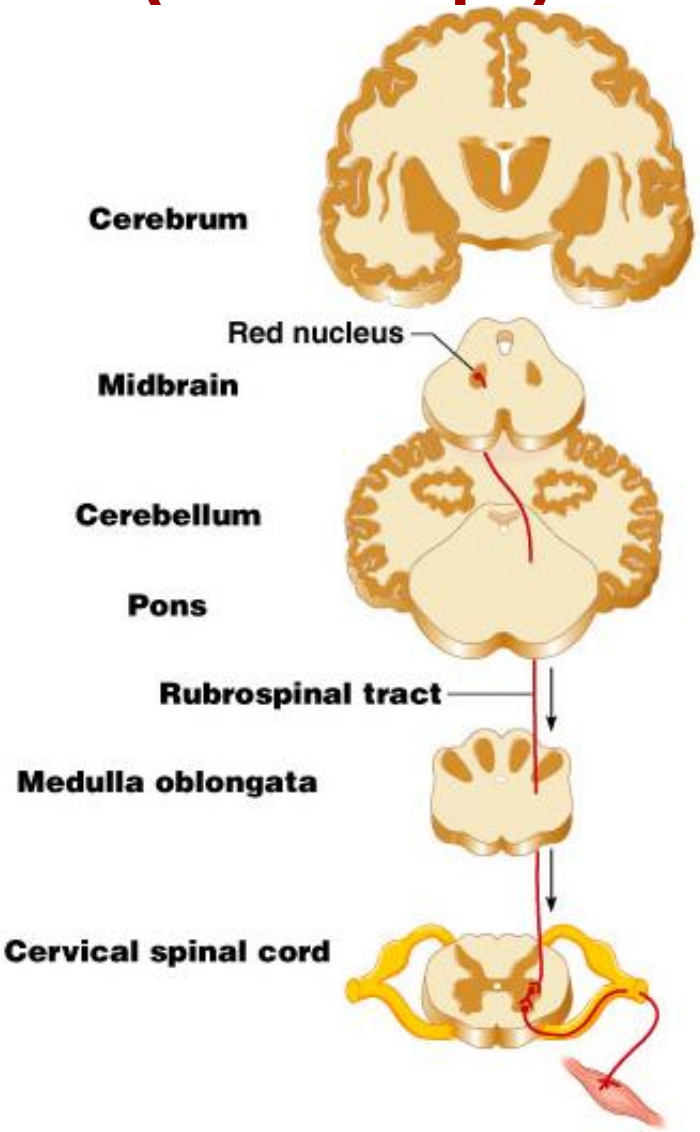


- The remaining tracts originate in different subcortical motor nuclei of the brain stem
- These tracts are lumped together as the extrapyramidal tracts

Indirect (Extrapyramidal) System

- Includes the brain stem, motor nuclei, and all motor pathways not part of the pyramidal system
- This system includes the rubrospinal, vestibulospinal, reticulospinal, and tectospinal tracts
- These motor pathways are complex and multisynaptic, and regulate:
  - Axial muscles that maintain balance and posture
  - Muscles controlling coarse movements of the proximal portions of limbs
  - Head, neck, and eye movement

Indirect (Extrapyramidal)



(b) Rubrospinal tract (an extrapyramidal tract)

Figure 12.34b

Extrapyramidal (Multineuronal) Pathways

- Reticulospinal tracts – maintain balance
- Rubrospinal tracts – control flexor muscles
- Superior colliculi and tectospinal tracts mediate head movements

Tract	Pathway	Function
Corticospinal tract	From the motor cortex to lower motor neurons in the ventral horn of the spinal cord	The major function of this pathway is fine voluntary motor control of the limbs. The pathway also controls voluntary body posture adjustments.
Corticobulbar tract	From the motor cortex to several nuclei in the pons and medulla	Involved in control of facial and jaw musculature, swallowing and tongue movements.

Tract	Source	Spinal Cord Location	Flexor/Extensor Bias	Principle Targeted Musculature	Function
Lateral & medial vestibulospinal	Lateral and medial vestibular nucleus in the dorsolateral medulla	Ventromedial	Extensor	Axial/proximal	Posture, axial movement & muscle tone
Pontine reticulospinal **(Medial)**	Nucleus reticularis pontis	Ventromedial	Extensor	Axial/proximal	Posture, axial movement & muscle tone
Medullary reticulospinal **(Lateral)**	Nucleus reticularis gigantocellula-ris	Lateral	Flexor	Axial/proximal	Posture, axial movement and muscle tone
Lateral corticospinal	Cerebral cortex	Lateral	Minimal	Distal	Distal, precision movement
Tecto-reticulo-spinal	Deep layers of superior colliculus	Ventromedial	None	Axial	Head movements required for orienting reactions

Difference between pyramidal and extrapyramidal tracts

Pyramidal tracts	Extrapyramidal tracts
• Newer system	Older system
• Origin	Origin
• Cerebrum	Basal ganglia and cerebellum
• Skilled movements	Posture and axial movements

Upper Motor Neurons

- **Upper motor neurons** are motor neurons that originate in motor region of the cerebral cortex or the brain stem and carry motor information down to the final common pathway.

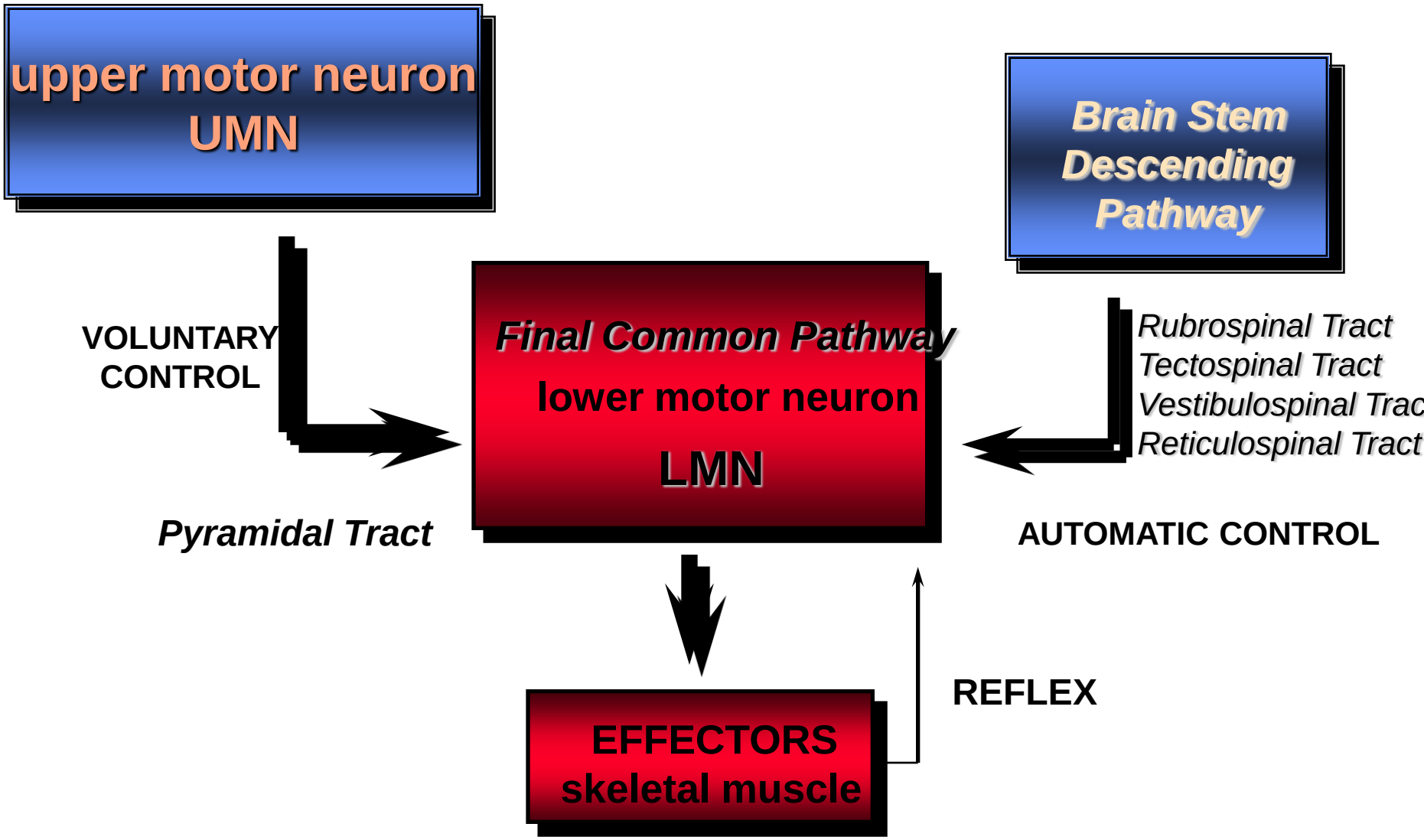
Lower Motor Neurons

- These include alpha and gamma motor neurons.
- Alpha motor neurons have their cell bodies in their CNS. Their axons course through cranial and spinal nerves and terminate on the motor end plates of skeletal muscle fibers
- Gamma neurons also have cell bodies within the CNS. Their axons pass through cranial and spinal nerves to innervate the intrafusal muscle fibers.

Lower Motor Neurons

- These are the only neurons that innervate the skeletal muscle fibers, they function as the final common pathway, the final link between the CNS and skeletal muscles.
- Axons are located both in the cranial and spinal nerves.

SOMATIC MOTOR SYSTEM

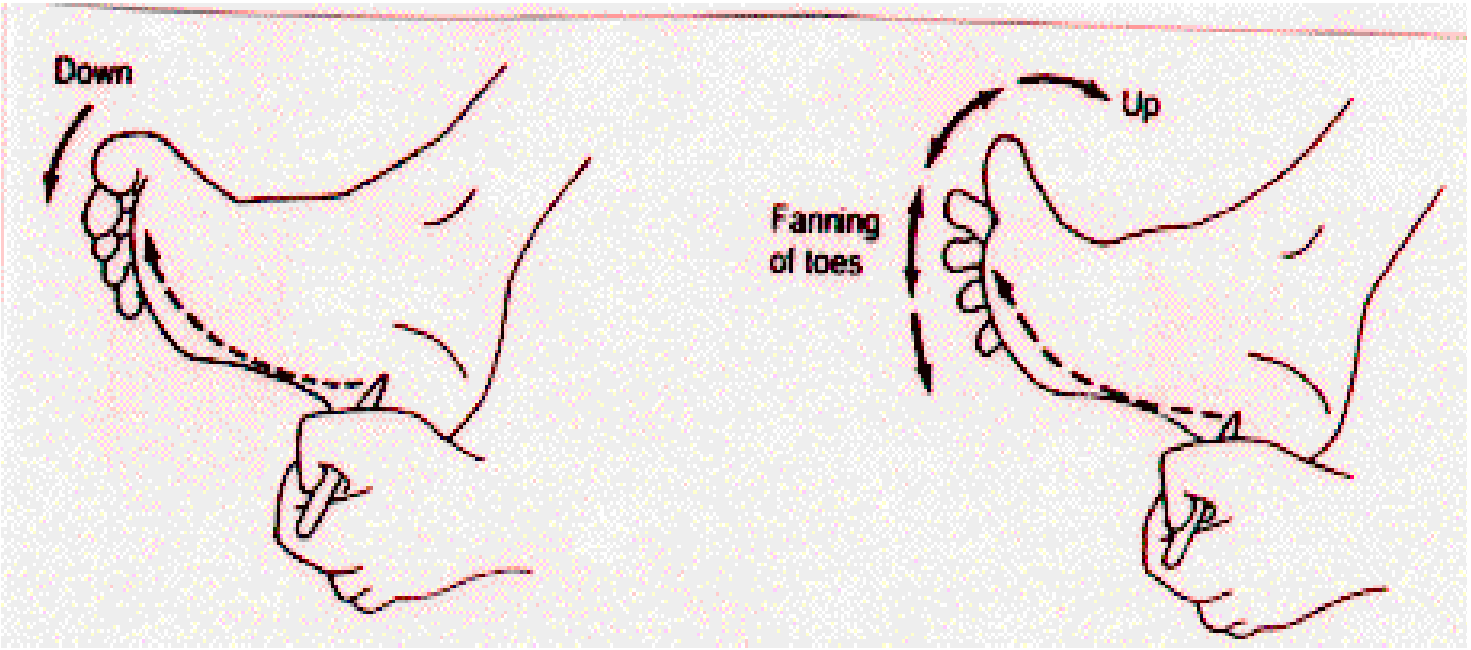


Upper Motor Neuron (UMN) vs. Lower Motor Neuron (LMN) Syndrome

	UMN syndrome	*LMN Syndrome*
Type of Paralysis	***Spastic Paresis***	***Flaccid Paralysis***
Atrophy	**No (Disuse) Atrophy**	**Severe *Atrophy***
Deep Tendon Reflex	***Increase***	**Absent DTR**
Pathological Reflex	**Positive *Babinski* Sign**	**Absent**
Superficial Reflex	**Absent**	**Present**
Fasciculation and Fibrillation	**Absent**	**Could be *Present***

Babinski reflex - an UMN sign

- Adult response - plantar flexion of the big toe and adduction of the smaller toes
- Pathological (Infant) response - dorsoflexion (extension) of the big toe and fanning of the other toes
- Indicative of upper motor neuron damage



Paralysis/Paresis

- **Hemiplegia** : Paralysis to one side of the body. A lesion of corticospinal tract in the internal capsule results in a hemiplegia
- **Monoplegia** : Paralysis of a single limb
- **Paraplegia and Quadriplegia**: If the spinal cord damage occurs at cervical level, then all four limbs will be paralyzed (**quadriplegia**). If the damage occurs below the cervical enlargement, then only the legs are paralyzed (**paraplegia**).