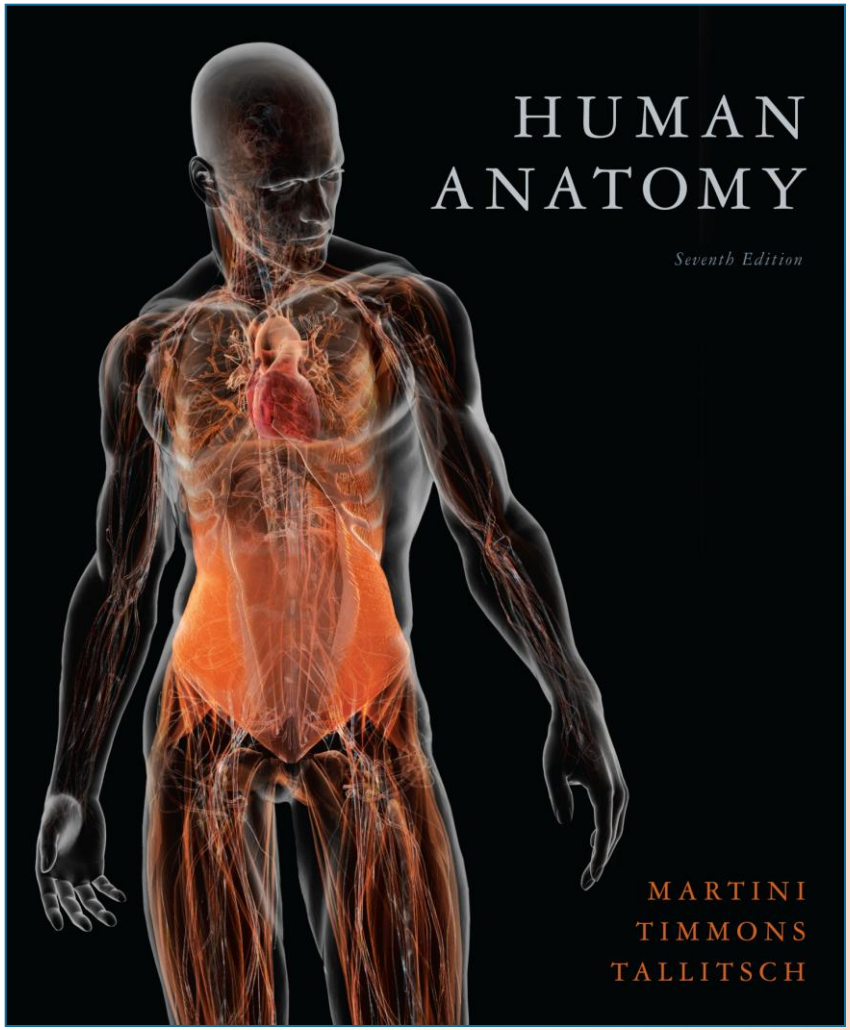

15

The Nervous System: Sensory and Motor Tracts of the Spinal Cord

PowerPoint® Lecture Presentations prepared by
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Introduction

- Millions of sensory neurons are delivering information to the CNS all the time
- Millions of motor neurons are causing the body to respond in a variety of ways
- Sensory and motor neurons travel by different tracts within the spinal cord

Sensory and Motor Tracts

- Communication to and from the brain involves **tracts**
- **Ascending tracts** are sensory
  - Deliver information to the brain
- **Descending tracts** are motor
  - Deliver information to the periphery

Sensory and Motor Tracts

- Naming the tracts
  - If the tract name begins with “spino” (as in **spino**cerebellar), the tract is a **sensory tract** delivering information from the spinal cord to the cerebellum (in this case)
  - If the tract name ends with “spinal” (as in vestibulo**spinal**), the tract is a **motor tract** that delivers information from the vestibular apparatus (in this case) to the spinal cord

Sensory and Motor Tracts

- There are three major sensory tracts
  - The **posterior column tract**
  - The **spinothalamic tract**
  - The **spinocerebellar tract**

Sensory and Motor Tracts

- The three major sensory tracts involve chains of neurons
  - **First-order neuron**
    - Delivers sensations to the CNS
    - The cell body is in the dorsal or cranial root ganglion
  - **Second-order neuron**
    - An interneuron with the cell body in the spinal cord or brain
  - **Third-order neuron**
    - Transmits information from the thalamus to the cerebral cortex

Sensory and Motor Tracts

- Neurons in the sensory tracts are arranged according to three anatomical principles
  - **Sensory modality**
  - **Somatotropic**
  - **Medial-lateral rule**

Sensory and Motor Tracts

- **Sensory modality**
  - Fine touch sensations are carried in one sensory tract
- **Somatotopic**
  - Ascending tracts are arranged according to the site of origin
- **Medial-lateral rule**
  - Sensory neurons that enter a low level of the spinal cord are more medial within the spinal cord
  - Sensory neurons that enter at a higher level of the spinal cord are more lateral within the spinal cord

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower–Motor Neurons in the Spinal Cord

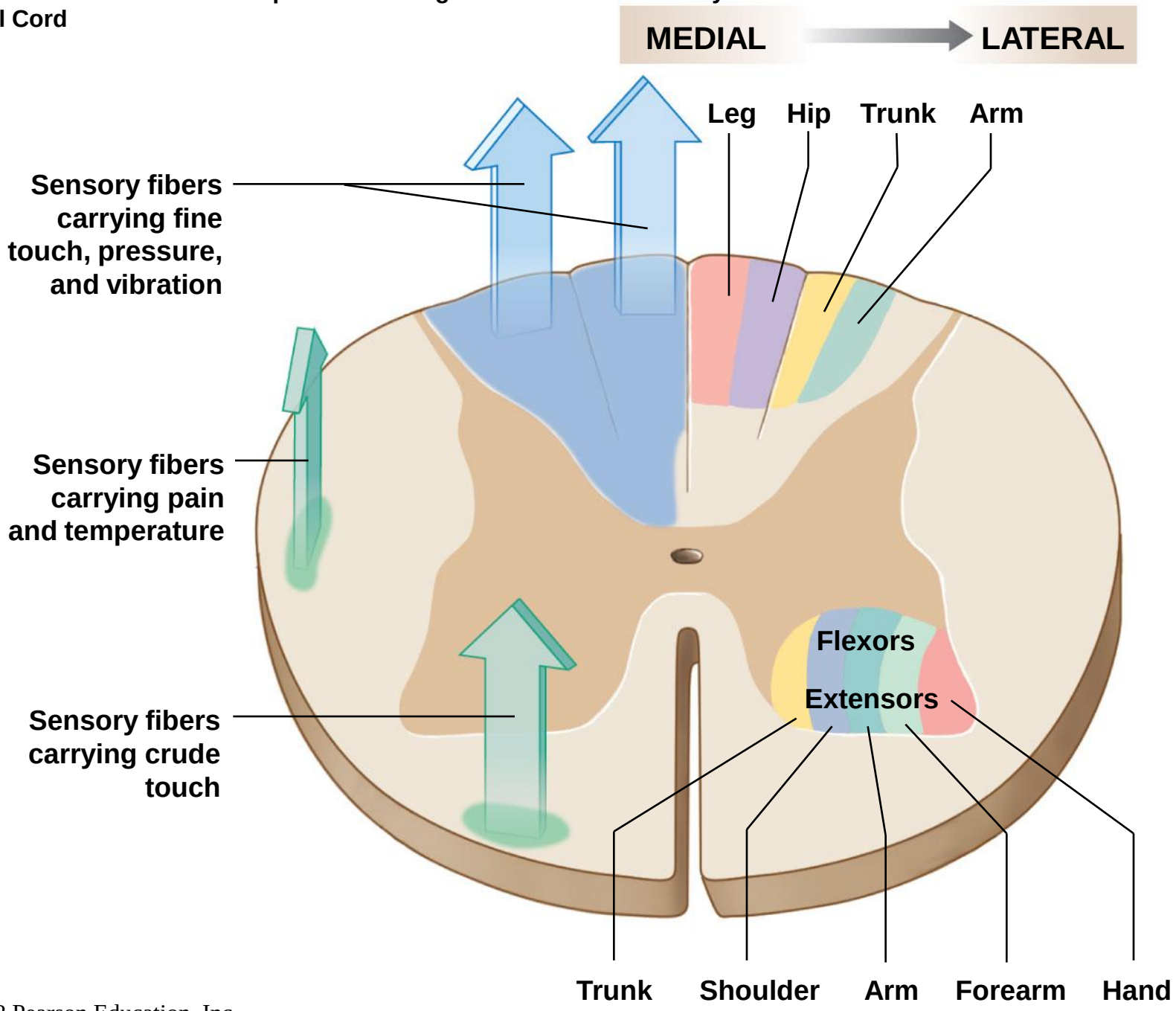


Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide

Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide

Tract	Sensations	Location of Neuron Cell Bodies: First-Order	Second-Order	Third-Order	Final Destination	Site of Crossover
POSTERIOR COLUMNS						
Fasciculus gracilis	Proprioception, fine touch, pressure, and vibration from levels inferior to T_6	Dorsal root ganglia of lower body; axons enter CNS in dorsal roots and ascend within fasciculus gracilis	Nucleus gracilis of medulla oblongata: axons cross over before entering medial lemniscus	Ventral posterolateral nucleus of thalamus	Primary sensory cortex on side opposite stimulus	Axons of second-order neurons, before joining medial lemniscus
Fasciculus cuneatus	Proprioception, fine touch, pressure, and vibration from levels at or superior to T_6	Dorsal root ganglia of upper body; axons enter CNS in dorsal roots and ascend within fasciculus cuneatus	Nucleus cuneatus of medulla oblongata: axons cross over before entering medial lemniscus	Ventral posterolateral nucleus of thalamus	As above	As above
SPINOTHALAMIC TRACT						
Lateral spinothalamic tracts	Pain and temperature sensations	Dorsal root ganglia; axons enter CNS in dorsal roots and enter posterior gray horn	In posterior gray horn: axons enter lateral spinothalamic tract	Ventral posterolateral nucleus of thalamus	Primary sensory cortex on side opposite stimulus	Axons of second-order neurons, at level of entry
Anterior spinothalamic tracts	Crude touch and pressure sensations	As above	In posterior gray horn: axons enter anterior spinothalamic tract on opposite side	As above	As above	As above
SPINOCEREBELLAR TRACTS						
Posterior spinocerebellar tracts	Proprioception	Dorsal root ganglia; axons enter CNS in dorsal roots	In posterior gray horn: axons enter posterior spinocerebellar tract on same side	Not present	Cerebellar cortex on side of stimulus	None
Anterior spinocerebellar tracts	Proprioception	As above	In same spinal segment: axons enter anterior spinocerebellar tract on same or opposite side	Not present	Cerebellar cortex, primarily on side of stimulus	Axons of most second-order neurons cross before entering tract and then cross again within cerebellum

Sensory and Motor Tracts

- **Posterior Column tract** consists of:
  - **Fasciculus gracilis**
    - Transmits information coming from areas inferior to T_6
  - **Fasciculus cuneatus**
    - Transmits information coming from areas superior to T_6

Figure 15.2 A Cross–sectional View Indicating the Locations of the Major Ascending (Sensory) Tracts in the Spinal Cord

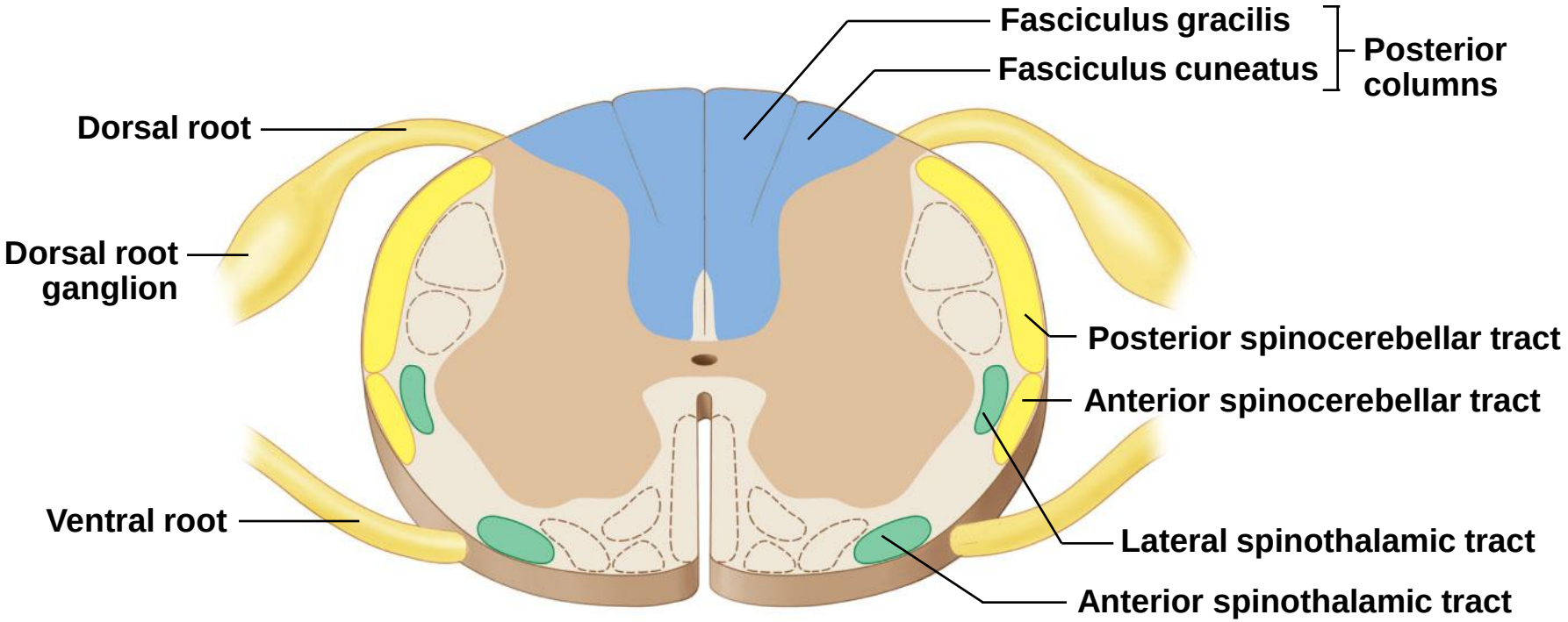
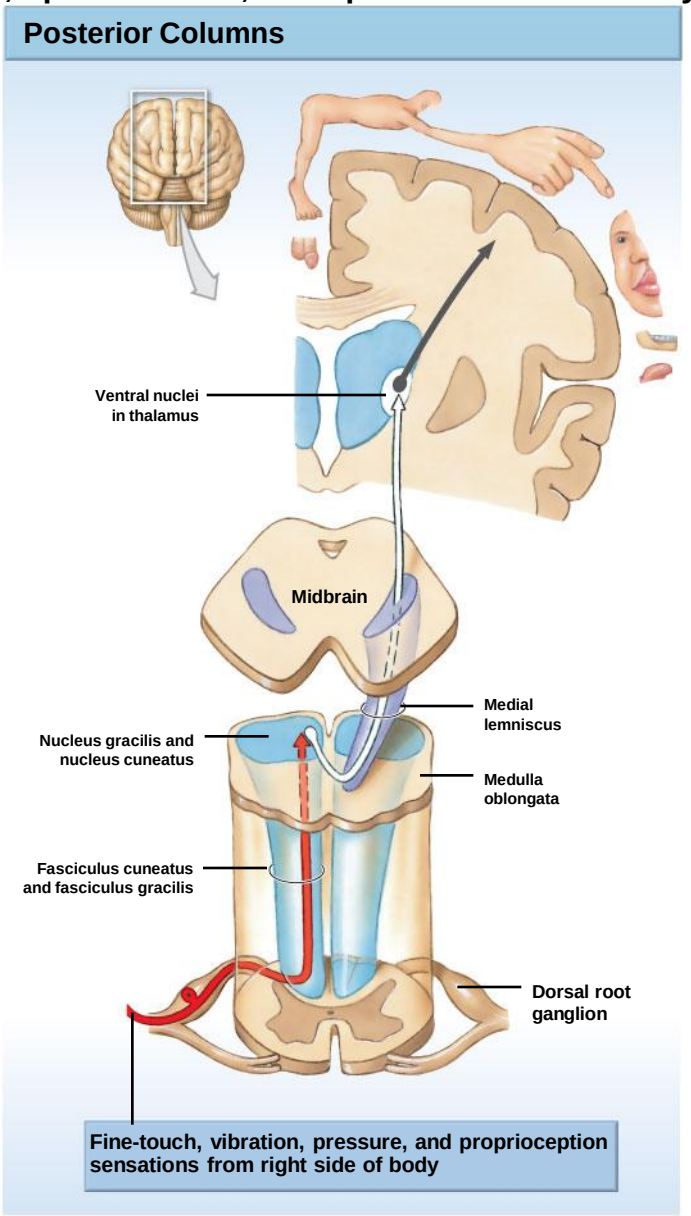


Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide (Part 1 of 2)

Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide

Tract	Sensations	Location of Neuron Cell Bodies: First-Order	Location of Neuron Cell Bodies: Second-Order	Location of Neuron Cell Bodies: Third-Order	Final Destination	Site of Crossover
POSTERIOR COLUMNS						
Fasciculus gracilis	Proprioception, fine touch, pressure, and vibration from levels inferior to T_6	Dorsal root ganglia of lower body; axons enter CNS in dorsal roots and ascend within fasciculus gracilis	Nucleus gracilis of medulla oblongata: axons cross over before entering medial lemniscus	Ventral posterolateral nucleus of thalamus	Primary sensory cortex on side opposite stimulus	Axons of second-order neurons, before joining medial lemniscus
Fasciculus cuneatus	Proprioception, fine touch, pressure, and vibration from levels at or superior to T_6	Dorsal root ganglia of upper body; axons enter CNS in dorsal roots and ascend within fasciculus cuneatus	Nucleus cuneatus of medulla oblongata: axons cross over before entering medial lemniscus	Ventral posterolateral nucleus of thalamus	As above	As above

Figure 15.3a The Posterior Column, Spinothalamic, and Spinocerebellar Sensory Tracts



a The posterior columns deliver fine-touch, vibration, and proprioception information to the primary sensory cortex of the cerebral hemisphere on the opposite side of the body. The crossover occurs in the medulla, after a synapse in the nucleus gracilis or nucleus cuneatus.

Sensory and Motor Tracts

- **Spinothalamic tract**
  - Transmits pain and temperature sensations to the thalamus and then to the cerebrum
- **Spinocerebellar tract**
  - Transmits proprioception sensations to the cerebellum

Figure 15.2 A Cross–sectional View Indicating the Locations of the Major Ascending (Sensory) Tracts in the Spinal Cord

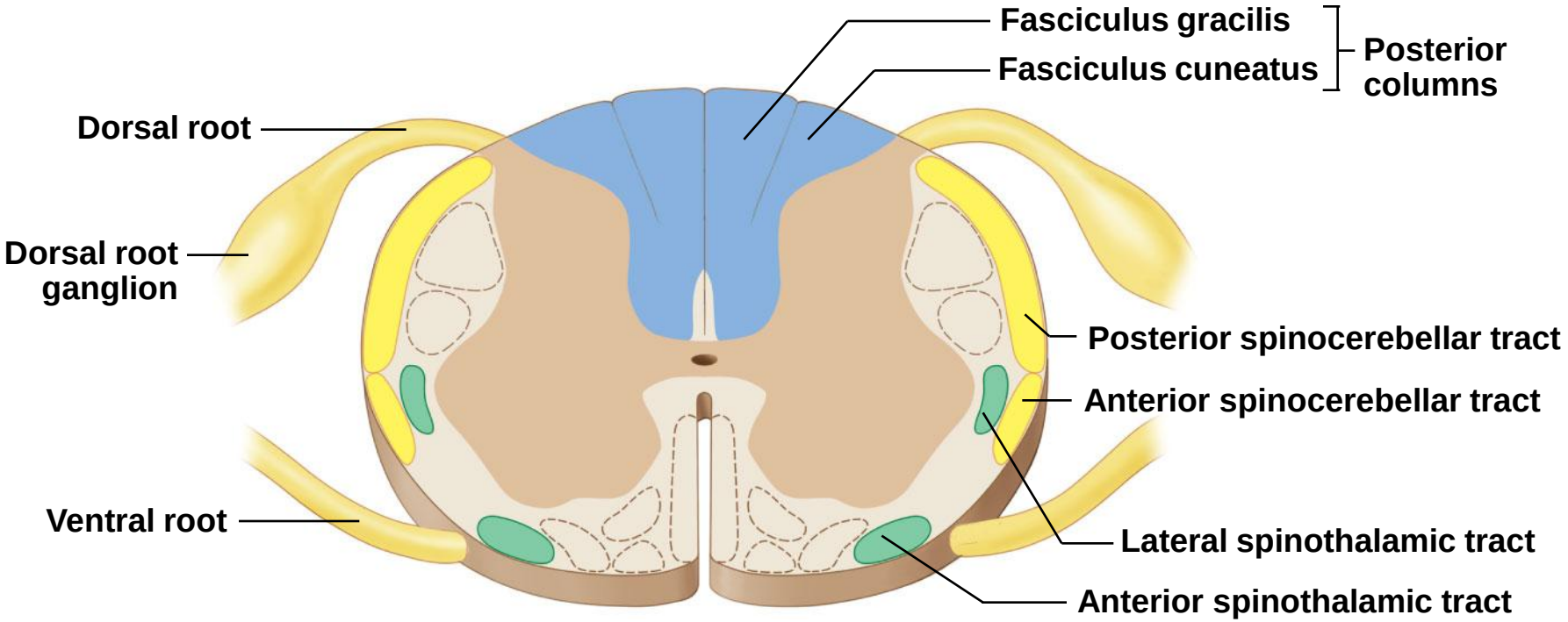
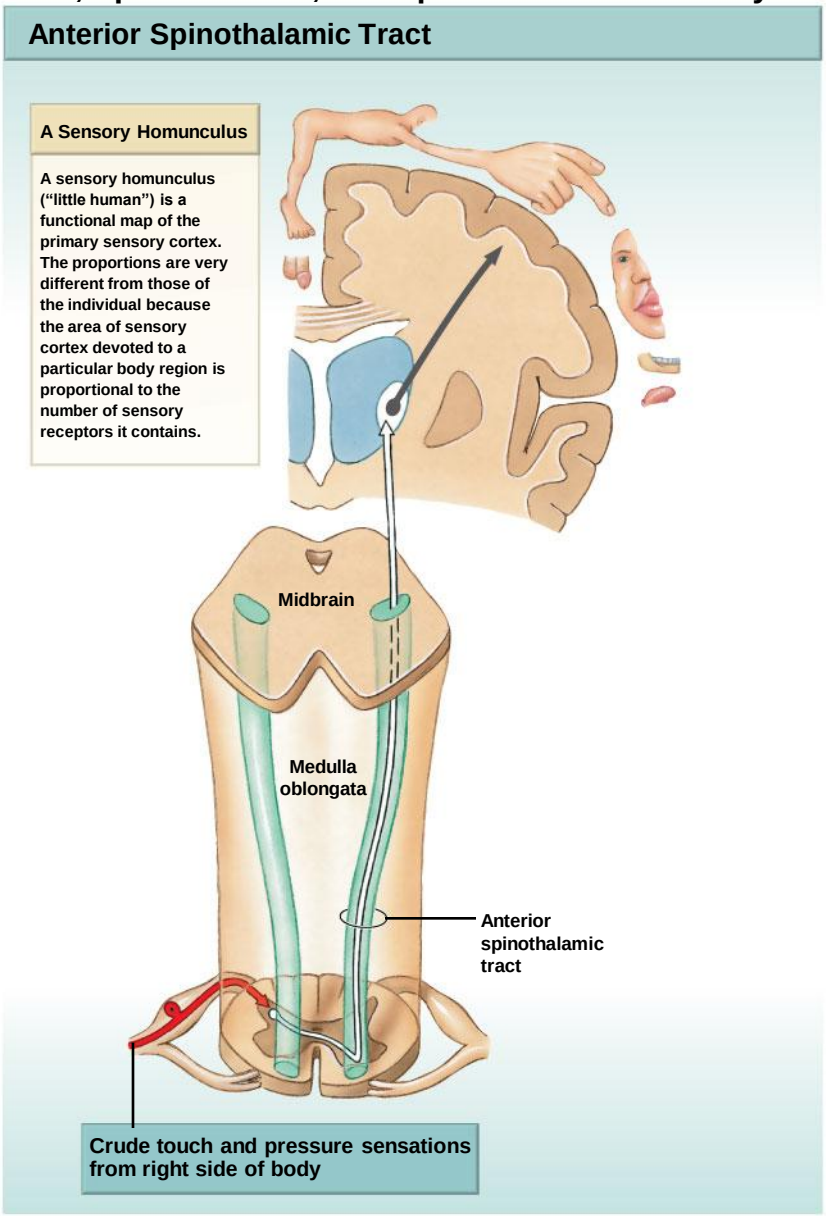


Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide (Part 2 of 2)

Table 15.1 Principal Ascending (Sensory) Tracts and the Sensory Information They Provide

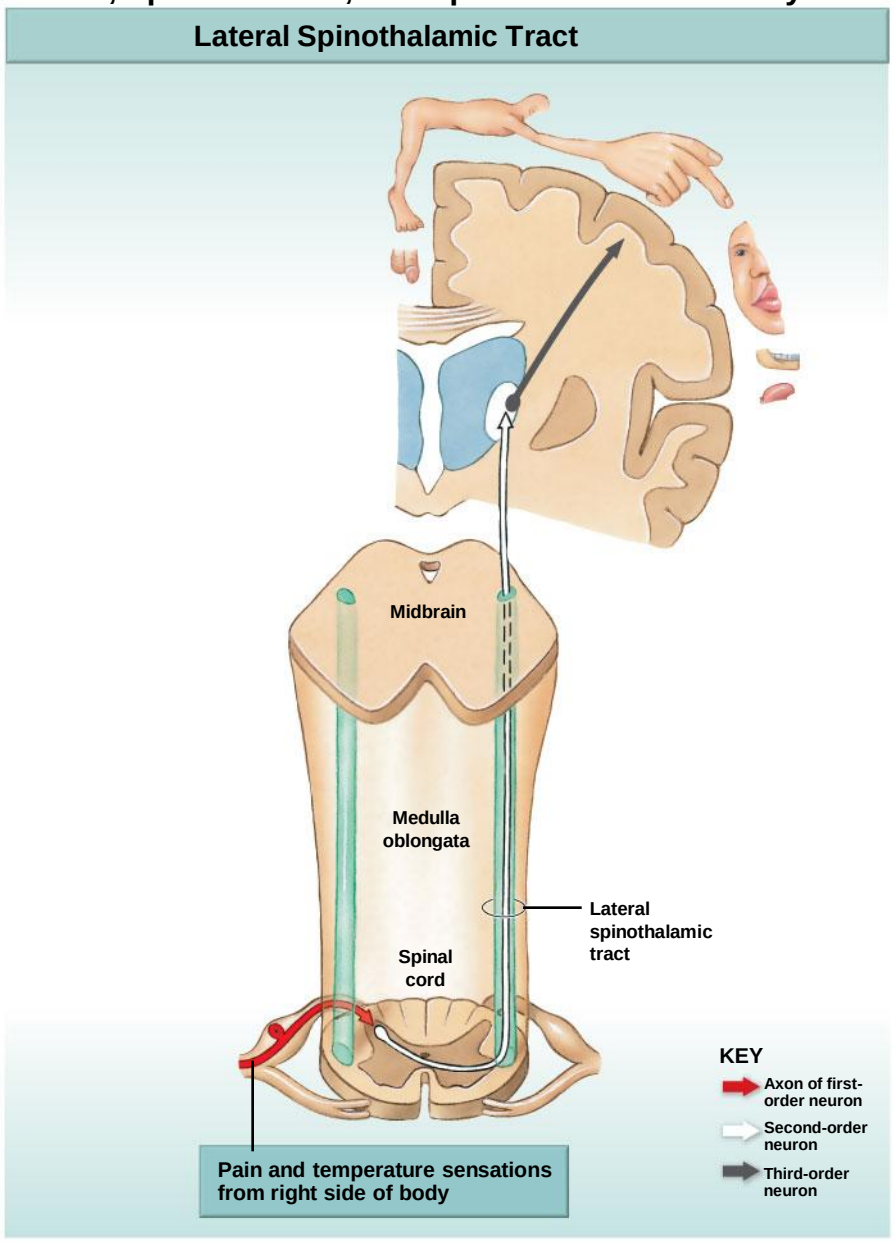
Tract	Sensations	Location of Neuron Cell Bodies: First-Order	Second-Order	Third-Order	Final Destination	Site of Crossover
SPINOTHALAMIC TRACT						
Lateral spinothalamic tracts	Pain and temperature sensations	Dorsal root ganglia; axons enter CNS in dorsal roots and enter posterior gray horn	In posterior gray horn: axons enter lateral spinothalamic tract	Ventral posterolateral nucleus of thalamus	Primary sensory cortex on side opposite stimulus	Axons of second-order neurons, at level of entry
Anterior spinothalamic tracts	Crude touch and pressure sensations	As above	In posterior gray horn: axons enter anterior spinothalamic tract on opposite side	As above	As above	As above
SPINOCEREBELLAR TRACTS						
Posterior spinocerebellar tracts	Proprioception	Dorsal root ganglia; axons enter CNS in dorsal roots	In posterior gray horn: axons enter posterior spinocerebellar tract on same side	Not present	Cerebellar cortex on side of stimulus	None
Anterior spinocerebellar tracts	Proprioception	As above	In same spinal segment: axons enter anterior spinocerebellar tract on same or opposite side	Not present	Cerebellar cortex, primarily on side of stimulus	Axons of most second-order neurons cross before entering tract and then cross again within cerebellum

Figure 15.3b The Posterior Column, Spinothalamic, and Spinocerebellar Sensory Tracts



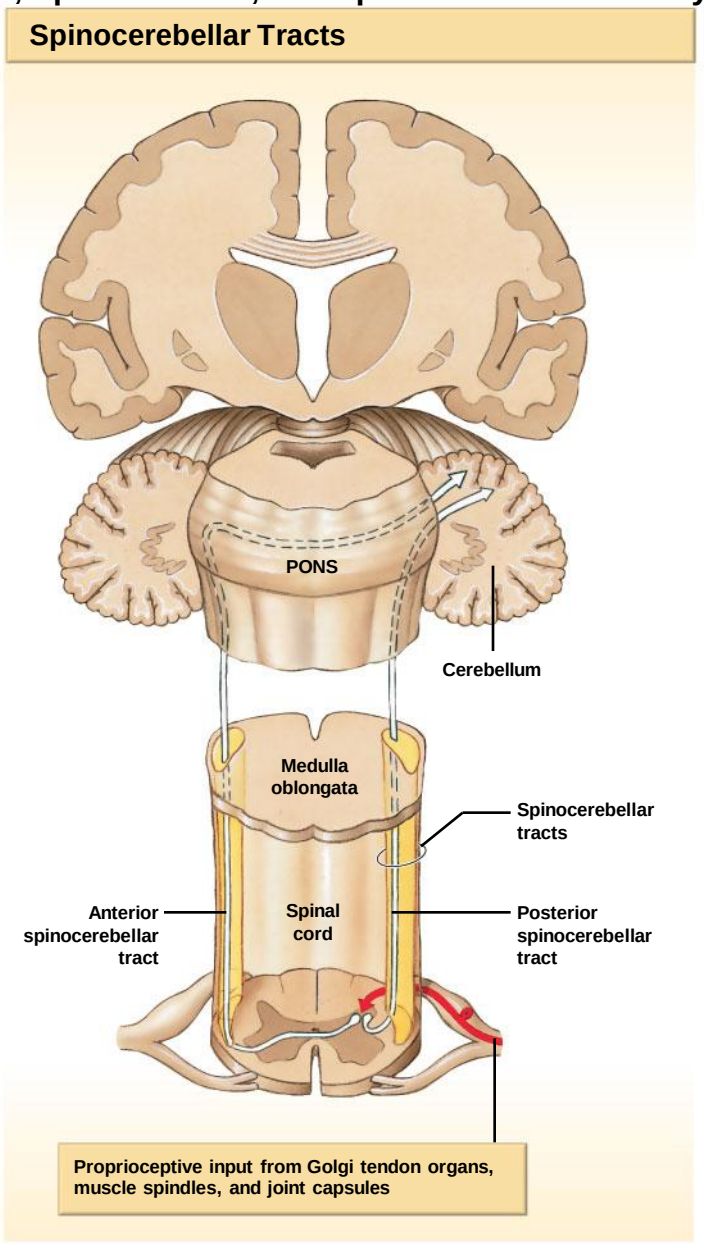
b The anterior spinothalamic tract carries crude touch and pressure sensations to the primary sensory cortex on the opposite side of the body. The crossover occurs in the spinal cord at the level of entry.

Figure 15.3c The Posterior Column, Spinothalamic, and Spinocerebellar Sensory Tracts



c The lateral spinothalamic tract carries sensations of pain and temperature to the primary sensory cortex on the opposite side of the body. The crossover occurs in the spinal cord, at the level of entry.

Figure 15.3d The Posterior Column, Spinothalamic, and Spinocerebellar Sensory Tracts

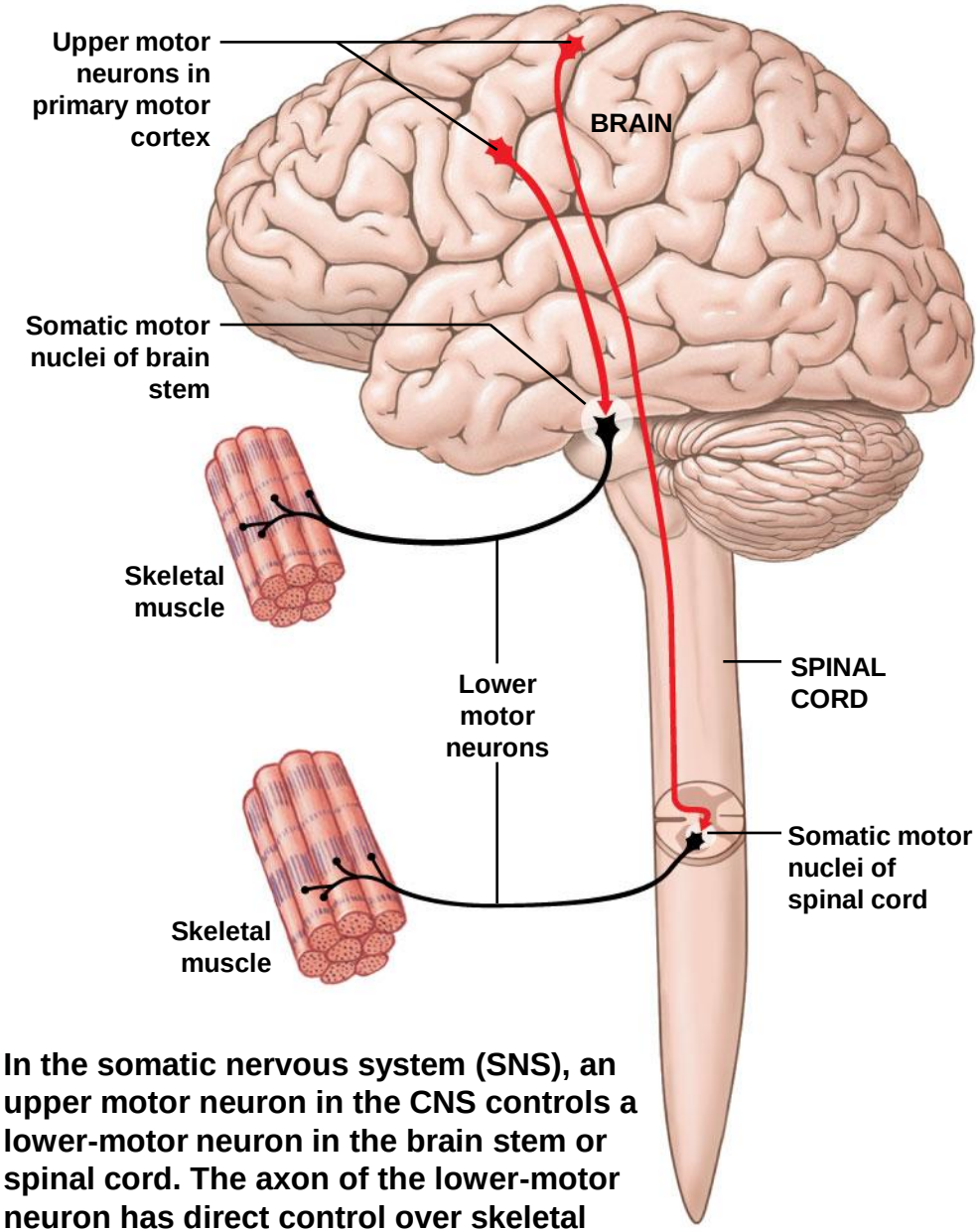


d The spinocerebellar tracts carry proprioceptive information to the cerebellum. (Only one tract is detailed on each side, although each side has both tracts.)

Sensory and Motor Tracts

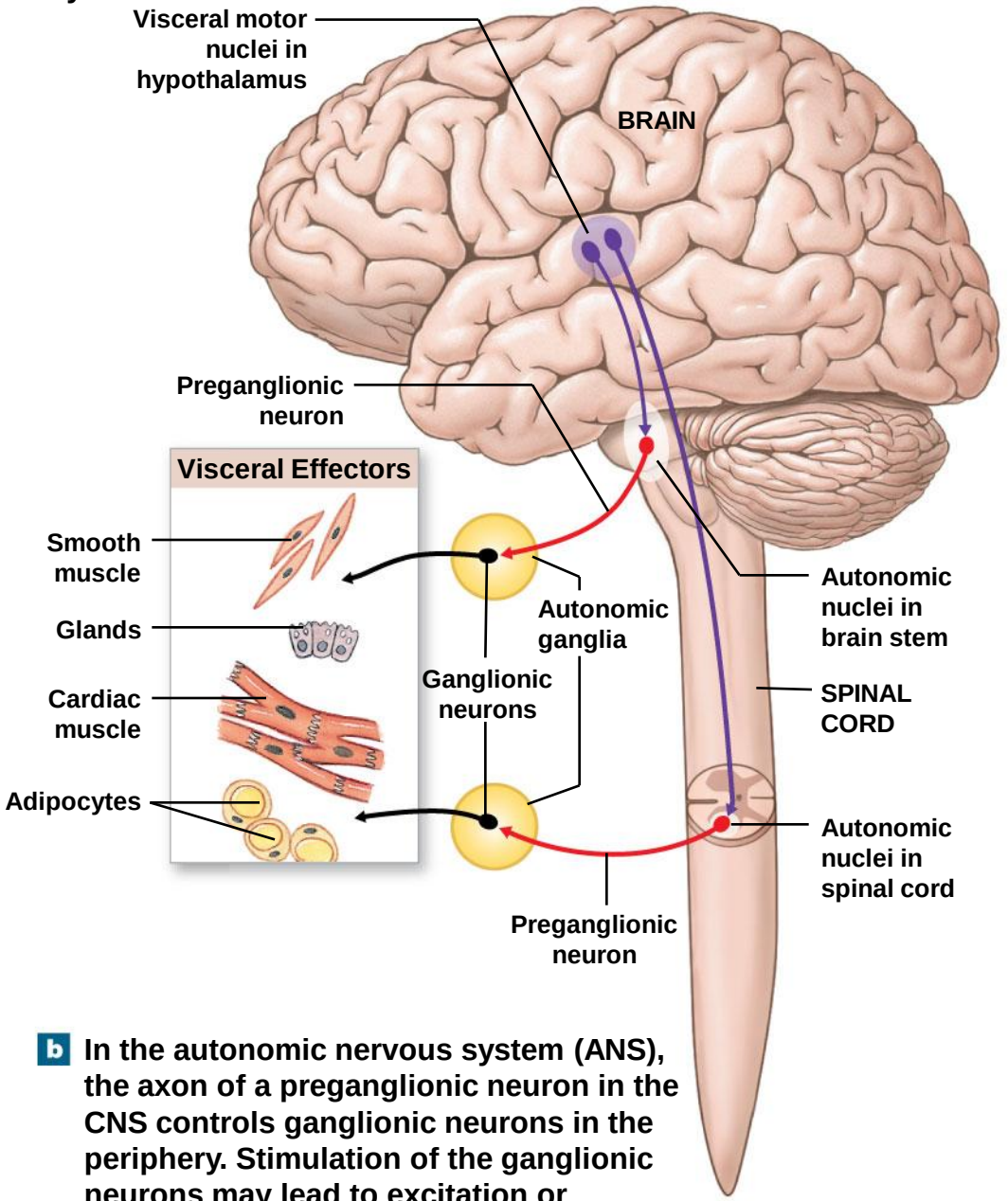
- **Motor tracts**
  - CNS transmits motor commands in response to sensory information
  - Motor commands are delivered by the:
    - **Somatic nervous system** (SNS): directs contraction of skeletal muscles
    - **Autonomic nervous system** (ANS): directs the activity of glands, smooth muscles, and cardiac muscle

Figure 15.4a Motor Pathways in the CNS and PNS



a In the somatic nervous system (SNS), an upper motor neuron in the CNS controls a lower-motor neuron in the brain stem or spinal cord. The axon of the lower-motor neuron has direct control over skeletal muscle fibers. Stimulation of the lower-motor neuron always has an excitatory effect on the skeletal muscle fibers.

Figure 15.4b Motor Pathways in the CNS and PNS



b **In the autonomic nervous system (ANS), the axon of a preganglionic neuron in the CNS controls ganglionic neurons in the periphery. Stimulation of the ganglionic neurons may lead to excitation or inhibition of the visceral effector innervated.**

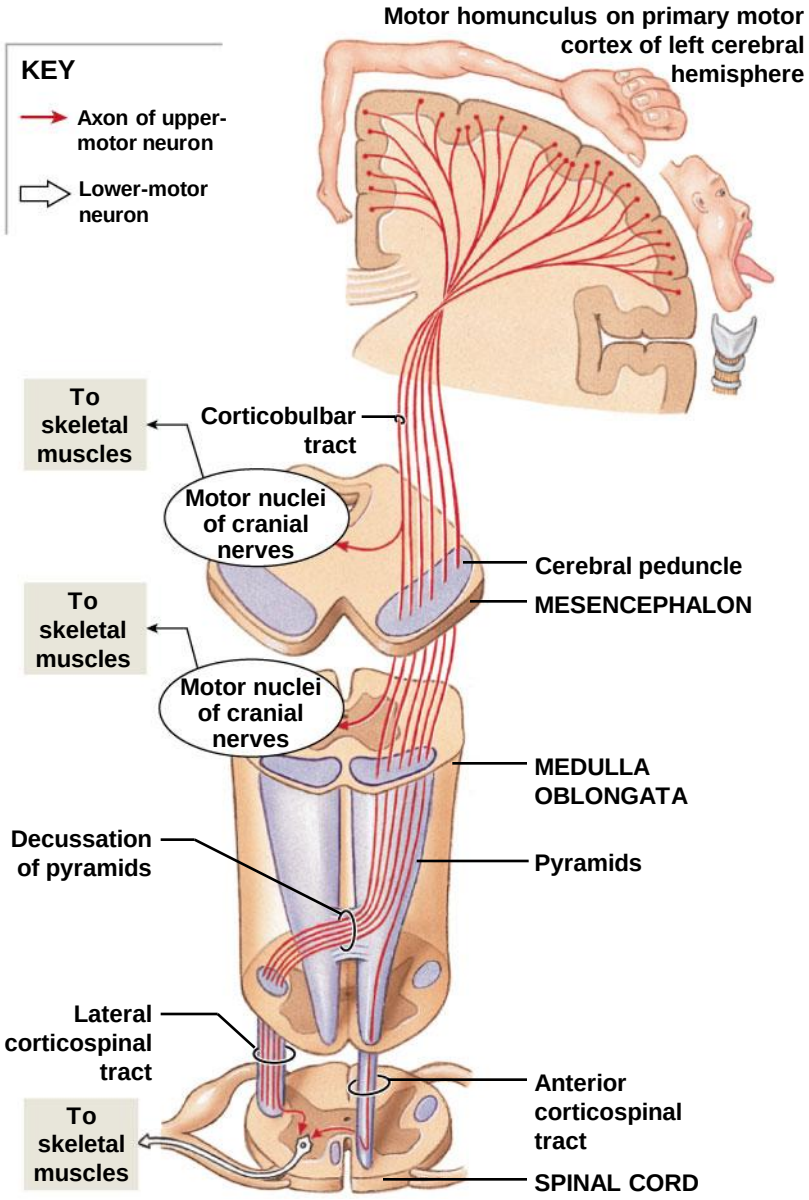
Sensory and Motor Tracts

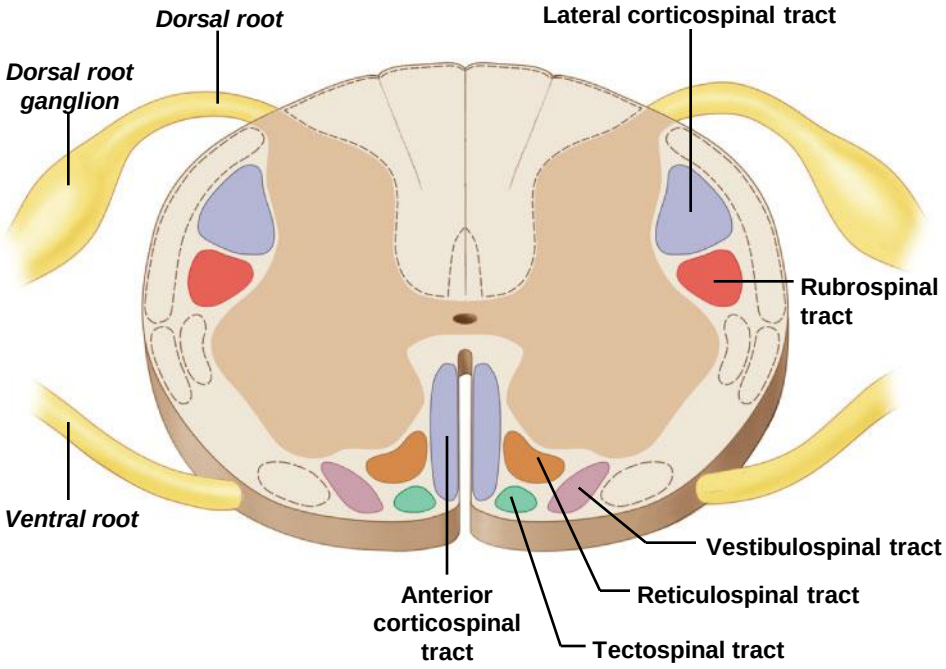
- **Motor tracts**
  - These are descending tracts
  - There are two major descending tracts
    - **Corticospinal tract:** Conscious control of skeletal muscles
    - **Subconscious tract:** Subconscious regulation of balance, muscle tone, eye, hand, and upper limb position

Sensory and Motor Tracts

- **The Corticospinal Tracts**
  - Consists of three pairs of descending tracts
    - **Corticobulbar tracts**: conscious control over eye, jaw, and face muscles
    - **Lateral corticospinal tracts**: conscious control over skeletal muscles
    - **Anterior corticospinal tracts**: conscious control over skeletal muscles

Figure 15.5 The Corticospinal Tracts and Other Descending Motor Tracts in the Spinal Cord





Sensory and Motor Tracts

- **The Subconscious Motor Tracts**
  - Consists of four tracts involved in monitoring the subconscious motor control
    - **Vestibulospinal tracts**
    - **Tectospinal tracts**
    - **Reticulospinal tracts**
    - **Rubrospinal tracts**

Sensory and Motor Tracts

- The Subconscious Motor Tracts
  - **Vestibulospinal tracts**
    - Send information from the inner ear to monitor position of the head
    - Vestibular nuclei respond by altering muscle tone, neck muscle contraction, and limbs for posture and balance

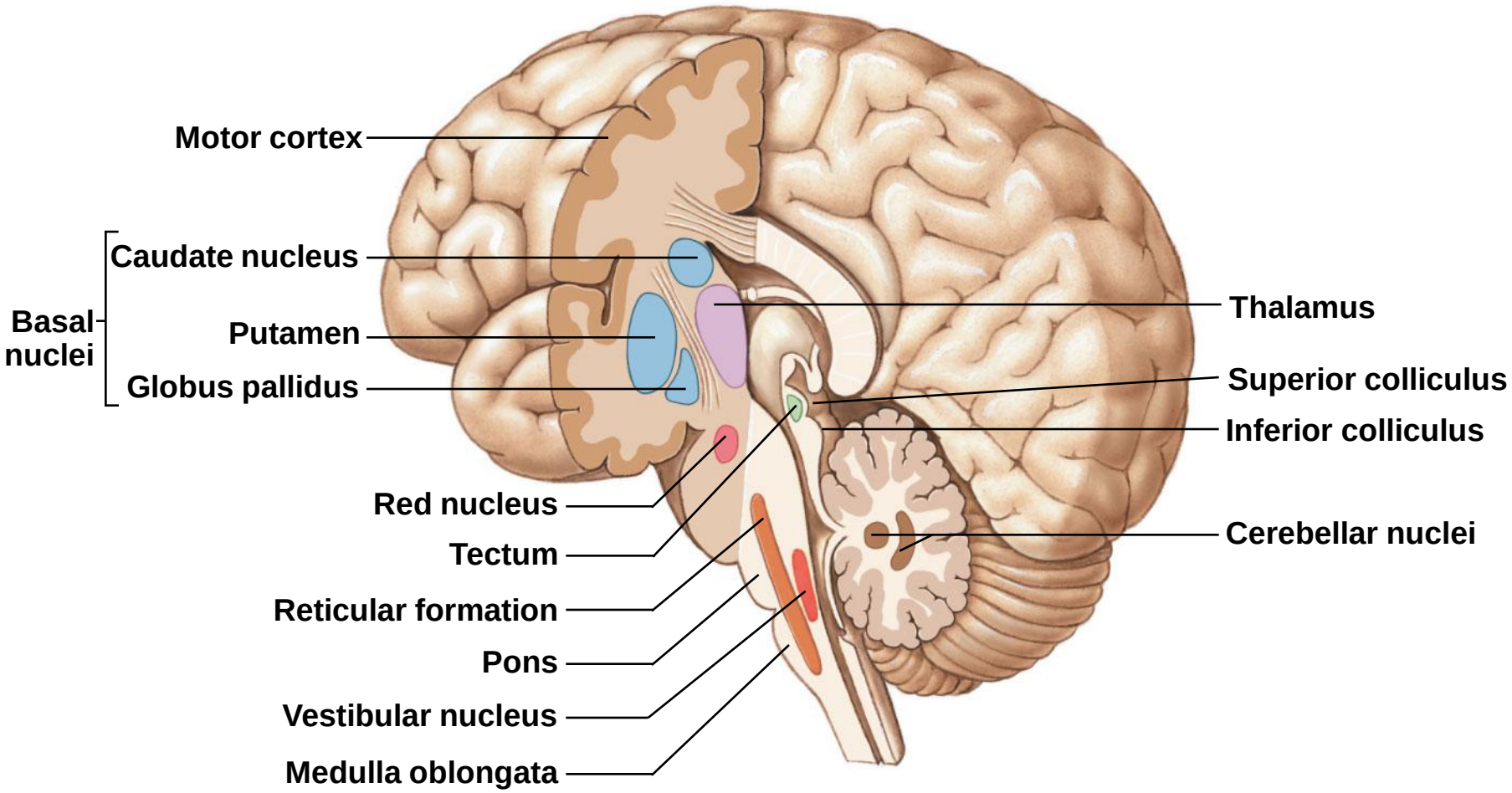
Sensory and Motor Tracts

- The Subconscious Motor Tracts
  - **Tectospinal tracts**
    - Send information to the head, neck, and upper limbs in response to bright and sudden movements and loud noises
    - The tectum area consists of superior and inferior colliculi
    - **Superior colliculi**: receives visual information
    - **Inferior colliculi**: receives auditory information

Sensory and Motor Tracts

- The Subconscious Motor Tracts
  - **Reticulospinal tracts**
    - Send information to cause eye movements and activate respiratory muscles
  - **Rubrospinal tracts**
    - Send information to the flexor and extensor muscles

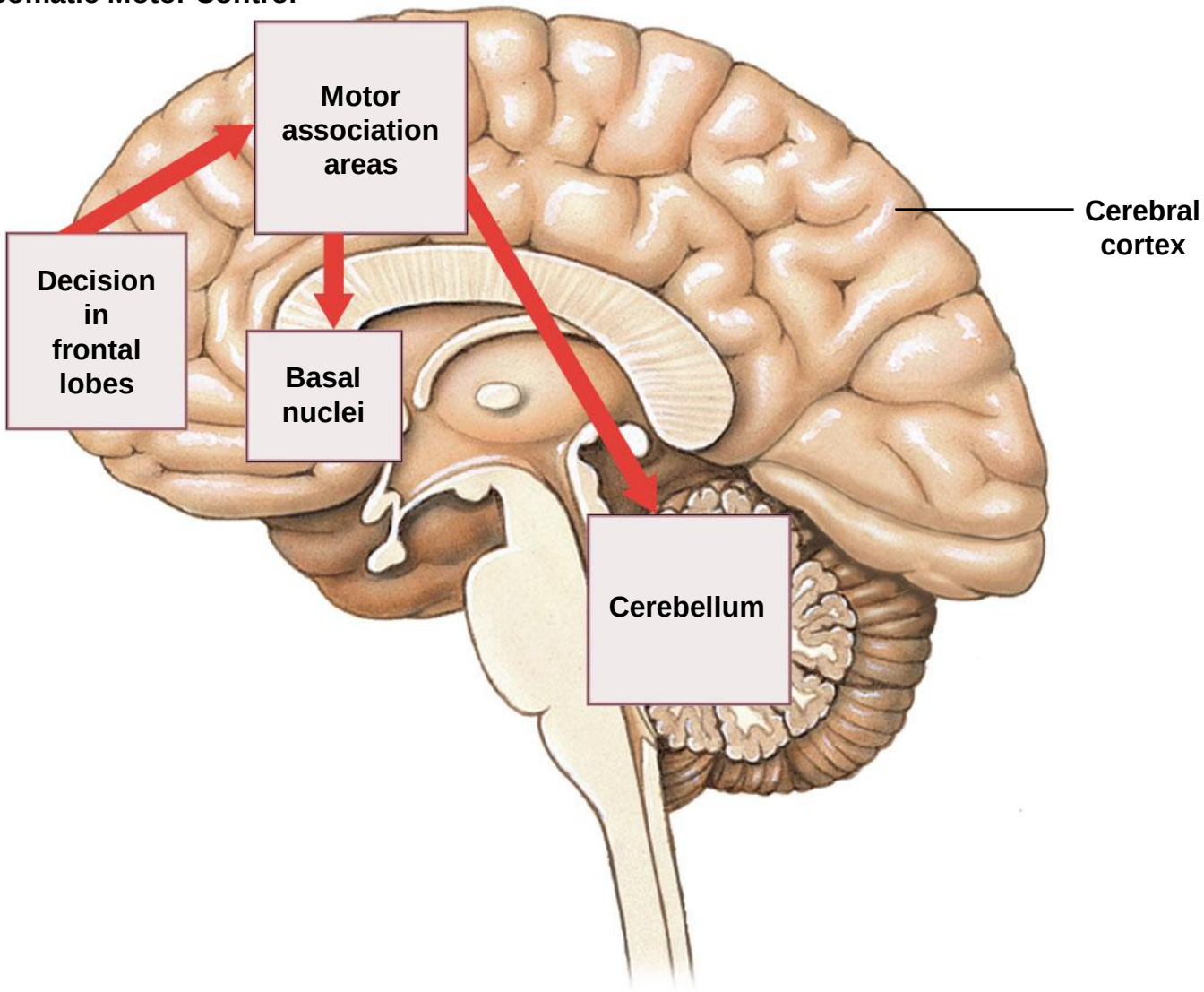
Figure 15.6 Nuclei of Subconscious Motor Pathways



Levels of Somatic Motor Control

- Summary of somatic motor control
  - Cerebral cortex initiates voluntary movement
  - Information goes to the **basal nuclei** and **cerebellum**
    - These structures modify and coordinate the movements so they are performed in a smooth manner

Figure 15.7b Somatic Motor Control

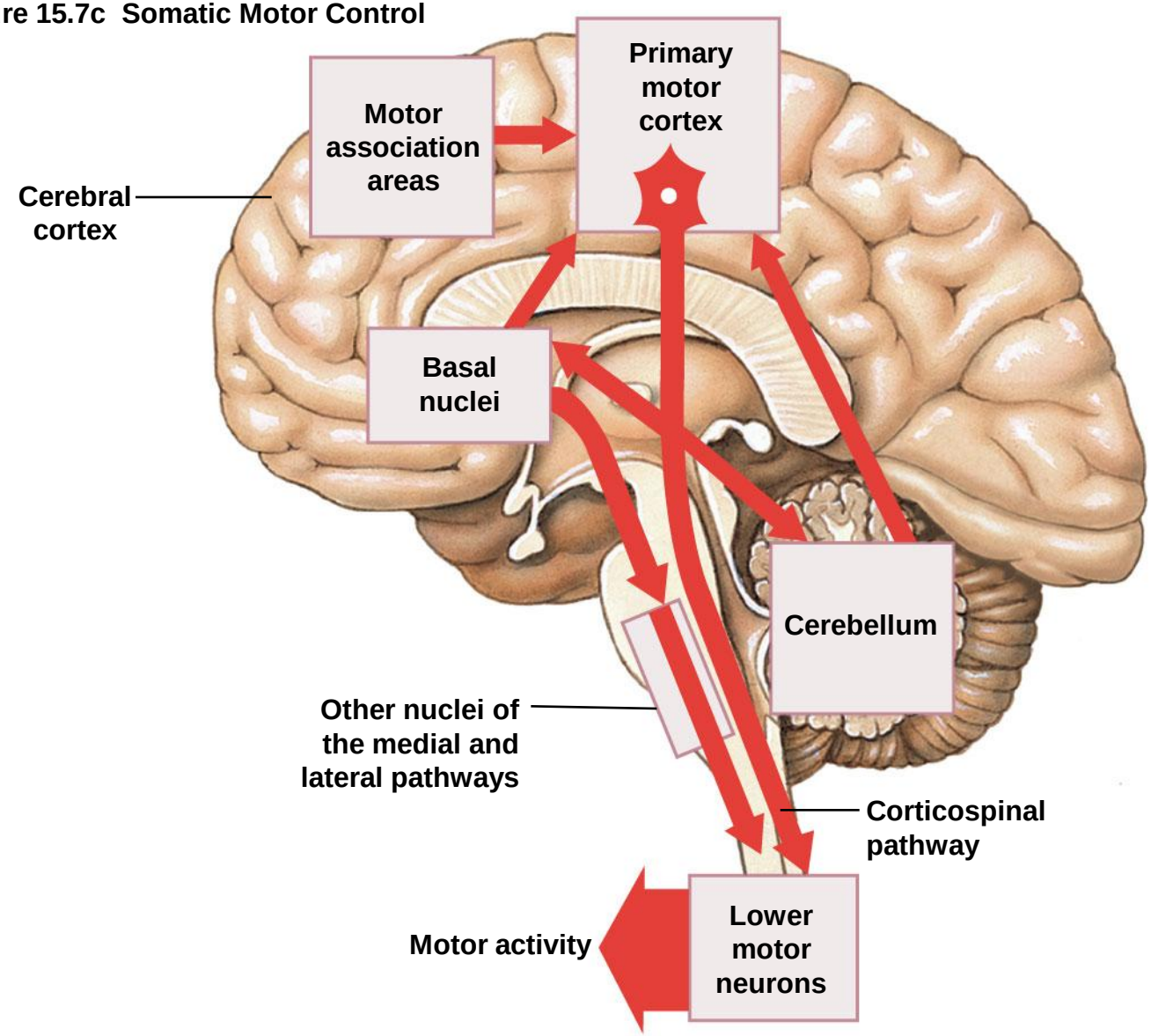


b **The planning stage: When a conscious decision is made to perform a specific movement, information is relayed from the frontal lobes to motor association areas. These areas in turn relay the information to the cerebellum and basal nuclei.**

Levels of Somatic Motor Control

- Summary of somatic motor control
  - Information goes from the basal nuclei and cerebellum back to the cerebral cortex to constantly monitor position and muscle tone

Figure 15.7c Somatic Motor Control

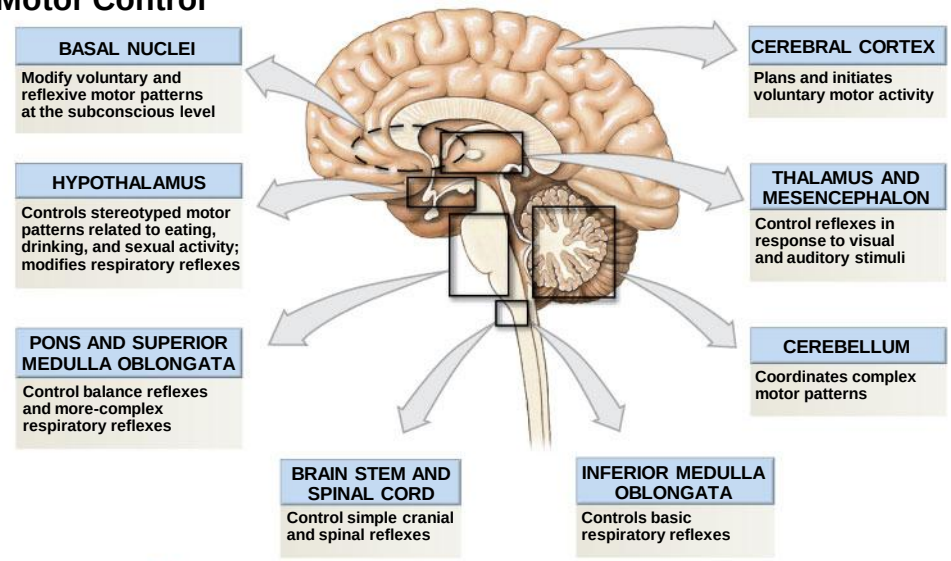


c **Movement: As the movement begins, the motor association areas send instructions to the primary motor cortex. Feedback from the basal nuclei and cerebellum modifies those commands, and output along the conscious and subconscious pathways directs involuntary adjustments in position and muscle tone.**

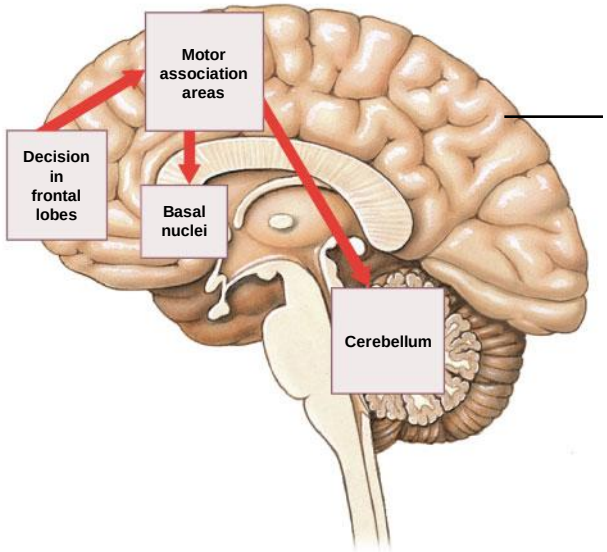
Levels of Somatic Motor Control

- Summary of somatic motor control
  - **Thalamus**
    - Controls reflexes associated with visual and auditory stimuli
  - **Hypothalamus**
    - Responds to hunger, thirst, and sexual activity
  - **Pons**
    - Regulates the rhythmic breathing patterns

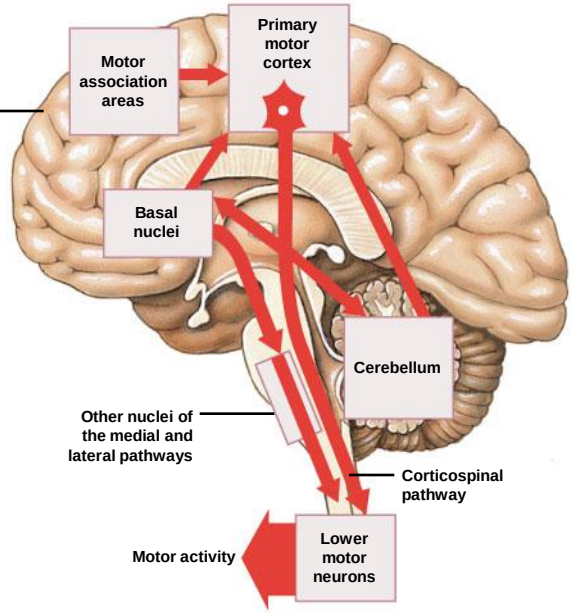
Figure 15.7 Somatic Motor Control



a Somatic motor control involves a series of levels, with simple spinal and cranial reflexes at the bottom and complex voluntary motor patterns at the top.



b The planning stage: When a conscious decision is made to perform a specific movement, information is relayed from the frontal lobes to motor association areas. These areas in turn relay the information to the cerebellum and basal nuclei.



c Movement: As the movement begins, the motor association areas send instructions to the primary motor cortex. Feedback from the basal nuclei and cerebellum modifies those commands, and output along the conscious and subconscious pathways directs involuntary adjustments in position and muscle tone.

Levels of Somatic Motor Control

- Summary of somatic motor control
  - **Medulla oblongata**
    - Alters the breathing patterns
  - **Brain stem**
    - Controls simple reflexes
  - **Spinal cord**
    - Controls simple reflexes