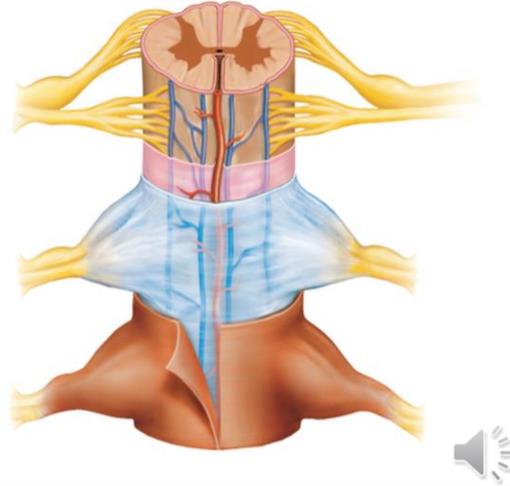


Central Nervous System



Meninges

- Dura Mater
- Arachnoid Mater
 - Subarachnoid Space
- Pia Mater



The meninges are protective connective tissue layers that surround the brain and spinal cord. There are three layers. The Dura mater is the outer most layer, it is leather like and tough. The Arachnoid mater contains fibers that look like a spider web. The spider web like structure forms the subarachnoid space, a small space found between the arachnoid and pia mater. This space is filled with cerebrospinal fluid and acts like a cushion around the brain and spinal cord. The innermost layer is the pia mater. This is a very thin membrane that is directly in contact with the brain and spinal cord.

Cerebrospinal Fluid (CSF)

- Colorless Liquid
- Fills subarachnoid space, ventricles, and canals of the CNS.
- Surrounds the brain.
- Mostly formed in the subarachnoid space, ependymal cells, and choroid plexuses.
- Functions:
 - Buoyancy
 - Protection
 - Chemical Stability



Cerebrospinal fluid is a clear, colorless liquid. It surrounds and bathes the external surfaces of the brain and spinal cord. It fills the subarachnoid space, ventricles (internal chambers of brain), and canals of the CNS. CSF is formed by ependymal cells in the CNS

The CSF functions in:

1. Buoyancy – keeps brain afloat
2. Protection – prevents brain from colliding into the cranium
3. Chemical stability – transportation system for removal of waste via choroid plexus

Brain Barrier System (BBS)

- Protects brain from agents in the blood.
- Barriers protects brain:
 - Blood-brain barrier (BBB)
 - Blood-CSF barrier
- BBS is permeable to water, glucose, gases, alcohol, and caffeine.



Brain Barrier System (BBS)

The brain is very sensitive to agents within the blood, more so than other tissues. The brain barrier system prevents harmful components in blood to come into contact with the brain tissue. The brain barrier system protects the brain tissue from two potential exposures: the blood vessels throughout the brain tissue and the choroid plexuses located in the ventricles. The blood vessels throughout the brain tissue are covered by astrocytes and forms the blood-brain barrier. The blood-brain barrier creates tight junctions that prevents unnecessary things to pass from the blood vessels into the surrounding brain tissue. The choroid plexuses are a network of capillaries found in the ventricles. They allow for exchange between the CSF and blood. The ependymal cells form a similar tight junction around the choroid plexus, this is referred to as the blood-CSF barrier.

The brain barrier systems are permeable to certain substances and allows the following to easily move between the membranes such as water, glucose, gases (CO₂ and O₂), alcohol, and caffeine.

Spinal Cord Functions

- Conduction
- Integration
- Locomotion
- Reflexes



The spinal cord has a number of functions such as:

1. Conduction, the spinal cord can carry impulses to and from the brain.
2. Integration, the spinal cord is capable of integrating or processing information from the PNS and sending out appropriate responses.
3. Locomotion, the spinal cord can control complex motor skills that involve repetitive muscle contractions. For example, when walking the brain may initiate the action, but then the spinal cord take over continuation of that action.
4. Reflex, the spinal cord plays an important role in coordination, posture, and quick protective responses to pain or injury.

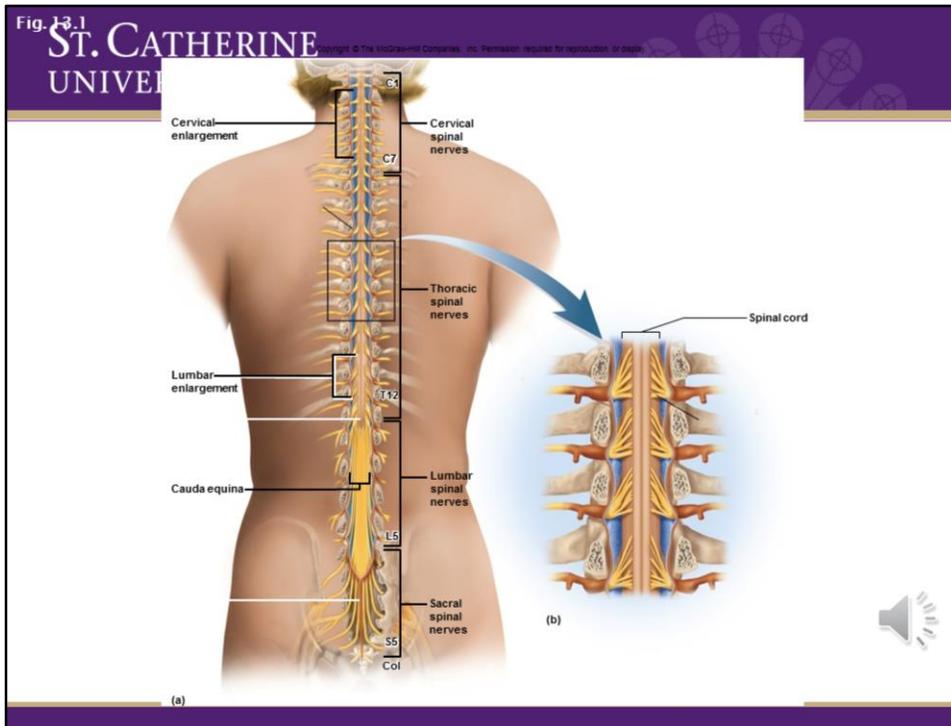
Spinal Cord Structure

- Regions: cervical, thoracic, lumbar and sacral
- 2 enlargements:
 - Cervical Enlargement
 - Lumbar Enlargement
- Cauda Equina
- Gives rise to 31 pairs of spinal nerves

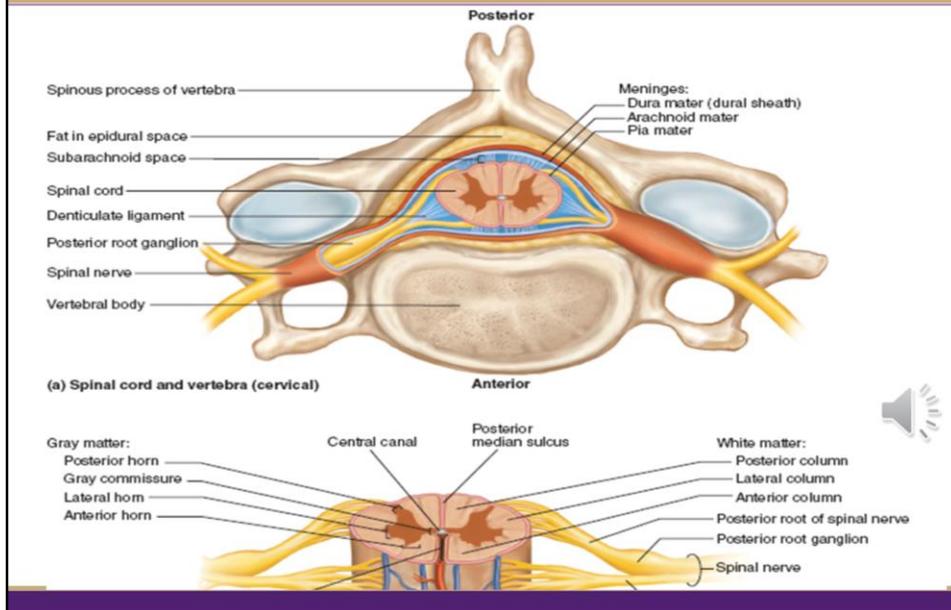


The spinal cord is divided into four regions: cervical, thoracic, lumbar, and sacral. Within the spinal cord there are 2 enlargements: The cervical enlargement (C5-C7), contains the start of the nerve branches that go to the upper limbs. The lumbar enlargement (L1-L2), is the start of nerve branches that go to lower limbs. It also has an area called the cauda equina. The cauda equine appears like a horses tail, hence its name. This is a bundle of nerves at the inferior portion of the spinal cord that runs through the lumbar and sacral vertebra. It innervates the pelvic organs and the lower limbs as well.

The spinal cord gives rise to 31 pairs of spinal nerves.



Here is the diagram of the spinal cord. Notice the enlargements and the cauda equine.



Anatomy of the spinal cord:

Gray matter (forms the H butterfly shape in the spinal cord) – it contains somas, dendrites, and parts of the axon. It is the site of neural integration as the synapses between neurons occur here.

Dorsal (posterior) horns: connects to dorsal root and ganglion

Ventral (anterior) horns: connects to ventral root

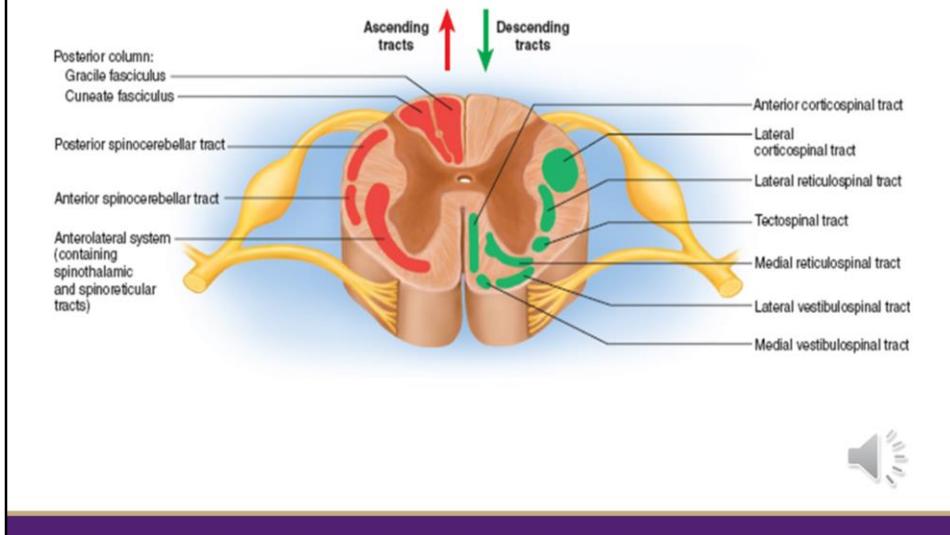
Central canal

White matter (surrounds the gray matter, columns contain spinal tracts)

Dorsal (posterior) columns

Ventral (anterior) columns

Lateral columns



Gray matter functions in neural integration, the processing of information. White matter functions in conducting the information between the spinal cord and brain.

In this diagram, the ascending tracts of the white matter are highlighted in red and the descending tracts are highlighted in green.

Spinal Nerve

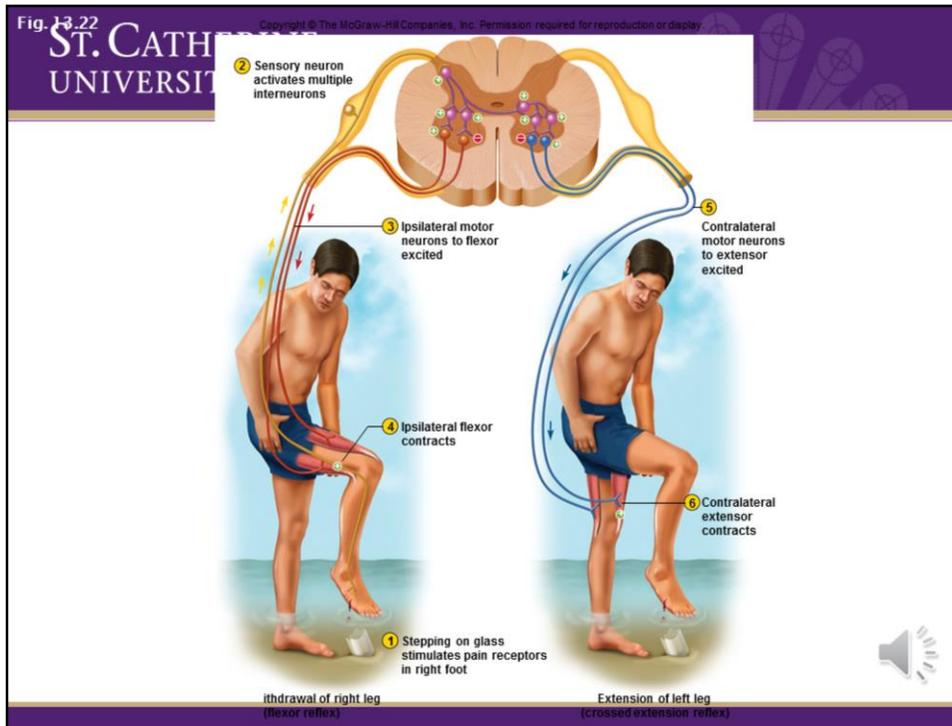
- Nerve:
 - A cord composed of numerous axons bound together by connective tissue
- How the spinal cord communicates with the rest of the body.
- 3 types:
 - Sensory
 - Motor
 - Mixed
- Ganglions



There are 31 pairs of spinal nerve that extend from the spinal cord. Each nerve is a cord composed of numerous axons bound together by connective tissue. The nerve allows the spinal cord to communicate with the rest of the body. There are three types of nerves:

- Sensory nerves contain only afferent fibers (carry sensory signals). Rare, examples of sensory nerves include ones for smell and vision)
- Motor nerves contain only efferent fibers (carry motor signals). Both sensory and motor nerves conduct signals in one direction.
- Mixed nerves are the most abundant, they carry a mix of afferent and efferent fibers and conduct signals in two directions

Certain nerves also have ganglions. Ganglions are clusters of neurosomas (cell bodies of neurons) outside of the CNS. Which type of nerves would have ganglions? Sensory and Mixed nerves.

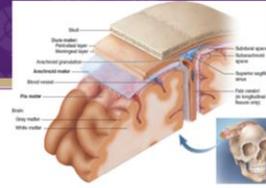


Recall a function of the spinal cord is reflexes. A Spinal Reflex is an involuntary response to a stimulus. It is rather simple and involves very few neurons. They are also very, very quick. There are 3 neurons that make up a spinal reflex path. The sensory neuron has dendrites that are located in muscle and responds to stretching. The dendrites run all the way from the muscle to the spinal cord and their somas are located outside of the spinal cord. The axons enter the spinal cord and form a synapse with the integration neuron. The integration neuron processes the information and sends out a response through the motor neuron. The motor neuron axons go all the way to the muscle, but their dendrites are in the spinal cord and synapse with integration neuron.

This diagram demonstrates how our reflexes work. When we step on something sharp, the sensory neurons detect the injury and send a message to the spinal cord, the interneurons process and send a message back through the motor neuron. They also send a message to the other leg to be prepared to adjust for a change in balance.

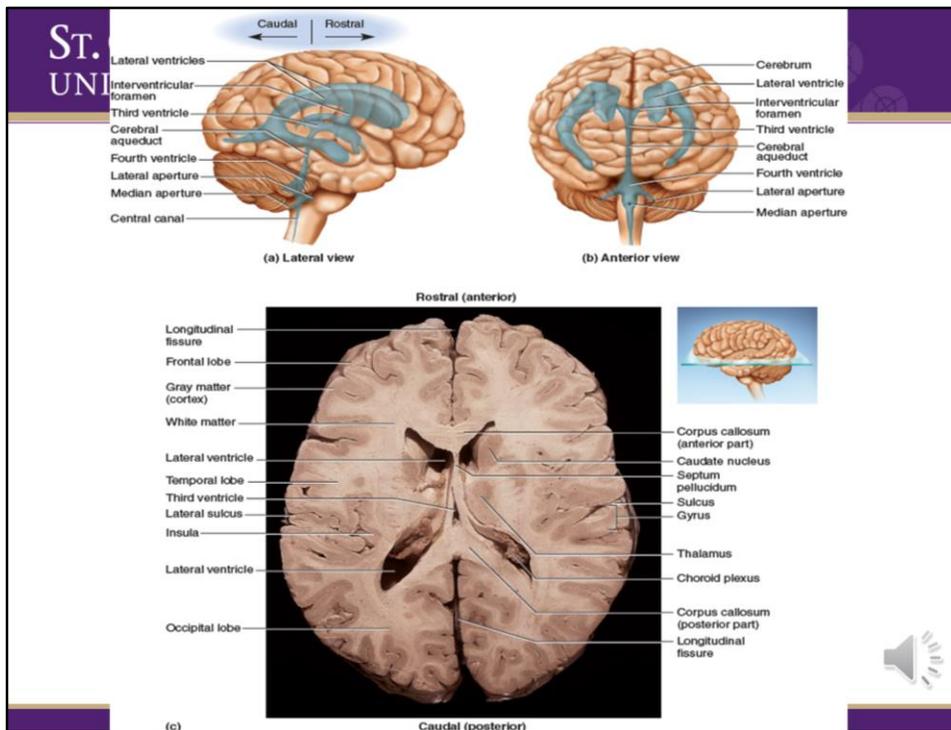
Brain

- 100 billion nervous cells.
- Surrounded by meninges
- 4 primary regions:
 - Brain stem
 - Diencephalon
 - Cerebellum
 - Cerebrum



In the remaining slides, I will be discussing the brain. There are 100 billion nerve cells in the brain. It is a very complex structure. The brain is protected and surrounded by the meninges – these are continuous with the meninges that surround the spinal cord.

There are 4 primary regions of the brain: brain stem, diencephalon, cerebellum, and cerebrum. We will be discussing these four regions in greater detail in the next slides.



The brain also has four ventricles which are internal chambers filled with CSF:

- There are two ventricles in each cerebral hemispheres called the lateral ventricles
- There is a ventricle located below the corpus callosum called the third ventricle
- The last ventricle is located between the pons and medulla oblongata, this is called the fourth ventricle

The CSF flow through these ventricles and canals to bath the brain and spinal cord. Each ventricle also contains a network of capillaries called the choroid plexus that allows for exchange of substances between the CSF and blood. Recall that we talked about this on slide about the brain barrier system.

Cerebrum

- Largest and most complex portion
- Landmarks:
 - Gyri
 - Sulci
 - Fissures
- Hemispheres
 - Right: imagination, artistic, communication
 - Left: logic, analytical, spatial, language, linear thinking
 - Corpus callosum



The Cerebrum is the largest and most complex portion of brain. The brain has landmarks that are significant in studying its function. The landmarks include:

- Gyri, the ridges or folds of the cerebrum
- Sulci, are the valleys or shallower grooves such as the lateral sulcus which you will be learning in lab.
- Fissure are very deep grooves in the cerebrum such as the longitudinal fissure is a fissure that separates the right and left hemispheres of the cerebrum.

The cerebrum is divided into hemispheres. The right hemisphere is responsible for imagination, artistic traits, and communication while the left is focused on problem solving, analytical and spatial reasoning, and language. The hemispheres do not operate independently, they are connected by a large bundle of myelinated axons called corpus callosum. The Corpus Callosum allows the hemispheres to integrate. It is also larger in females than males, and allows more access to emotions.

Cerebrum Cont'd

- Gray matter
 - 2-3 mm thick, but 40% of mass
 - Cerebral Cortex
 - Integration
- White matter
 - Myelinated neurons
 - Majority of cerebrum
 - Complex web of neurons
 - Communication between hemispheres and other parts of brain



The cerebral cortex is the gray matter that covers the entire cerebrum. It is 2-3 mm thick, but constitutes 40% of brain mass, so it is very dense. It functions in neural integration. The white matter is the majority of the cerebrum. It is a very complex web of interconnected neurons. It allows communication between the 2 hemispheres, carries information from the cerebrum to other portions of the brain, and links different portions of the same hemisphere.

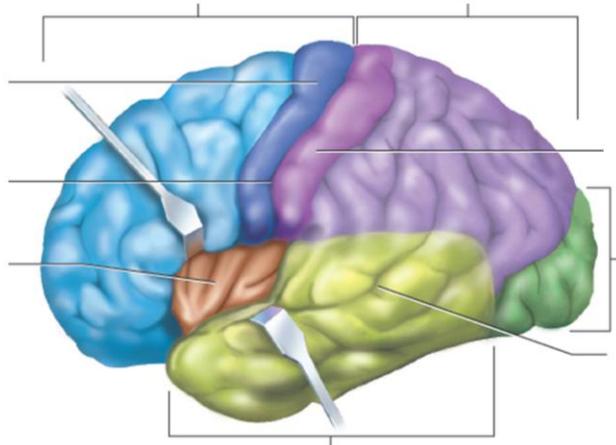
Cerebrum Cont'd

- Lobes:
 - Frontal: Motor responses
 - Parietal: Sensory reception
 - Occipital: Vision center
 - Temporal: Hearing and smell
 - Insula: Less understood



The cerebrum is broken into lobes:

- Frontal lobe controls voluntary motor functions - motivation, foresight, planning, memory, mood, emotion, social judgement, and aggression.
- Parietal lobe, receiving and interpreting signals of general senses – integration of taste, some visual information, and somesthetic (general sensory)
- Occipital lobe is the principle visual center
- Temporal lobe processes hearing and smell - learning, visual, recognition, and emotional behavior.
- Insula is less understood as it is a small mass of cortex deep to the lateral sulcus. Apparently it is important for understanding spoken language, interpreting taste, and integration of visual receptors.



Using your notes and the textbook to see if you can label this diagram of the cerebrum

Diencephalon

- Thalamus
 - Relays station from spinal cord to appropriate cerebral cortex
- Hypothalamus
 - Major control center for autonomic and endocrine systems
 - Key to maintaining homeostasis
 - Functions: Hormone secretion, autonomic effects, thermoregulation, hunger/full sensations, circadian rhythms, memory, emotions



The middle portion of the brain is called the diencephalon.

Thalamus

Relay station from spinal cord, brain stem, cerebellum, and parts of cerebrum to the cerebral cortex

Hypothalamus

Controls the ANS and endocrine (heart rate, urinary bladder, GI tract) – maintain homeostasis

Controls body temperature

Controls food and water intake (hunger, satiety, thirst centers)

Regulates sleep and circadian rhythms

Controls memory and emotional behaviors (emotional responses: anger, aggression, pleasure, etc)

Brain Stem

- Attaches to spinal cord
- Mid-brain
 - Contains motor and sensory tracts
- Pons
 - Pneumotaxic Center
- Medulla Oblongata
 - Cardiovascular center, medullary rhythmicity center



The Brain Stem makes connections between the brain and spinal cord. It is the most primal part of brain. There are 3 areas of the brain stem.

1. Midbrain: Motor and sensory tracts

2. Pons:

- Motor and sensory tracts
- Pons respiratory center - This center regulates the change from inhalation to exhalation
- Relays signals from cerebrum to cerebellum
- Sleep, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation, respiration, swallowing, bladder control, and posture

3. Medulla oblongata:

- Motor and sensory tracts
- Contains cardiac center, which adjusts the rate and force of the heartbeat and vasomotor center, which adjusts blood vessel diameter to regulate blood pressure
- Contains respiratory center, which control the rate and depth of breathing

Cerebellum

- “Movement Control Center”
- Complex movements
- Equilibrium
- Time keeper
- Language output
- Impulse control
- Some impact on emotional reactions



The cerebellum is the “movement control center”. It is vital in the coordination of skeletal movement, and maintains equilibrium and balance. It also acts like a time keeper and is involved in language output, impulse control, and can also impact emotional reactions.



Using your notes and textbook, label the main parts of the brain

Autonomic Nervous System



ANS

- General features
 - Involuntary
 - Smooth muscle control
 - Respiratory, cardiac, digestive systems
 - Big role in homeostasis
- Divisions
 - Parasympathetic
 - Sympathetic
- Tissue can be stimulated by one or both of the divisions



The autonomic nervous system is responsible for involuntary actions of the body, especially those that involves the smooth muscle of the respiratory, cardiac, and digestive systems. It plays a big role in homeostasis

There are two divisions:

The Parasympathetic has calming effects on the body, like slowing down heart rate and respiration while increasing our digestive functions.. We often refer to this as the “rest and digest” system.

Sympathetic adapts the body for physical activity, like increasing heart rate and respiration while decreasing digestion. This system is responsible for our “fight-or-flight” responses.

Both divisions have the ability to excite or inhibit depending on the tissues

Need both divisions to maintain homeostasis

Dual Innervations

- Antagonistic Effects
 - Example: Regulation of blood pressure
- Cooperative Effects
 - Example: Saliva production



Most viscera (organs) receive signals from both divisions, this is called dual innervation. The systems can have either antagonistic or cooperative effects. Antagonistic effects oppose each other. For example, the sympathetic speeds up the heart and parasympathetic slows it down. They stimulate different cells within an organ, so there are different responses. Another example is blood pressure control. The sympathetic keeps blood vessels partially constricted to keep BP up. If BP gets too high, parasympathetic slows the heart so it is not putting out as much blood and lowers BP.

Cooperative effects act on different cells but have the same overall effect. For example, the parasympathetic stimulates salivary glands to release a watery substance while the sympathetic stimulates mucous cells of the same gland, the end result is saliva.