SPINAL CORD, NERVES, AND REFLEXES
PART I: SPINAL CORD

What are the structures and functions of the three meningeal layers that surround the central nervous system?

The 3 Meningeal Layers
- Continuous system surrounding brain and spinal cord (central nervous system)
  - Dura mater:
    - Tough, fibrous outer layer
  - Arachnoid mater:
    - Network containing cerebral spinal fluid
      - CSF is made in brain, contains dissolved gasses, nutrients, waste, ..
  - Pia mater:
    - Layer adhering to spinal cord, contains small vessels

Inter-Layer Spaces
- Epidural space:
  - Between dura mater and walls of vertebral canal
- Subdural space:
  - Between arachnoid mater and dura mater
- Subarachnoid space:
  - Between arachnoid mater and pia mater
  - Filled with cerebrospinal fluid (CSF)

The Adult Spinal Cord
- About 18 inches long
- 1/2 inch wide
- Ends between vertebrae L1 and L2

Enlargements of the Spinal Cord
- Caused by:
  - Amount of gray matter in segment
  - Involvement with sensory and motor nerves of limbs
- Cervical enlargement:
  - Nerves of shoulders and upper limbs
- Lumbar enlargement:
  - Nerves of pelvis and lower limbs
Roots
2 branches of spinal nerves:
- Ventral root:
  - Efferent neurons
  - Contains axons of motor neurons
- Dorsal root:
  - Afferent neurons
  - Contains axons of sensory neurons

The Distal End
- Conus medullaris:
  - thin, conical spinal cord below lumbar enlargement
- Cauda equina:
  - nerve roots extending below conus medullaris

Spinal Cord Cross-Section Anatomy
- Anterior median fissure
- Central canal
- Posterior horn
- Lateral horn
- Anterior horn
- Gray commissure
- White matter
  (ascending/descending tracts)

White & Gray Matter
White
- Is superficial
- Contains myelinated and unmyelinated axons
Gray
- Contains neuron cell bodies, synaptic knobs, neuroglia, unmyelinated axons

Horns of Gray Matter
- Posterior gray horns:
  - Location of synaptic knobs for sensory neurons
- Anterior gray horns:
  - Location of cell bodies for motor neurons
- Lateral gray horns:
  - are in thoracic and lumbar segments
  - contain visceral motor cell bodies
**White Matter Tracts**
- **Tracts:**
  - bundles of axons
  - relay same information in same direction
- **Ascending tracts (pathway):**
  - Afferent neurons
  - carry information to brain (sensory)
- **Descending tracts (pathway):**
  - Efferent neurons
  - carry motor commands to spinal cord (motor)

**Nerve Roots**
- **Ventral root**
  - Axons for motor neurons
- **Dorsal root**
  - Axons for sensory neurons
- **Dorsal root ganglion**
  - Sensory neuron cell bodies
Spinal Nerves

- 31 pairs
- Named for vertebrae above nerve
  - Except for cervical vertebrae
  - 7 cervical vertebrae but 8 nerves

The Spinal Nerve

- Each side of spine:
  - dorsal and ventral roots join
to form a spinal nerve
- Spinal nerves are mixed
  - Carry both afferent (sensory) and efferent (motor) fibers

3 Connective Tissue Layers

- Epineurium:
  - outer layer
- Perineurium:
  - middle layer
  - divides nerve into fascicles (axon bundles)
- Endoneurium:
  - inner layer
  - surrounds individual axons

Dermatomes

- Strip of skin innervated by a pair of spinal nerves
- Named for the nerve that serves it: T4, L1, etc.
Nerve Plexuses: The 4 Major Plexuses of Ventral Rami

• Cervical plexus (C1–C5)
• Brachial plexus (C5–T1)
• Lumbar plexus (T12–L4)
• Sacral plexus (L4–S4)

Cervical Plexus (C1–C5)
• Innervates neck, thoracic cavity, diaphragmatic muscles
  • Major nerve:
    • C3-C5 Phrenic nerve (controls diaphragm)

Brachial Plexus (C5-T1)
• Innervates pectoral girdle and upper limbs
  • Major nerves:
    • Axillary nerve (shoulder area)
    • Radial nerve (posterior-lateral upper limb)
    • Ulnar nerve (posterior-medial forearm, hand)
    • Median nerve (anterior-medial forearm, hand)
    • Musculocutaneous nerve (anterior arm)
Lumbar Plexus (T12 - L4)
- Major nerves:
  - Femoral nerve (anterior thigh)
  - Genitofemoral nerve (genital region)
  - Obturator nerve (adductor muscles of thigh)

Sacral Plexus (L4 - S4)
- Major nerves:
  - Pudendal nerve (genitalia & sphincters)
  - Sciatic nerve (posterior thigh, lower leg)
    - Peroneal (fibular) nerve (dorsiflexion, eversion)
    - Tibial nerve (hamstrings, plantar flexion)
SPINAL CORD, NERVES, AND REFLEXES
PART III: SPINAL REFLEXES

The Reflex Arc
- The wiring of a single reflex
- Beginning at receptor
- Through grey matter of spinal cord
- Ending at peripheral effector
- Generally opposes original stimulus (negative feedback)

5 Steps in a Neural Reflex
1. Activation of receptor
2. Activation of sensory neuron
3. Spinal cord interneurons
   - Info out to effector & to brain
4. Activation of motor neuron
5. Effector response

Reflexes
“Involuntary response to a stimulus”

Spinal Reflexes
- Stretch reflex
- Golgi tendon reflex
- Flexor reflex (withdrawal reflex)
- Crossed extensor reflex

Stretch Reflex
- Activated by rapid stretch of muscle
- Muscle spindles
  - Bundles of small, specialized intrafusal and extrafusal muscle fibers:
  - innervated by sensory and motor neurons
The (Golgi) Tendon Reflex
• Prevents skeletal muscles from:
  - tearing or breaking bones
• Sensory receptors in tendons
• Activated reflex: inhibits muscular contraction

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
  - Antagonist is inhibited when agonist is activated

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

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
  - maintained by reverberating circuits

The Babinski Reflexes
• Normal in infants (<2 yrs old)
• May indicate CNS damage in adults