The Nervous System
The Autonomic Nervous System (ANS)

- Controls involuntary responses
- Divided into the sympathetic division and the parasympathetic division
- **Sympathetic**: “fight or flight”
- **Parasympathetic**: “rest and digest”
The CNS & PNS

- **CNS** = Central Nervous System
  - Brain
  - Spinal Cord

- **PNS** = Peripheral Nervous System
  - Cranial Nerves
  - Spinal Nerves
  - Plexuses
    - Cervical Plexus
    - Brachial Plexus
    - Lumbosacral plexus
Neurons = Nerve Cells

- Contains a cell body, axon and dendrites
- Dendrites receive impulses and bring them toward the cell body, while axons transmit impulses away from the cell body

Lippert, p54
Afferent Nerves = sensory nerves
- Conducts afferent impulses from the periphery to the spinal cord
- The dendrite is in the skin or peripheral areas and its cell body is located in the posterior aspect of the spinal cord

Efferent Nerves = motor nerves
- Conducts efferent impulses from the spinal cord to the periphery
- The cell body and dendrites for efferent motor nerves are located in the anterior aspect of the spinal cord

Lippert, p54-55
The brain is made up of the:

- **Cerebrum**
  - Largest portion
  - Made up of right and left cerebral hemispheres joined together by the corpus callosum
  - Each hemisphere has 4 lobes:
    - Frontal Lobe: personality
    - Occipital Lobe: vision
    - Parietal Lobe: sensation
    - Temporal Lobe: behavior

- **Brainstem**

- **Cerebellum**
Deep within the brain lies the...

- Thalamus: pain perception
- Hypothalamus: hormone function
- Basal Ganglia: coordination of movement
The brain is made up of the:

- **Cerebrum** (see previous slide)
- **Brainstem** (most of the cranial nerves come from the brainstem area)
  - Midbrain: visual reflexes
  - Pons: connects the midbrain to the medulla
  - Medulla (oblongata): connects to spinal cord, autonomic control of respiration and heart rate
- **Cerebellum**: Muscle coordination, tone and posture
A continuation of the medulla

It runs through the vertebral foramen in each individual vertebra from the medulla oblongata (proximally) to the conus medullaris (distally), at the approx level of the 2nd lumbar vertebra.

Let’s take a look at the spinal cord...
A cross-sectional view of the spinal cord shows both white matter and gray matter. The gray matter is in the center and looks like an “H” or a butterfly.

There is an anterior aspect (the anterior horn) and a posterior aspect (the posterior horn).

- **Posterior horn**: transmits sensory impulses
- **Anterior horn**: transmits motor impulses
“Motor impulses travel from the brain, down the spinal cord, through the anterior horn, and out to the periphery via peripheral nerves.”

“Sensory impulses from the periphery travel up the peripheral nerves, into the spinal cord via the posterior horn, then up the spinal cord to the brain.”
Q: Where does the CNS end and the PNS begin?
A: At the anterior horn of the spinal cord.

CNS: From the brain to the anterior horn of each spinal level

PNS: The anterior horn and below

Upper Motor Neurons are part of the CNS

Lower Motor Neurons are part of the PNS

Injury to these 2 types of neurons will result in different clinical pictures
### Upper Motor Neuron Lesion vs. Lower Motor Neuron Lesion

<table>
<thead>
<tr>
<th>UMNL</th>
<th>LMNL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinal cord injuries (SCI)</td>
<td>Muscular dystrophy</td>
</tr>
<tr>
<td>Multiple sclerosis (MS)</td>
<td>Poliomyelitis</td>
</tr>
<tr>
<td>Parkinsonism</td>
<td>Myasthenia gravis</td>
</tr>
<tr>
<td>Cerebral vascular accident (CVA)</td>
<td>Peripheral nerve injuries</td>
</tr>
<tr>
<td>Head injuries</td>
<td></td>
</tr>
</tbody>
</table>
Cranial Nerves

- I Olfactory
- II Optic
- III Oculomotor
- IV Trochlear
- V Trigeminal
- VI Abducens
- VII Facial
- VIII Vestibulocochlear
- IX Glossopharyngeal
- X Vagus
- XI Accessory
- XII Hypoglossal
<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Mneumonic</th>
<th>Type</th>
<th>Mneumonic</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Olfactory</td>
<td>On</td>
<td>Sensory</td>
<td>Some</td>
<td>Smell</td>
</tr>
<tr>
<td>II</td>
<td>Optic</td>
<td>Old</td>
<td>Sensory</td>
<td>Say</td>
<td>Vision</td>
</tr>
<tr>
<td>III</td>
<td>Oculomotor</td>
<td>Olympus</td>
<td>Motor</td>
<td>Marry</td>
<td>Eye muscles</td>
</tr>
<tr>
<td>IV</td>
<td>Trochlear</td>
<td>Towering</td>
<td>Motor</td>
<td>Money</td>
<td>Eye muscles</td>
</tr>
<tr>
<td>V</td>
<td>Trigeminal</td>
<td>Top</td>
<td>Both</td>
<td>But</td>
<td>Sensory: face, Motor: chewing</td>
</tr>
<tr>
<td>VI</td>
<td>Abducens</td>
<td>A</td>
<td>Motor</td>
<td>My</td>
<td>Eye muscles</td>
</tr>
<tr>
<td>VII</td>
<td>Facial</td>
<td>Finn</td>
<td>Both</td>
<td>Brother</td>
<td>Sensory: tongue, Motor: face expression</td>
</tr>
<tr>
<td>VIII</td>
<td>Auditory</td>
<td>And</td>
<td>Sensory</td>
<td>Says</td>
<td>Hearing &amp; equilibrium</td>
</tr>
<tr>
<td>IX</td>
<td>Glossopharyngeal</td>
<td>German</td>
<td>Both</td>
<td>“Bad”</td>
<td>Sensory: taste, Motor: pharynx</td>
</tr>
<tr>
<td>X</td>
<td>Vagus</td>
<td>Viewed</td>
<td>Both</td>
<td>Business</td>
<td>Both: heart, lungs, GI Sensory: ear</td>
</tr>
<tr>
<td>XI</td>
<td>Spinal Accessory</td>
<td>Some</td>
<td>Motor</td>
<td>Marrying</td>
<td>SCM, traps, swallow</td>
</tr>
<tr>
<td>XII</td>
<td>Hypoglossal</td>
<td>Hops</td>
<td>Motor</td>
<td>Money!”</td>
<td>Tongue muscles</td>
</tr>
</tbody>
</table>
There are 31 pairs of spinal nerves:
- 8 cervical nerves
- 12 thoracic nerves
- 5 lumbar nerves
- 5 sacral nerves
- 1 coccygeal nerve

The first 7 spinal nerves (C1-C7) exit the vertebral column above the corresponding vertebra. (ie the C3 nerve exits proximal to the C3 vertebra)

However, all other spinal nerves exit the vertebral column distal to the corresponding vertebra

What about the C8 nerve?
“Once outside the spinal cord, the anterior (motor) and posterior (sensory) roots join together to form the spinal nerve, which passes through the intervertebral foramen.”
Dermatome:
- The area of skin supplied with the sensory part of a spinal nerve

Myotome:
- A muscle (or group of muscles) innervated by a single spinal segment
<table>
<thead>
<tr>
<th>Level</th>
<th>Action to be Tested</th>
<th>Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5</td>
<td>Shoulder Abduction</td>
<td>Deltoid</td>
</tr>
<tr>
<td>C5, C6</td>
<td>Elbow Flexion</td>
<td>Biceps</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow Extension</td>
<td>Triceps</td>
</tr>
<tr>
<td>C8</td>
<td>Ulnar Deviation</td>
<td>FCU &amp; ECU</td>
</tr>
<tr>
<td>T1</td>
<td>Digit Abd/adduction</td>
<td>Interossei</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Action to be Tested</th>
<th>Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2, L3</td>
<td>Hip Flexion</td>
<td>Iliopsoas</td>
</tr>
<tr>
<td>L3, L4</td>
<td>Knee Extension</td>
<td>Quadriceps</td>
</tr>
<tr>
<td>L5</td>
<td>Ankle Dorsiflexion</td>
<td>Anterior Tibialis</td>
</tr>
<tr>
<td>S1</td>
<td>Ankle Plantarflexion</td>
<td>Gastrocnemius</td>
</tr>
</tbody>
</table>

O’Sullivan & Schmitz, p185
There are 12 pairs of thoracic spinal nerves.

“With the exception of T1, which is part of the brachial plexus, thoracic nerves do not join with other nerves to form a plexus.”

Each of these thoracic nerves branches into a posterior and anterior branch.

- **Posterior branch**: innervates the back muscles (motor) and the overlying skin (sensory)
- **Anterior branches**: become intercostal nerves, which innervate the anterior trunk and intercostal muscles (motor) as well as the skin on the anterior and lateral trunk (sensory)
With the exception of the thoracic nerves, spinal nerves join together and/or branch out, forming a network known as a plexus.

There are 3 major plexuses:

<table>
<thead>
<tr>
<th>Name of Plexus</th>
<th>Made up of spinal nerves...</th>
<th>Innervates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>C1-C4</td>
<td>Neck muscles</td>
</tr>
<tr>
<td>Brachial</td>
<td>C5-T1</td>
<td>Upper Extremity muscles</td>
</tr>
<tr>
<td>Lumbosacral</td>
<td>L1-S5</td>
<td>Lower Extremity muscles</td>
</tr>
</tbody>
</table>

- **Lumbar portion** (L1-L4): supplies mostly thigh muscles
- **Sacral portion** (L5-S3): supplies mostly leg & foot muscles

Lippert, p64
We are going to watch the first 4 minutes of this video on the Brachial Plexus.

You are not expected to memorize the details of each of the plexuses. However, it is important to understand the general structure of a plexus (roots, trunks, branches, cords, nerves) and how that structure allows most muscles to take innervation from more than one spinal level.

Once we understand that, it is easier to understand that an injury at one spinal level may weaken a muscle, but some function may remain.

For example, the elbow flexors are innervated by C5 and C6. An injury at the C5 level will weaken elbow flexion, but function will not be completely lost if C6 was unaffected.
Hopefully this video allows you to more fully understand the concept of nerve innervation as we work through the muscles of the body this semester.