Introduction – Spinal Cord

- Contains neural circuits that control some of your quickest reactions to environmental changes.

- Site for integration of neuronal stimulation that arises locally or from the PNS and the brain.

- Relays sensory nerve impulses headed for the brain, as well as motor nerve impulses from the brain to skeletal muscles and other effectors.

- The spinal cord is continuous with the brain and together they constitute the central nervous system (CNS).
Spinal Cord

- Spinal meninges - cover the spinal nerves to the intervertebral foramina exit point.
- Cerebrospinal fluid - a shock absorber and suspension system for the spinal cord and brain.
- Denticulate ligaments - thickenings of the pia mater project and fuse with the arachnoid mater and inner surface of the dura mater between the anterior and posterior nerve roots of spinal nerves on either side.

Meninges

- Dura mater - most superficial - dense, irregular connective tissue.
- Epidural space - cushion of fat and connective tissue between the dura mater and the wall of the vertebral canal.
- Arachnoid - middle meninx - avascular covering - spider’s web arrangement of delicate collagen fibers and some elastic fibers.
- Subdural space - between the dura and arachnoid mater - contains interstitial fluid.
- Pia mater - innermost meninx - thin transparent connective tissue layer that adheres to the surface of the spinal cord and brain.
- Subarachnoid space - between the arachnoid and pia mater - contains CFS

Transverse section of the spinal cord within a cervical vertebrae (Fig. 18.1b) insert figure 18.1b
External Anatomy of the Spinal Cord

- Adult spinal cord length - 42 to 45 cm (16–18 in.).
- Diameter about 2 cm (0.75 in.) in the mid-thoracic region.
- The **cervical enlargement** - from the fourth cervical vertebra to the first thoracic vertebra.
- The **lumbar enlargement** - from the ninth to the twelfth thoracic vertebra.
- **Conus medullaris** - tapering, conical structure at end of cord.  
  - ends at the intervertebral disc between the first and second lumbar vertebrae in adults.
  - arising from the conus medullaris is the **filum terminale**.

Internal Anatomy of the Spinal Cord

- Two grooves divide the white matter into right and left sides.
  - **Anterior median fissure** - wide groove on the anterior (ventral) side.
  - **Posterior median sulcus** - narrow groove on the posterior (dorsal) side.
- **Gray matter** - is shaped like the letter H or a butterfly and is surrounded by white matter.
  - Cell bodies of neurons, neuroglia, unmyelinated axons, and dendrites of interneurons and motor neurons.
- **White matter** - bundles of myelinated axons of sensory neurons, interneurons, and motor neurons.
Internal Anatomy of the Spinal Cord

- **Gray Commissure** - forms the crossbar of the H.
  - **Central Canal** - center is a small space - extends the length of the spinal cord and contains cerebrospinal fluid.

- **Horns** - divisions of the gray matter on each side of the cord
  - **Anterior (ventral) gray horns** - somatic motor nuclei (clusters of cell bodies)
    - provide nerve impulses for skeletal muscle contraction.
  - **Posterior (dorsal) gray horns** - cell bodies and axons of interneurons and axons of incoming sensory neurons.
  - **Lateral gray horns** - only in thoracic, upper lumbar, and sacral segments of the spinal cord.
    - autonomic motor nuclei that regulate activity of smooth muscle, cardiac muscle, and glands.

---

Internal anatomy of the spinal cord
(Fig. 18.3a)

---

---
Internal Anatomy of the Spinal Cord

- The white matter, like the gray matter, is organized into regions. The anterior and posterior gray horns divide the white matter.

- Anterior to the gray commissure is the anterior (ventral) white commissure, which connects the white matter of the right and left sides of the spinal cord.

Internal Anatomy of the Spinal Cord

- **Columns** - white matter divisions
  - **Posterior and Lateral White Columns**
    - Bundles of axons
  - **Tracts** - carry information to and from specific regions
    - Sensory and motor tracts
Spinal Nerves

- Spinal nerves and the nerves that branch from them are part of the peripheral nervous system (PNS).
- They connect the CNS to sensory receptors, muscles, and glands in all parts of the body.
- There are 31 pairs of spinal nerves. Each pair of spinal nerves arises from the spinal cord.
- There are 8 pairs of cervical nerves (C1–C8), 12 pairs of thoracic nerves (T1–T12), 5 pairs of lumbar nerves (L1–L5), 5 pairs of sacral nerves (S1–S5), and 1 pair of coccygeal nerves (Co1).
Branches of the Spinal Nerves

- **Posterior Root Ganglion** - cell bodies

- **Spinal nerve trunk** - mixed nerve
  - Sensory posterior root and motor anterior root project laterally from the spinal cord and converge.
  - **Ramus** - trunk branches into two large branches
    - becomes a series of smaller branches

---

Branches of the Spinal Nerves

- **Anterior (ventral) ramus and posterior (dorsal) ramus**, are somatic branches in the musculoskeletal system.
  - Posterior (dorsal) ramus - serves the deep muscles and skin of the posterior surface of the trunk.
  - Anterior (ventral) ramus serves the muscles and structures of the upper and lower limbs and the muscles and skin of the lateral and anterior regions of the trunk.

- Smaller visceral branches (meningeal branch and the communicating rami) form the autonomic pathways to smooth muscle and glandular tissue.

---

Plexuses

- Axons from the anterior rami of spinal nerves, except for thoracic nerves T2–T12, do not go directly to the body structures they supply
  - Form cervical plexus, brachial plexus, lumbar plexus, and sacral plexus. A smaller coccygeal plexus is also present.
- Groups of nerves emerge from the plexuses.
- T2-T12 form Intercostal or Thoracic nerves
Cervical Plexus (Fig. 18.5a)

Brachial Plexus (Fig. 18.6a)

Lumbar Plexus (Fig. 18.7a)
Sacral and Coccygeal Plexuses

- The anterior rami of spinal nerves L4–L5 and S1–S4 form the **sacral plexus**.
  - This plexus is situated largely anterior to the sacrum.
  - The sacral plexus supplies the buttocks, perineum, and lower limbs.
  - The **sciatic nerve** arises from the sacral plexus.
  - Coccygeal nerves form the small **coccygeal plexus** (S4-S5)

Sacral plexus (Fig. 18.8a)

Dermatomes

- Each spinal nerve contains sensory neurons that serve a specific, predictable segment of the body.
- Dermatomes are the areas of the skin that provides sensory input to the CNS via one pair of spinal nerves.
- The nerve supply in adjacent dermatomes overlaps somewhat.
- Knowing which spinal cord segments supply each dermatome makes it possible to locate damaged regions of the spinal cord.
Connective tissue coverings of a spinal nerve (Fig. 18.10 a)

Connective Tissue Coverings of Spinal Nerves

- **Nerve fiber** - axon and its associated glial cells

- **Endoneurium** - Each nerve fiber sits in a loose connective tissue
  - mesh of collagen fibers, fibroblasts, and macrophages surrounded by endoneurial fluid (extracellular fluid) derived from the capillaries
  - nourish neurons, allows environment for action potentials

Connective Tissue Coverings of Spinal Nerves

- **Perineurium** - A thicker sheath of connective tissue that packages nerve fibers into bundles called **fasciculi**.
  - sheaths with up to 15 layers of fibroblasts distributed in a meshwork of collagen.
  - Diffusion barrier - blood brain barrier, osmotic pressure maintained

- **Epineurium** - Outer sheath
  - Bundles fascicles to form one nerve
  - Fibroblasts and thick collagen
  - Protects the nerve
Tracts and Columns

- **White Matter Tracts** - sensory to brain, motor from brain

- **Gray Matter** - receives and integrates information from white matter

- **Tracts** - Named for where they come from and where they go to

Sensory Tracts and Columns

- **Lateral and Anterior Spinothalamic Tract** -
  - Sensation for pain, coolness, itch, tickle, deep pressure, diffuse touch

- **Posterior Columns** -
  - Proprioception, discrimination touch, two point discrimination, light pressure, vibration
Motor Tracts and Columns

- **Lateral Corticospinal, Anterior Corticospinal, and Corticobulbar Tracts**
  - Control voluntary muscles

- **Rubrospinal, Tectospinal, Vestibulospinal Tracts**
  - Control automatic movements (postural muscles)

Reflexes and Reflex Arcs

- Spinal cord serves as an integrating center for some reflexes.

- Reflex is a fast, involuntary, unplanned sequence of actions that occurs in response to a particular stimulus.

- Some reflexes are inborn, while other reflexes are learned or acquired.

Reflexes and Reflex Arcs

- **Spinal reflex** - integration in the spinal cord gray matter,
  - Knee jerk

- **Cranial reflex** - integration in the brain stem
  - Tandem eye movement when reading

- **Somatic reflexes** involve contraction of skeletal muscles.

- **Autonomic (visceral) reflexes** generally are not consciously perceived.
  - Smooth muscle, cardiac muscle, or glands
Reflexes and Reflex Arcs

- **Sensory receptor**: Responds to a specific type of stimulus by generating one or more nerve impulses.
- **Sensory neuron**: Conducts from the sensory receptor along the axon of a sensory neuron to its axon terminals, located in the CNS gray matter. Axon branches also relay nerve impulses to the brain, allowing conscious awareness that the reflex has occurred.
- **Integrating center**: One or more regions of gray matter in the CNS act as an integrating center.
- **Motor neuron**: Impulses triggered by the integrating center pass out of the spinal cord along a motor neuron to the part of the body that will respond.
- **Effector**: The part of the body that responds to the motor nerve impulse, such as a muscle or gland.

Patellar reflex (Fig. 18.12)