I. Basics of the spinal cord
   a. Encased by the vertebral column
   b. Provides a conduction pathway to and from the brain.
II. Major functions of the spinal cord
   a. Transmit sensory information from the periphery to the brain.
   b. Transmit motor commands from the brain to the periphery.
   c. Serve as an integration center for reflexes.
III. Spinal cord protection
   a. Protected by the vertebrae, a system of membranes (the meninges (sing. meninx)), and cerebrospinal fluid.
   b. 24 adult vertebrae plus the sacrum and coccyx protect the cord and its associated nerves.
   c. Meninges
      i. There is a single meninx, the pia mater, on the surface of the spinal cord.
      ii. Superficial to the pia mater is another delicate meninx, the arachnoid mater.
      iii. Between the pia and arachnoid mater is the subarachnoid space and it contains CSF.
      iv. External to the arachnoid mater is a tough fibrous meninx, the dura mater.
      v. The space between the dura mater and the vertebrae is the epidural space and it contains mostly fat and blood vessels.
   d. CSF is derived from blood and made at choroid plexuses – vascular structures associated with the ventricles (i.e. cavities) of the brain. CSF cushions, buffers, and protects the CNS.
IV. Spinal cord gross anatomy
   a. Cord runs from the foramen magnum to the level of L1.
   b. 31 pairs of spinal nerves issue from the spinal cord.
   c. There are 8 cervical spinal nerves, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.
   d. Each nerve pair defines a spinal segment.
   e. The cord has a cervical enlargement and a lumbosacral enlargement where the spinal nerves serving the appendages arise.
   f. The end of the spinal cord is a tapered structure called the conus medullaris which is anchored to the coccyx by an extension of the pia mater called the filum terminale.
   g. Since the spinal cord ends before the sacrum, the roots of the lumbar and sacral spinal nerves travel inferiorly in the vertebral canal before exiting via their foramina. This collection of nerve roots is known as the cauda equina.
V. Spinal cord cross-sectional anatomy
   a. In cross-section the spinal cord is asymmetrical.
   b. It contains a deep cleft on the anterior surface known as the anterior median fissure.
   c. It contains a shallow furrow on the posterior surface known as the posterior median sulcus.
   d. The x-section shows the arrangement of the gray matter and white matter of the spinal cord.
   e. Gray matter is primarily somata, dendrites, and unmyelinated axons.
   f. White matter is primarily myelinated axons.
   g. The gray matter in the spinal cord cross section has the appearance of a butterfly. The 2 “wings” are linked by a short segment called the gray commissure.
   h. The gray commissure primarily consists of unmyelinated axons connecting the right and left sides of the spinal cord.
   i. W/i the gray commissure is an opening called the central canal which is usually filled with CSF.
   j. Each “wing” of gray matter has 2 parts: a posterior horn and an anterior horn.
   k. The posterior horn is almost entirely interneurons and incoming axons of sensory neurons.
   l. The anterior horn has some interneurons but mainly consists of somata and dendrites of somatic motor neurons.
The amount of gray matter at a particular level of the cord reflects the level of skeletal muscle innervation that is taking place – hence the cervical and lumbar enlargements.

The axons of the anterior horn motor neurons are bundled together into ventral rootlets that fuse to form a ventral root.

Similarly, the incoming sensory neuron axons are bundled together into a dorsal root that splits into dorsal rootlets which enter the posterior horn to synapse with interneurons.

The combination of a ventral root and dorsal root in a particular segment of the spinal cord forms the spinal nerve that links the spinal cord to peripheral structures.

A nerve is a bundle of axons outside of the CNS.

The sensory somata are clustered together in an enlarged region of the dorsal root known as the dorsal root ganglion. Recall that a ganglion is a cluster of somata outside the CNS.

Lateral horns are found in the spinal cord gray matter between T1 and L2. They contain somata of autonomic motor neurons which innervate cardiac muscle, smooth muscle, and glands.

The white matter in the spinal cord is divided into columns (funiculi) of ascending and descending myelinated axons. There are anterior, posterior, and lateral columns. These allow for communication between different levels of the spinal cord and between the spinal cord and the brain. Within the columns are collections of axons known as tracts.

VI. Spinal nerves

Each axon is surrounded by a delicate layer of connective tissue known as the endoneurium.

Axon fibers are then grouped into bundles known as fascicles. Each fascicle is enclosed by a fibrous connective tissue wrapping known as the perineurium.

Then, all of the fascicles within a nerve are enclosed by a tough connective tissue sheath known as the epineurium.

After the spinal nerve exits the intervertebral foramen, it branches into a dorsal ramus and a ventral ramus.

Like the spinal nerve itself, both the dorsal ramus and the ventral ramus are mixed, i.e. they contain both sensory and motor fibers.

The dorsal ramus contains fibers that serve the dorsal portions of the trunk, carrying visceral motor, somatic motor, and sensory fibers to and from the skin and muscles of the back.

The ventral ramus contains fibers that serve the ventral parts of the trunk and the limbs, carrying visceral motor, somatic motor, and sensory fibers.

Joined to the bases of the ventral rami in the thoracic portion of the spinal cord, are branches called rami communicantes. These contain the autonomic (visceral) nerve fibers.

VII. Nerve plexuses

Except for those of T2-T12, all ventral rami join together to form interlaced networks of nerve fibers known as nerve plexuses.

Plexuses are found in the cervical, brachial, lumbar, & sacral regions and mostly serve the limbs.

VIII. Cervical plexus

Ventral rami of the 1st 4 cervical nerves form the cervical plexus, (deep to the sternocleidomastoid).

Most of its branches are cutaneous nerves that supply the skin of the neck, ear, back, and shoulder. Other branches innervate muscles of the anterior neck.

One very important nerve is the phrenic nerve which emerges from the cervical plexus and supplies motor and sensory fibers to the diaphragm – the main respiratory muscle.

IX. Brachial plexus

The brachial plexus is found in the neck and axilla and it gives rise to almost all the nerves of the upper limb.

It’s primarily formed by the ventral rami of nerves C5-C8 as well as T1.
c. It sits superior to the clavicle and just lateral to the sternocleidomastoid.
d. It gives rise to several important nerves:
  i. **Axillary nerve** - carries sensory info from the shoulder and supplies motor commands to the deltoid muscle.
  ii. **Musculocutaneous nerve** – carries sensory info from the lateral arm and primarily supplies motor commands to 2 muscles: the *brachialis* and the *biceps brachii*.
  iii. **Radial nerve** – carries sensory info from the posterior arm and supplies motor commands muscles including: the *triceps brachii*, *wrist extensors*, and the *brachioradialis*.
  iv. **Ulnar nerve** – carries sensory info from the palm and medial hand/fingers and supplies motor commands to *wrist flexors* and *intrinsic hand muscles*.

**X. Lumbosacral plexus**
a. The **lumbar plexus** and **sacral plexus** are often grouped together as the **lumbosacral plexus**.
b. The lumbar plexus arises from the ventral rami of spinal nerves L1-L4 and is found alongside the psoas major muscle. It provides much of the cutaneous and muscular innervation for the thigh. It gives rise to several important nerves including:
  i. **Femoral nerve** – carries sensory info from much of the thigh, leg, and foot and supplies motor commands to the *quadriceps femoris muscle*.
  ii. **Obturator nerve** – carries sensory info from the thigh and supplies motor commands to the *adductor muscles* of the thigh.
c. The sacral plexus arises from spinal nerves L4-S4 and gives rise to several important nerves including:
  i. **Sciatic nerve** – carries sensory info from the skin of much of the lower limb and supplies motor commands to the *hamstring muscles* as well as other muscles of the lower leg and foot.
  ii. **Gluteal nerve** – primarily supplies motor commands to the *abductor muscles* of the thigh as well as the *gluteus maximus*.
  iii. **Pudendal nerve** – carries sensory info from the *external genitalia* and supplies motor commands to several muscle including the *external urethral sphincter* and the *external anal sphincter*. 