Objectives
- Be able to concisely describe the gross anatomy of the spinal cord.
- Be able to explain the distinct anatomy and function of the dorsal and ventral roots.
- Be able to describe the structure, organization, and basic function of the cord in cross-section.
- Be able to describe what information enters and leaves the spinal cord.
- Be able to explain the basic organization of the stretch and withdrawal reflexes.
- Be able to describe what a central pattern generator is.
- Be able to describe how spinal functions can be regulated by, and interact with, descending pathways.

I. Overview
The spinal cord is the long extension of the brain running down the middle of the back. In some ways the spinal cord looks and functions like a cable bringing sensory information from the body to the brain and sending movement commands from the brain to the body. It is also a complicated processor of sensory and motor information that regulates sensory inflow and contributes to the control of effective movements. Note that for everything discussed in sections III - VI below, there are analogous structures and functions for the head and face, mediated by cranial nuclei and other brainstem neurons.

II. Spinal Cord Anatomy
A. Gross anatomy
1. Cord segments are symmetric about the midline and are labeled for associated vertebrae.
2. Each level of the cord receives somatic sensory information from, and sends somatic motor commands to, a specific part of the body. In addition, the T1-L2 segments include sympathetic neurons and the S1-S5 segments contain parasympathetic neurons.
3. Because the spinal cord stops growing earlier in development than the rest of the body, the cord is shorter than the vertebral column; it ends at ~L1 in adults, below which the vertebral canal contains only dorsal and ventral roots.
4. Dorsal and ventral roots join after the dorsal root ganglion to form spinal nerves that exit the vertebral column at the associated vertebral level; below the cervical segments the nerve roots travel more and more caudally to reach their exit points.
5. 31 pairs of afferent and efferent spinal nerves branch outside the vertebral column to form peripheral nerves.
B. Cross sectional anatomy

1. Spinal gray matter (cell bodies) is arranged in "H" pattern inside white matter (axons). This "H" is functionally arranged in the sensory-dorsal, motor-ventral organization that is fairly consistent throughout the brainstem.

2. Somatosensory information enters the cord through primary afferent axons in dorsal roots; cell bodies of these neurons are in the dorsal root ganglia; branches of these axons synapse in the ipsilateral dorsal horns (the top arms of the "H").

3. Axons of motoneurons leave the cord through ventral roots to activate ipsilateral muscles. Motoneuron cell bodies are in the ventral horns (the bottom arms of the "H"), motoneurons for axial muscles are in the medial ventral horn, and motoneurons for distal muscles are in the lateral ventral horn.

4. Cord cross section looks different at different segments.
   a. Cervical and lumbar segments are enlarged because they contain sensory neurons, motoneurons and interneurons related to the arms and legs, respectively.
   b. There is a rostral-to-caudal decrease in the amount of white matter because each level of the cord contains the fibers ascending from, and descending to, all segments more caudal.
To the right you can see the general somatotopy of motoneurons in the cord.

Very briefly:

- Motoneurons for axial muscles are medial
- Motoneurons for distal muscles are lateral
- Motoneurons for flexors are dorsal
- Motoneurons for extensors are ventral

Below you can see the differences between cord cross sections at different levels.

Very briefly:

S2 – smallest white matter
L2 – more white matter, particularly dorsal and medial
T4 – smallest gray matter

C6 largest cross section
III. Somatosensory inputs to the dorsal horns
   A. Primary afferent axons in the dorsal roots originate from different types of somatosensory receptors in the periphery – touch (cutaneous or tactile), pain (nociception), temperature, and proprioception (e.g., muscle spindles, Golgi tendon organs). Dorsal roots also carry afferent axons from viscera.
   B. Modality, intensity and location of somatosensory stimuli are established by the peripheral receptors.

IV. Spinal Reflexes
   A. Activation of primary somatosensory afferents elicits stereotyped behaviors known as spinal reflexes, which can be mediated entirely by spinal pathways.
   B. Stretch (or monosynaptic or deep tendon) reflex resists changes in muscle length, usually at a single joint.
      1. Stretch activates group Ia muscle spindle afferents that monosynaptically excite motoneurons of the same and synergistic muscles.
      2. Reciprocal inhibition of antagonist muscles is mediated by an interposed inhibitory interneuron.
   C. Flexion (or withdrawal) and cross-extension reflexes withdraw a limb from noxious stimuli and provide postural support with the opposite limb.
      1. Polysynaptic pathways excite flexor and inhibit extensor muscles on the side ipsilateral to the stimulus and excite extensor and inhibit flexor muscles on the contralateral side.
      2. Reflex involves neurons in multiple segments controlling multiple joints.
V1. Descending Control of Spinal Circuits

A. Brainstem and cerebral cortical signals converge on the same spinal neurons that mediate sensory transmission and execute reflexes and rhythmic movements.

1. This convergence allows for descending modulation of reflex movements, CPG function, and ascending sensory transmission.

2. This convergence also allows somatosensory information entering the spinal cord to modulate descending commands for movement.