Carlson (7e)

PowerPoint Lecture Outline

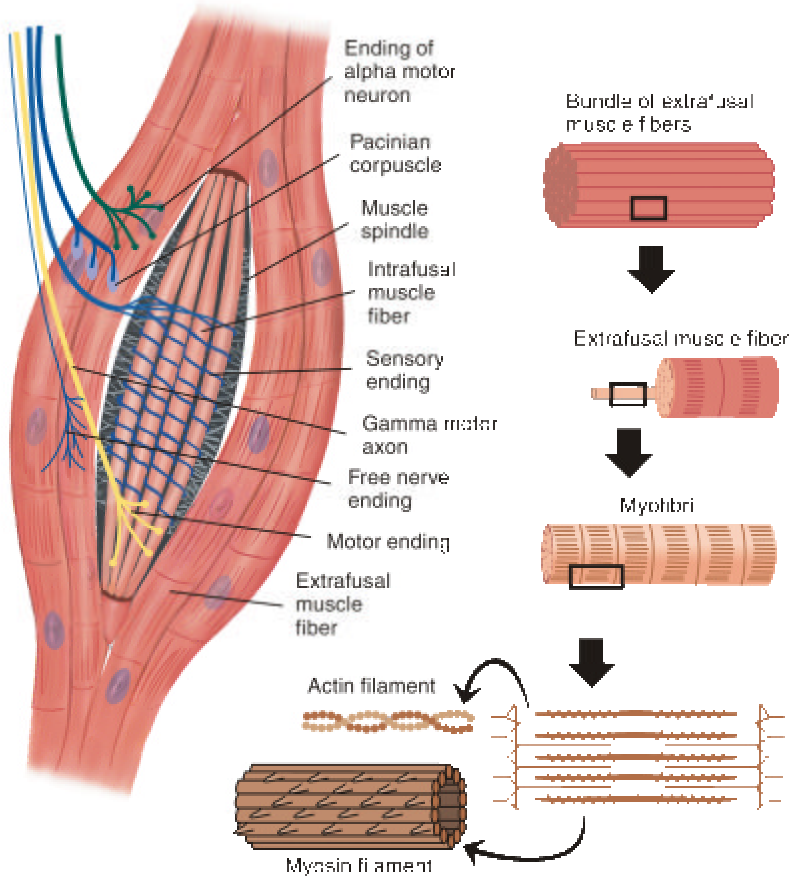
Chapter 8: Control of Movement

Skeletal Muscle

- Movements of our body are accomplished by contraction of the skeletal muscles
  - Flexion: contraction of a flexor muscle draws in a limb
  - Extension: contraction of extensor muscle
- Skeletal muscle fibers have a striated appearance
- Skeletal muscle is composed of two fiber types:
  - Extrafusal: innervated by alpha-motoneurons from the spinal cord: exert force
  - Intrafusal: sensory fibers that detect stretch of the muscle
    - Afferent fibers: report length of intrafusal: when stretched, the fibers stimulate the alpha-neuron that innervates the muscle fiber: maintains muscle tone
    - Efferent fibers: contraction adjusts sensitivity of afferent fibers.

Skeletal Muscle Anatomy

- Each muscle fiber consists of a bundle of myofibrils
  - Each myofibril is made up of overlapping strands of actin and myosin
  - During a muscle twitch, the myosin filaments move relative to the actin filaments, thereby shortening the muscle fiber



Neuromuscular Junction

- The neuromuscular junction is the synapse formed between an alpha motor neuron axon and a muscle fiber
  - Each axon can form synapses with several muscle fibers (forming a motor unit)
  - The precision of muscle control is related to motor unit size
    - Small: precise movements of the hand
    - Large: movements of the leg
- ACh is the neuromuscular junction neurotransmitter
  - Release of ACh produces a large endplate potential
    - Voltage changes open CA^{++} channels
  - CA^{++} entry triggers myosin-actin interaction (rowing action)
  - Movement of myosin bridges shortens muscle fiber

Smooth and Cardiac Muscle

- Smooth muscle is controlled by the autonomic nervous system
  - Multiunit smooth muscle is normally inactive
    - Located in large arteries, around hair and in the eye
    - Responds to neural or hormonal stimulation
  - Single-unit smooth muscle exhibits rhythmic contraction
    - Muscle fibers produce spontaneous pacemaker potentials that elicit action potentials in adjacent smooth muscle fibers
    - Single-unit muscle is found in gastrointestinal tract, uterus, small blood vessels
- Cardiac muscle fibers resemble striated muscle in appearance, but exhibit rhythmic contractions like that of single-unit smooth muscle

Muscle Sensory Feedback

- Striated muscle contraction is governed by sensory feedback
  - Intrafusal fibers are in parallel with extrafusal fibers
  - Intrafusal receptors fire when the extrafusal muscle fibers lengthen (load on muscle)
    - Intrafusal fibers activate agonist muscle fibers and inhibit antagonist muscle fibers
    - Extrafusal contraction eliminates intrafusal firing
  - Golgi tendon organ (GTO) receptors are located within tendons
    - Sense degree of stretch on muscle
    - GTO activation inhibits the agonist muscle (via release of glycine onto alpha-motoneuron
    - GTO receptors function to prevent over-contraction of striated muscle

Spinal Cord Anatomy

- Spinal cord is organized into dorsal and ventral aspects
  - Dorsal horn receives incoming sensory information
  - Ventral horn issues efferent fibers (alpha-motoneurons) that innervate extrafusal fibers

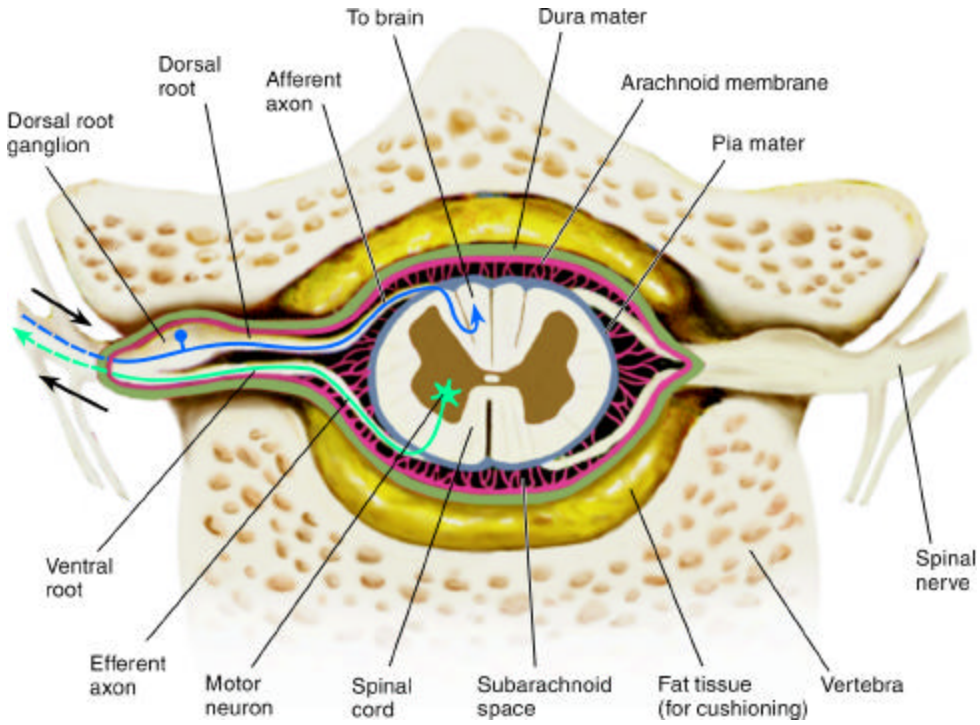
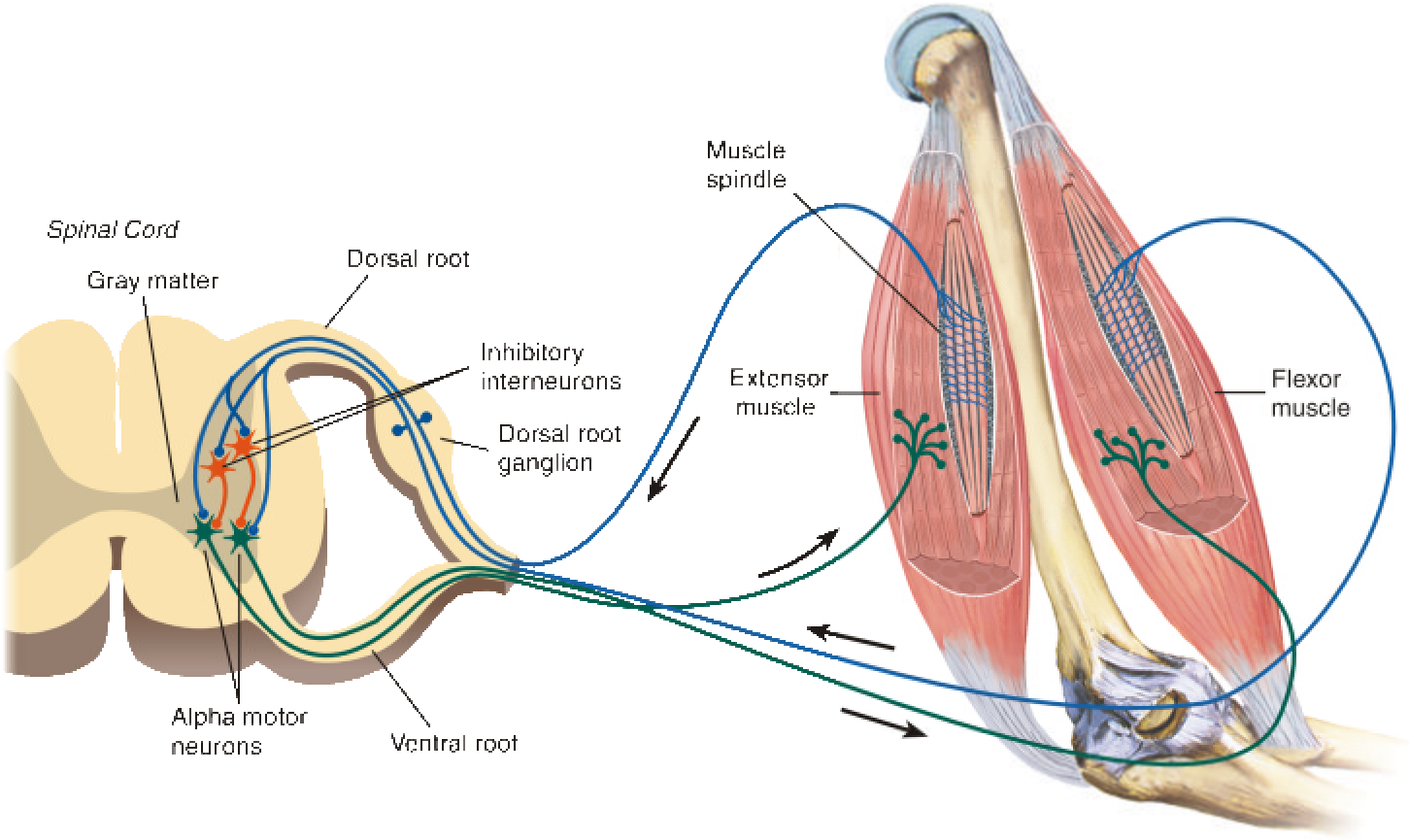


Fig 3.23

Spinal Cord Reflexes

- Monosynaptic reflexes involve a single synapse between a sensory fiber from a muscle and an alpha-motor neuron
  - Sensory fiber activation quickly activates the alpha motor neuron which contracts muscle fibers
    - Patellar reflex
    - Monosynaptic stretch stretch (posture)
- Polysynaptic reflexes involve multiple synapses between sensory axons, interneurons, and motor neurons
  - Axons from the afferent muscle spindles can synapse onto
    - Alpha motoneuron connected to the agonist muscle
    - An inhibitory interneuron connected to the antagonist muscle
    - Signals from the muscle spindle activate the agonist and inhibit the antagonist muscle

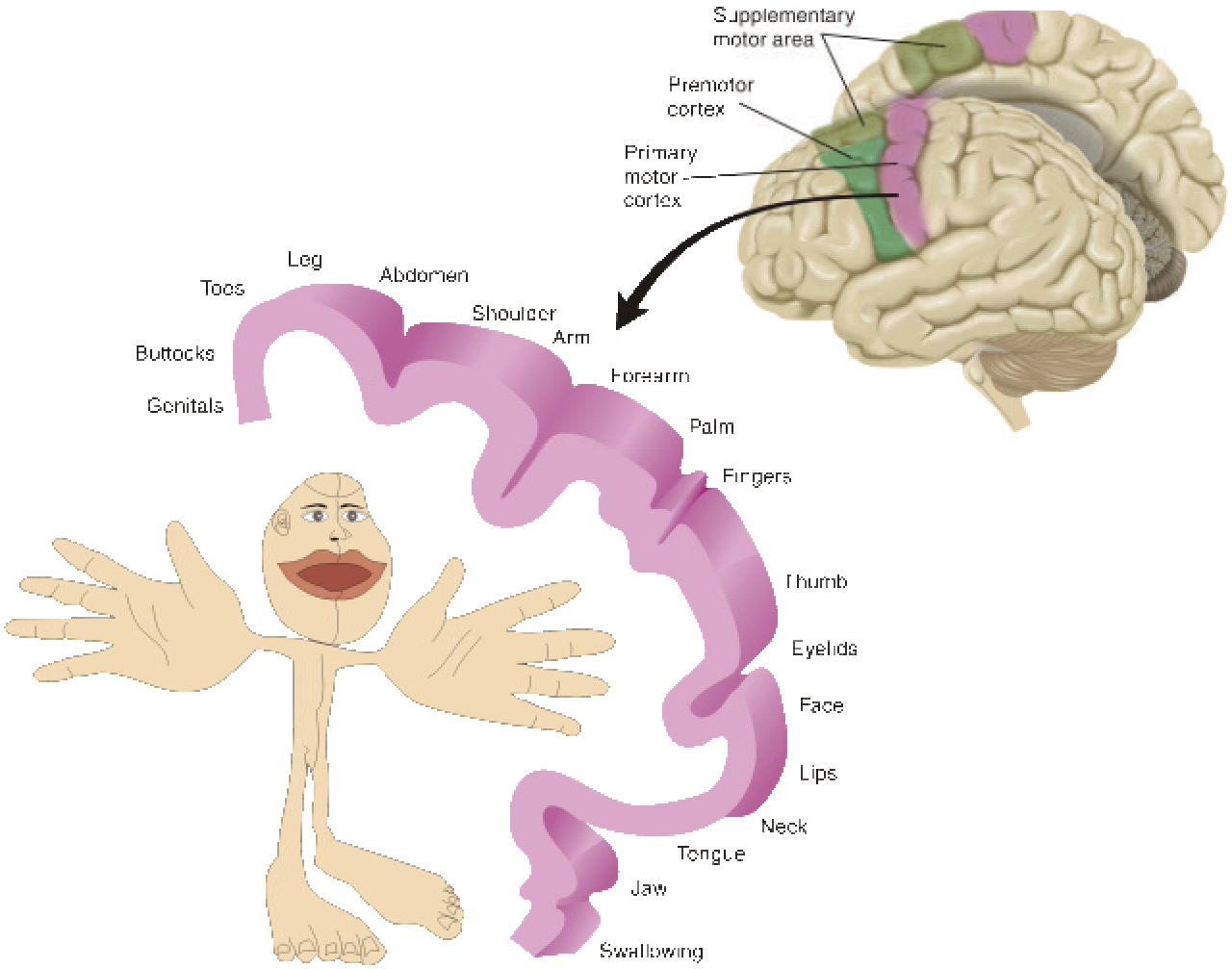
Polysynaptic Reflex



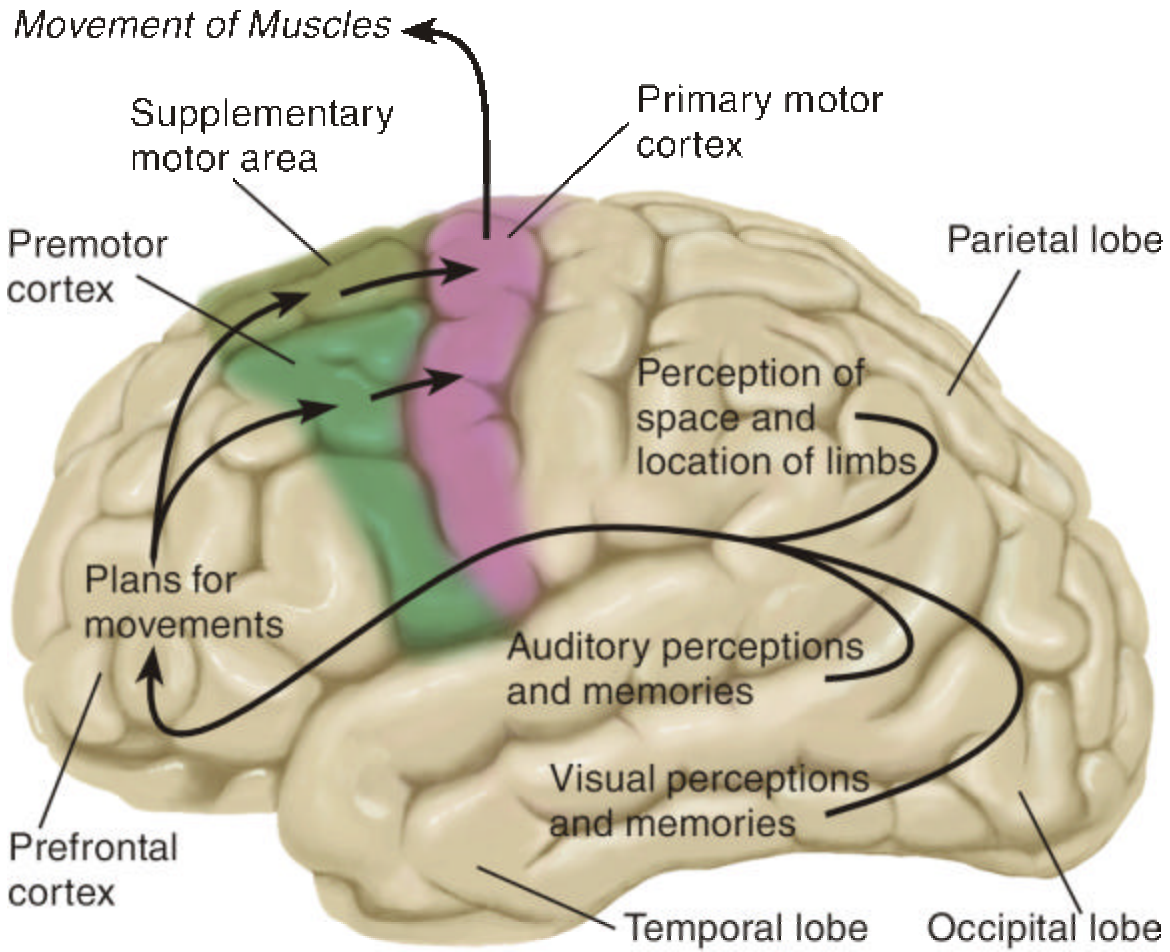
Motor Cortex

- Multiple motor systems control body movements
  - Walking, talking, postural, arm and finger movements
- Primary motor cortex is located on the precentral gyrus
  - Motor cortex is somatotopically organized (motor homunculus)
  - Motor cortex receives input from
    - Premotor cortex
    - Supplemental motor area
    - Frontal association cortex
    - Primary somatosensory cortex
  - Planning of movements involves the premotor cortex and the supplemental motor area which influence the primary motor cortex

Motor “Homunculus”



Cortical Control of Movement



Descending Motor Pathways

- Axons from primary motor cortex descend to the spinal cord via two groups
  - Lateral group: controls independent limb movements
    - Corticospinal tract: hand/finger movements
    - Corticobulbar tract: movements of face, neck, tongue, eye
    - Rubrospinal tract: fore- and hind-limb muscles
  - Ventromedial group control gross limb movements
    - Vestibulospinal tract: control of posture
    - Tectospinal tract: coordinate eye and head/trunk movements
    - Reticulospinal tract: walking, sneezing, muscle tone
    - Ventral corticospinal tract: muscles of upper leg/trunk

Corticospinal Tract

- Neurons of the corticospinal tract terminate on motor neurons within the gray matter of the spinal cord
  - Corticospinal tract starts in layer 5 of primary motor cortex
  - Passes through the cerebral peduncles of the midbrain
  - Corticospinal neurons decussate (crossover) in the medulla
    - 80% become the lat. corticospinal tract
    - 20% become the ventral corticospinal tract
  - Terminate onto internuncial neurons or alpha-motoneurons of ventral horn
- Corticospinal tracts control fine movements
  - Destruction: loss of muscle strength, reduced dexterity of hands and fingers
  - No effect of corticospinal lesions on posture or use of limbs for reaching

The Apraxias

- Apraxia refers to an inability to properly execute a learned skilled movement following brain damage
  - Limb apraxia involves movement of the wrong portion of a limb, incorrect movement of the correct limb part, or an incorrect sequence of movements
    - Callosal apraxia: person cannot perform movement of left hand to a verbal request (anterior callosum interruption prevents information from reaching right hemisphere)
    - Sympathetic apraxia: damage to anterior left hemisphere causes apraxia of the left arm (as well as paralysis of right arm and hand)
    - Left parietal apraxia: difficulty in initiating movements to verbal request
  - Constructional apraxia is caused by right parietal lobe damage
    - Person has difficulty with drawing pictures or assembling objects