Chapter 13: The Spinal Cord, Spinal Nerves, and Spinal Reflexes

Gross Anatomy of the Spinal Cord
The Distal End

- **Conus medullaris:**
  - thin, conical spinal cord below lumbar enlargement

- **Filum terminale:**
  - thin thread of fibrous tissue at end of conus medullaris
  - attaches to coccygeal ligament

- **Cauda equina:**
  - nerve roots extending below conus medullaris

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Spinal Meninges
The 3 Meningeal Layers

- Dura mater:
  - outer layer of spinal cord
- Arachnoid mater:
  - middle meningeal layer
- Pia mater:
  - inner meningeal layer

Cerebrospinal Fluid (CSF)

- Is found in subarachnoid space
- Carries dissolved gases, nutrients, and wastes
- Spinal tap:
  - withdraws CSF
The Spinal Cord

Sectional Anatomy of the Spinal Cord
The Gray Horns

- Posterior gray horns:
  - contain somatic and visceral sensory nuclei

- Anterior gray horns:
  - contain somatic motor nuclei

- Lateral gray horns:
  - are in thoracic and lumbar segments
  - contain visceral motor nuclei

Organization of White Matter

- 3 columns (funiculi) on each side of spinal cord:
  - posterior white columns
  - anterior white columns
  - lateral white columns
Tracts

- **Tracts or fasciculi:**
  - in white columns
  - bundles of axons
  - relay same information in same direction

- **Ascending tracts:**
  - carry information to brain

- **Descending tracts:**
  - carry motor commands to spinal cord

Sectional Anatomy of the Spinal Cord
Spinal Nerves

Organization of Spinal Nerves

- Every spinal cord segment:
  - is connected to a pair of **spinal nerves**

- Every spinal nerve:
  - is surrounded by 3 connective tissue layers
  - that support structures and contain blood vessels
3 Connective Tissue Layers

- **Epineurium**:  
  - outer layer  
  - dense network of collagen fibers

- **Perineurium**:  
  - middle layer  
  - divides nerve into fascicles (axon bundles)

- **Endoneurium**:  
  - inner layer  
  - surrounds individual axons

Dorsal and Ventral Rami

- **Dorsal ramus**:  
  - contains somatic and visceral motor fibers  
  - innervates the back

- **Ventral ramus**:  
  - larger branch  
  - innervates ventrolateral structures and limbs
Peripheral Distribution of Spinal Nerves

- Sensory fibers

![Diagram of Peripheral Distribution of Spinal Nerves]

Nerve Plexuses

![Diagram of Nerve Plexuses]

Figure 13–7b

Peripheral Distribution of Spinal Nerves

Sensory fibers

Figure 13–9

Nerve Plexuses
Nerve Plexuses

- Complex, interwoven networks of nerve fibers
- Formed from blended fibers of ventral rami of adjacent spinal nerves
- Control skeletal muscles of the neck and limbs

The 4 Major Plexuses of Ventral Rami

1. Cervical plexus
2. Brachial plexus
3. Lumbar plexus
4. Sacral plexus
The Cervical Plexus

- Includes ventral rami of spinal nerves C₁–C₅
- Innervates neck, thoracic cavity, diaphragmatic muscles
- Major nerve:
  - phrenic nerve (controls diaphragm)
The Brachial Plexus

- Includes ventral rami of spinal nerves C₅–T₁
- Innervates pectoral girdle and upper limbs

Major Nerves of Brachial Plexus

- Musculocutaneous nerve (lateral cord)
- Median nerve (lateral and medial cords)
- Ulnar nerve (medial cord)
- Axillary nerve (posterior cord)
- Radial nerve (posterior cord)
The Lumbar and Sacral Plexuses

- Innervate pelvic girdle and lower limbs
The Lumbar Plexus

- Includes ventral rami of spinal nerves $T_{12}-L_4$
- Major nerves:
  - genitofemoral nerve
  - lateral femoral cutaneous nerve
  - femoral nerve

The Sacral Plexus

- Includes ventral rami of spinal nerves $L_4-S_4$
- Major nerves:
  - pudendal nerve
  - sciatic nerve
- Branches of sciatic nerve:
  - fibular nerve
  - tibial nerve
Reflexes

- Automatic responses coordinated within spinal cord
- Through interconnected sensory, motor, and interneurons
- Produce simple and complex reflexes

Neural Reflexes

- Rapid, automatic responses to specific stimuli
- Basic building blocks of neural function
- 1 neural reflex produces 1 motor response
The Reflex Arc

- The wiring of a single reflex
- Beginning at receptor
- Ending at peripheral effector
- Generally opposes original stimulus (negative feedback)

5 Steps in a Neural Reflex

STEP 1: Arrival of stimulus and activation of receptor
STEP 2: Activation of a sensory neuron
STEP 3: Information processing in CNS
STEP 4: Activation of a motor neuron
STEP 5: Response by effector

KEY
- Sensory neuron (stimulated)
- Excitatory interneuron
- Motor neuron (stimulated)
Development

- How reflex was developed:
  - innate reflexes:
    - basic neural reflexes
    - formed before birth
  - acquired reflexes:
    - rapid, automatic
    - learned motor patterns

Response

- Nature of resulting motor response:
  - somatic reflexes:
    - involuntary control of nervous system
      - superficial reflexes of skin, mucous membranes
      - stretch reflexes (deep tendon reflexes) e.g., patellar reflex
  - visceral reflexes (autonomic reflexes):
    - control systems other than muscular system
Complexity

- Complexity of neural circuit:
  - monosynaptic reflex:
    - sensory neuron synapses directly onto motor neuron
  - polysynaptic reflex:
    - at least 1 interneuron between sensory neuron and motor neuron

Monosynaptic Reflexes

- A stretch reflex
**Monosynaptic Reflexes**

- Have least delay between sensory input and motor output:
  - *e.g.*, stretch reflex (such as patellar reflex)
- Completed in 20–40 msec

**A Muscle Spindle**
Muscle Spindles

- The receptors in stretch reflexes
- Bundles of small, specialized *intrafusal muscle fibers*:
  - innervated by sensory and motor neurons
- Surrounded by *extrafusal muscle fibers*:
  - which maintain tone and contract muscle

The Tendon Reflex

- Prevents skeletal muscles from:
  - developing too much tension
  - tearing or breaking tendons
- Sensory receptors unlike muscle spindles or proprioceptors
A Flexor Reflex

Withdrawal Reflexes

- Move body part away from stimulus (pain or pressure):
  - e.g., flexor reflex:
    - pulls hand away from hot stove

- Strength and extent of response:
  - depends on intensity and location of stimulus
Reciprocal Inhibition

- For flexor reflex to work:
  - the stretch reflex of antagonistic (extensor) muscle must be inhibited (reciprocal inhibition) by interneurons in spinal cord

Reflex Arcs

- Ipsilateral reflex arcs:
  - occur on same side of body as stimulus
  - stretch, tendon, and withdrawal reflexes
- Crossed extensor reflexes:
  - involves a contralateral reflex arc
  - occurs on side opposite stimulus
The Crossed Extensor Reflex

Crossed Extensor Reflexes

- Occur simultaneously, coordinated with flexor reflex
- *e.g.*, flexor reflex causes leg to pull up:
  - crossed extensor reflex straightens other leg
  - to receive body weight
The Babinski Reflexes

- Normal in infants
- May indicate CNS damage in adults