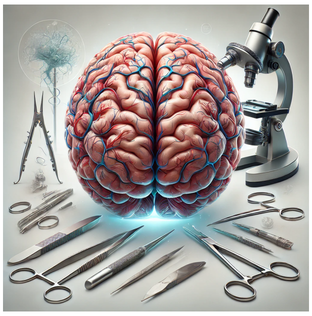


CNS—Anatomy~1
Written by: Dr.Ali Abujammil

The Nervous System is a complex network of cells and nerves that transmit signals between different parts of the body and the brain it is responsible for controlling all body activities, whether voluntary (like moving a hand) or involuntary (like heartbeats and breathing).

Divisions:

1. Central Nervous System (CNS): consists of the Brain and Spinal Cord and controls information processing and decision-making.

2. Peripheral Nervous System (PNS): consists of nerves extending outside the brain and spinal cord and transmitting signals between the CNS and the rest of the body.

Types:

1-Somatic Nervous System: controls voluntary movements like walking and speaking.

2-Autonomic Nervous System: controls involuntary functions like heartbeats and digestion it is divided into: Sympathetic Nervous System activates during emergencies, such as fear or fight-or-flight situations and Parasympathetic Nervous System helps calm the body after stress.

"A network of billions of nerve cells linked together in a highly organized fashion to form the rapid control center of the body"

Detailed Explanation:

Network: this refers to an interconnected system of nerve cells that function together, similar to wires in an electronic device these cells communicate efficiently to ensure the proper functioning of the nervous system.

Billions of Nerve Cells: the nervous system is composed of neurons, the fundamental units responsible for transmitting electrical and chemical signals the brain alone contains approximately 86 billion neurons, highlighting the complexity of this system.

Linked Together in a Highly Organized Fashion: neurons are not randomly connected; they follow a precise structure where they communicate through synapses (specialized junctions) this organization ensures that signals travel efficiently to the correct destinations additionally, the nervous system is divided into different parts (such as the central and peripheral nervous systems), each with a specific function, demonstrating its high level of organization.

Rapid Control Center of the Body: The nervous system acts as the body's command center, regulating almost all bodily functions it sends immediate signals to muscles for movement, processes sensory information (such as pain and temperature), and controls involuntary

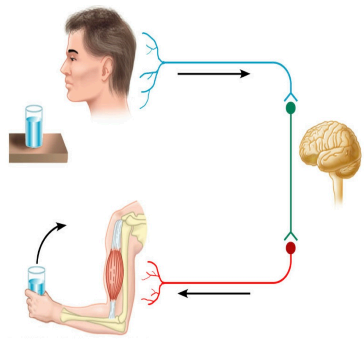
actions like heartbeat and breathing the speed of nerve signal transmission can reach 120 meters per second, making it the fastest control system in the body.

Basic Functions of the Nervous System:

1. **Sensation: the nervous system monitors changes and events occurring inside and outside the body these changes are called stimuli, such as a change in temperature or feeling of pain the cells responsible for detecting these changes are called sensory receptors, which are found in the skin, eyes, ears, and many other organs example, when you touch something hot, the receptors in your skin send nerve signals to your brain to alert you of the danger.**

2. Integration: after receiving sensory information, the nervous system processes and interprets it this involves parallel processing, where multiple sensory inputs are analyzed simultaneously to determine an appropriate response the nervous system then decides the appropriate reaction based on the information received example, when you touch something hot, your brain quickly determines that you need to withdraw your hand to avoid getting burned.

3. Reaction: also known as motor output, this is the stage where the response is carried out this involves activating muscles or glands to perform the required action the response is usually carried out via the release of neurotransmitters (NTs), which are chemical messengers that transmit signals between nerve cells example, after the brain decides to pull your hand away from a hot surface, nerve signals are sent to your hand muscles, making them contract and move your hand away from danger.



The image shows the neural pathway involved in picking a glass of water highlighting the process of sensory input, neural processing, and motor response.

1-First stage (sensation): the sensory receptor in the skin, detects the presence of glass, and the sensory signal travels through the sensory neurons in the blue pathway to the brain via the spinal cord.

2- second stage (neural processing): the brain reserves and processes the signal, then makes a command.

3- third stage (motor response): the motor signal is sent from the brain to the muscle controlling the arm, the muscles contract allowing the hand to reach for and grasp the glass.

This process happens almost instantly and is part of sensory-motor interaction that enables smooth coordination with our environment.

Nervous Tissue main characteristics: highly cellular is composed mainly of cells rather than extracellular material, ensuring efficient signal transmission, and has two cell types: Neurons and Neuroglia.

1. Neurons

Functional, Signal Conducting Cells: these are the primary units of the nervous system, responsible for transmitting electrical and chemical signals.

Do Not Divide: neurons cannot reproduce once they are fully developed, making nerve damage difficult to recover from.

Long-Lived: neurons can survive for a person's entire lifetime, unlike many other body cells that regenerate frequently.

High Metabolic Activity: they require a continuous supply of oxygen and glucose because they consume large amounts of energy (ATP).

Electrically Excitable: neurons generate and conduct electrical signals rapidly, allowing instant communication between the brain and the body.

2. Neuroglia

Support, Nourish, and Protect Neurons: these cells provide structural and functional support for neurons, ensuring their proper functioning.

Divide: unlike neurons, neuroglia can divide and regenerate, aiding in tissue repair after injury.

Smaller but Outnumber Neurons by 5 to 50 Times: they are much smaller than neurons but exist in significantly greater numbers (5 to 50 times more neurons).

Types of Neuroglia:

Neuroglia in the Central Nervous System (CNS):

1. Astrocytes: provide structural support for neurons, regulate the chemical environment around neurons, and help form the Blood-Brain Barrier (BBB) to protect the brain from toxins.

2. Oligodendrocytes: produce myelin sheath, which insulates nerve fibers and increases signal transmission speed.

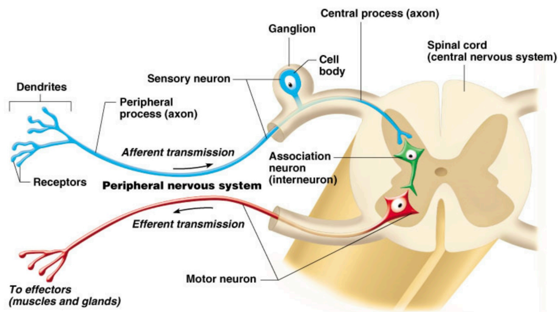
3. Microglia: act as the immune cells of the nervous system, removing damaged cells and foreign substances.

4. Ependymal Cells: line the brain ventricles and spinal cord, and help produce Cerebrospinal Fluid (CSF), which cushions and protects the brain and spinal cord.

Neuroglia in the Peripheral Nervous System (PNS):

5. Schwann Cells: produce myelin in the peripheral nervous system, aiding in faster nerve signal transmission, and assisting in nerve fiber regeneration.

6. Satellite Cells: surround neurons in the ganglia (clusters of nerve cells) and provide them with nutrients and protection.



This image explains how neurons are functionally classified based on their role in transmitting, processing, and responding to nerve signals this process occurs between the peripheral nervous system and central nervous system.
1- sensory pathway afferent transmission: it starts at sensory receptors which are found in the skin muscles or organs then the nerve impulse travels through sensory neurons which include: dendrites that receive signals from receptors and the peripheral process or axon carries the signal from receptors to ganglion and ganglion contains the cell bodies of sensory neurons and central process or axon sends the impulse to the spinal cord where it is processed.
2- neural processing interneurons or association neurons: are located in the spinal cord and act as a bridge between sensory and motor neurons they either transmit the information to the brain or generate a quick response via the reflex arc.
3- motor pathway efferent transmission: sends commands from the central nervous system to muscles or glands the motor neuron consists of an axon that transmits the signal from the spinal cord to effectors such as muscle contraction.
The purpose of this process is how the body quickly responds to external stimuli through a coordinate loop involving sensory receptors, The spinal cord, and motor neurons.

Concepts in Nervous System Organization:

1. White Matter: composed of bundles of axons, both myelinated and unmyelinated, myelin is a fatty sheath that acts as an electrical insulator, increasing the speed of nerve signal transmission white matter forms neural pathways that allow communication between different parts of the brain(inner portion like corpus calsom) and spinal cord(outer portion).

2. Gray Matter: composed of Neuronal cell bodies that contain the nucleus and essential cellular components, Dendrites that receive nerve signals, Unmyelinated axons that transmit signals over short distances, Axon terminals where neurotransmitters are released to communicate with other cells, Neuroglia which support, nourish, and protect neurons, Gray matter is abundant in the cerebral cortex and nuclei within the brain(outer portion) and spinal cord(inner portion).

3. Nerves (in the PNS): bundles of axons extending through the peripheral nervous system contain connective tissue for protection and nourishment and connect the CNS to the rest of the body.

4. Tracts (in the CNS): bundles of axons within the brain or spinal cord do not contain connective tissue unlike peripheral nerves function as pathways for signal transmission within the CNS.

5. Ganglia (in the PNS): clusters of neuron cell bodies in the peripheral nervous system function as processing centers for sensory and autonomic signals before they reach the CNS.

6. Nuclei (in the CNS): clusters of neuron cell bodies in the CNS, surrounded by white matter play critical roles in motor control, emotions, and other vital functions if not surrounded by white matter it cortex.

7. Cortex: if Nuclei Are Not Surrounded by White Matter, Cerebral Cortex the outer layer of the brain responsible for higher cognitive functions, such as thinking, memory, and perception, and Cerebellar Cortex controls balance and motor coordination.

Nerve Structure in the Peripheral Nervous System (PNS)

1. Definition of a Nerve: is a bundle of axons in the Peripheral Nervous System (PNS), contain both myelinated and unmyelinated axons and serve as communication pathways between the Central Nervous System (CNS) and the rest of the body.

2. Layers Surrounding a Nerve: are composed of multiple layers of connective tissue that provide protection and support:

A. Endoneurium: the innermost layer that surrounds each axon is made of loose connective tissue and contains nutrient-rich fluids that support the axons.

B. Perineurium: bundles multiple axons together into fascicles (small nerve bundles) made of dense connective tissue, which provides structural support and isolation for nerve fibers.

C. Epineurium: the outermost layer that encloses all fascicles within a nerve composed of strong, dense connective tissue and contains blood vessels that nourish the entire nerve, providing nerves with strength and flexibility, protecting them from damage due to movement or pressure.

Organization of the Nervous System is divided into two main anatomical divisions:

1. Central Nervous System (CNS): consists of the brain and spinal cord and its main function is the center of integration and control of all nervous system activities, processes sensory information, makes decisions, sends motor responses, controls voluntary functions (e.g., movement, thinking) and involuntary functions (e.g., heartbeat, breathing).

2. Peripheral Nervous System (PNS): comprises all nerves outside the CNS, connects the CNS to the rest of the body, Consists of:

A. Spinal Nerves: 31 pairs of nerves connected to the spinal cord, carry sensory signals from the body to the spinal cord and transmit motor commands from the spinal cord to muscles and glands.

B. Cranial Nerves: 12 pairs of nerves connected directly to the brain, transmit sensory information (e.g., vision, hearing, taste) to the brain and control facial movements, swallowing, and other essential functions.

Brain: Its Divisions and Functions

The brain is the most complex part of the central nervous system (CNS), and it is divided into three main regions: Forebrain, Midbrain, and Hindbrain. Each region contains specialized parts that play vital roles in movement, perception, and regulation of vital functions.

1. Forebrain (Prosencephalon): is the largest and most important part of the brain. It is divided into two main parts:

A. Cerebrum (Telencephalon): the largest part of the brain, making up about 85% of its volume and functions are Cognitive functions thinking- memory-language….., Voluntary movement controlling conscious movements, Sensory processing sensory information like hearing, vision, and touch, examples: Cerebral Cortex the outer layer of the cerebrum responsible for conscious thought and awareness and Lobes of the Brain the frontal lobe controls movement, while the temporal lobe handles hearing.

B. Diencephalon: it regulates involuntary processes like temperature, hormonal functions, and emotions, Components: Thalamus acts as a switchboard for sensory information, directing it to the appropriate areas of the brain, Hypothalamus controls involuntary functions like hunger, thirst, and body temperature regulation and regulation the pituitary gland, Epithalamus involved in regulating sleep and memory and contains pineal gland, and Subthalamus Associated with movement control.

2. Midbrain (Mesencephalon): functions are sensory processing controls the processing of vision and hearing, and Motor Coordination assists in controlling movement and balance, examples: superior colliculus controls visual reflexes, and the inferior colliculus processes auditory information, and also acts as a bridge between the forebrain and hindbrain.

3. Hindbrain (Rhombencephalon): it consists of the Pons, Medulla Oblongata, and Cerebellum.

A. Pons: Connects the cerebellum to the spinal cord, Participates in controlling breathing and sleep, and Helps coordinate movements.

B. Medulla Oblongata: Controls vital functions such as breathing, heartbeat, and blood pressure, Situated at the base of the brain, directly connected to the spinal cord.

C. Cerebellum: function is Motor Coordination: Controls fine motor skills and balance, Example: When playing a musical instrument, the cerebellum coordinates finger movements precisely.

Peripheral Nervous System (PNS): is responsible for communication between the CNS and the rest of the body. It is made up of all the nerves that lie outside the brain and spinal cord, and it plays a critical role in carrying messages to and from the brain and spinal cord to other parts of the body.

Main Divisions of the PNS:

1. Sensory Division: also known as the Afferent Division, conducts impulses from receptors to the CNS. It informs the CNS about the state of the internal and external environment of the body and it is components: Somatic Sensory Nerves carry information from skin, skeletal muscles, and joints and Visceral Sensory Nerves carry information from internal organs.

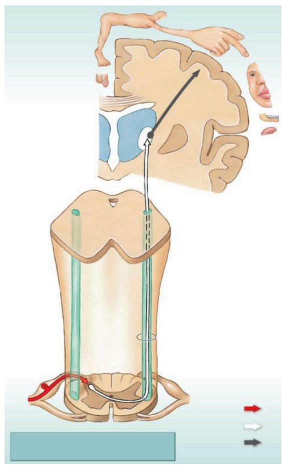
2. Motor Division: also known as the Efferent Division, conducts impulses from the CNS to effectors such as muscles and glands.

Subdivisions of the PNS:

A. Somatic Nervous System: controls voluntary movements and sensations from the external body, Components: Somatic Sensory Neurons convey information from sensory receptors in the skin, skeletal muscles, and joints and Somatic Motor Neurons transmit impulses from the CNS to skeletal muscles to initiate voluntary movements.

B. Autonomic Nervous System (ANS): regulates involuntary functions such as heart rate, digestion, and breathing, Components: Autonomic Sensory Neurons transmit information from receptors in the internal organs and Autonomic Motor Neurons carry impulses to smooth muscles, cardiac muscles, and glands for involuntary control.

Conclusion: The PNS plays a crucial role in connecting the brain and spinal cord to the body, ensuring communication for both voluntary actions (like moving a limb) and involuntary processes (like regulating heart rate). It has two major parts: the sensory division, which sends information to the CNS, and the motor division, which carries commands from the CNS to various effectors. Understanding these divisions helps clarify how the nervous system controls both conscious actions and automatic body functions.

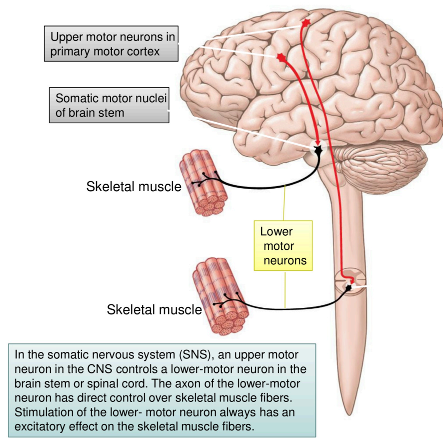


This image shows the pathway of nerve signals between the central nervous system and the peripheral nervous system.

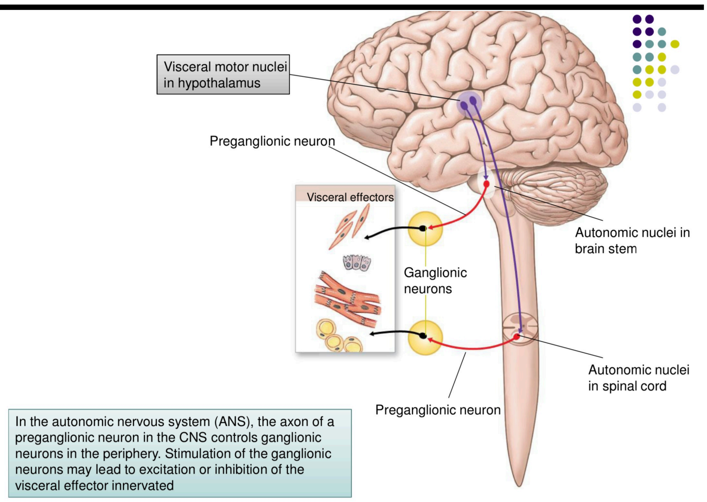
1. sensory input reception: the nerve signal starts from sensory receptors in the skin or muscles then the signal travels through sensory nerves to the spinal cord red arrow.
2 . transmission to the brain: The nerve impulse moves through an ascending pathway _ white matter of the spinal cord _ indicated by the white arrow - signal reaches the brain where it is analyzed and an appropriate response is determined.
3. motor command execution: after processing the brain sends commands via the descending pathway - motor pathway - indicated by the black arrow In en signal reaches the spinal cord and is transmitted to motor nerves muscles

respond to the command by performing the appropriate movement.

This mechanism is essential for voluntary movements as well as involuntary reflexes.

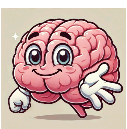


The image shows the mechanism of motor control in the somatic nervous system and the pathway of the nerve signal from the primary motor cortex in the brain to the skeletal muscles.
-upper motor neurons these neurons are located in the primary motor cortex of the brain. Their function is to send signals to the lower motor neuron.
-somatic motor nuclei of the brain stem and the spinal cord these nuclei act as intermediate stations in pathways receiving signals from the upper motor neuron and transmitting them to the lower motor neuron.
-Low motor neuron neurons receive signals from the upper motor neuron and send them directly to the skeletal muscle.
-skeletal muscles are the muscles controlled by the nerve signal, causing their contraction or relaxation.
In short, the upper motor neuron sends signals to the lower motor neuron which in turn sends signals to the skeletal muscle to cause movement this stimulation process is always excitatory meaning it is contraction muscle contraction.



The image shows the autonomic nervous system and the pathway of the nerve signal from the brain to the internal organ or visceral effector.
-visceral motor nuclei in the hypothalamus a major control center for the autonomic nervous system.
-autonomic nuclei in the brain stem and spinal cord These nuclei are additional control centers for the autonomic nervous system.
-preganglionic neuron neurons transmit signals from the brain to the ganglia.
-ganglia intermediate station receiving signals from preganglionic neurons and transmitting them to postganglionic neurons.
-postganglionic neurons send signals to the internal organ, the visceral effector.
-visceral effectors are internal organs such as the heart, lungs, and stomach.., controlled by nerve signals.

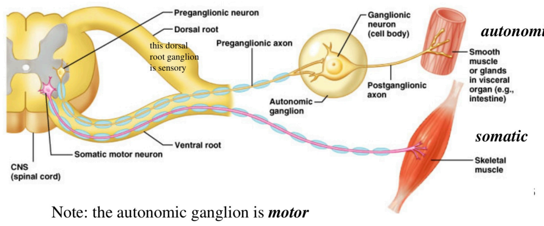
In short, preganglionic neurons send signals to the ganglia, which in turn send signals to the internal organ by postganglionic neurons to control their function.



The autonomic nervous system differs from the somatic nervous system in that it has two neuron pathways (preganglionic - postganglionic) instead of one.

The image compares the somatic nervous system and the autonomic nervous system, illustrating how each transmits nerve signals from the central nervous system (CNS) to muscles.

Diagram contrasts somatic (lower) and autonomic:



Note: the autonomic ganglion is ***motor***

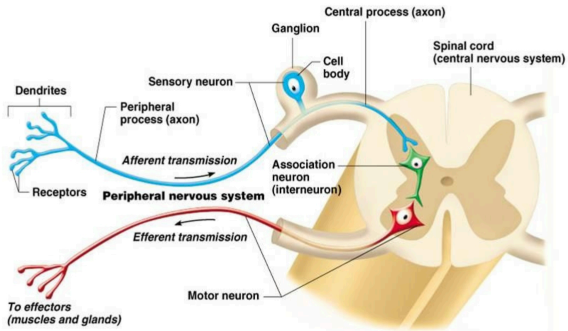
Somatic Nervous System: Shows a single neuron pathway from the CNS to skeletal muscle. The somatic motor neuron sends a signal directly to the skeletal muscle, causing contraction.

Autonomic Nervous System shows a two-neuron pathway: The preganglionic neuron Sends a signal from the CNS to an autonomic ganglion and the Postganglionic neuron Sends a signal from the autonomic ganglion to the effector organ (such as smooth muscle or glands).

In short, the image highlights the key difference: the somatic nervous system has a direct one-neuron pathway, while the autonomic nervous system has a two-neuron pathway with an intermediate autonomic ganglion.

The image is a diagram of a reflex arc in the peripheral nervous system. It shows the pathway of a nerve signal from sensory receptors to muscles.

Sensory ganglion



Ganglion cells in dorsal root ganglia do not receive synapses

Receptors: These receptors detect stimuli (such as touch, heat, or pain).

Sensory neuron: This neuron transmits the nerve signal from the receptors to the spinal cord via the sensory ganglion. Note that the cell body of the sensory neuron is located in the sensory ganglion, not in the spinal cord.

Association neuron (Interneuron): This neuron is located in the spinal cord and transmits the nerve signal from the sensory neuron to the motor neuron.

Motor neuron: This neuron transmits the nerve signal from the spinal cord to the muscles.

Effectors (muscles): These muscles respond to the nerve signal from the motor neuron by contracting or relaxing.

Sensory ganglion: Contains the cell bodies of the sensory neurons. Importantly, it does not receive synapses.

In short, the image shows how a nerve signal is transmitted from sensory receptors to muscles via a simple neural pathway in the peripheral nervous system. This pathway is called a reflex arc, which is a rapid and involuntary response to a stimulus.

The Autonomic Ganglion is a Motor Ganglion

The Autonomic Ganglion is a cluster of neuron cell bodies in the Autonomic Nervous System (ANS) that functions as a relay station between preganglionic and postganglionic neurons.

Why is the Autonomic Ganglion considered a Motor Ganglion? Because it transmits motor signals from the Central Nervous System (CNS) to smooth muscles, cardiac muscles, and glands, controlling involuntary responses like heart rate regulation, blood vessel dilation, and sweating.

Types of Neurons in the Autonomic Ganglion

Preganglionic Neurons: Originate from the brain or spinal cord (CNS), Use Acetylcholine (ACh) as a neurotransmitter, Synapse in the autonomic ganglion, transmitting the nerve impulse to the postganglionic neurons.

Postganglionic Neurons: Carry signals from the autonomic ganglion to the target organ (e.g., heart, intestines), Use either Acetylcholine (ACh) or Norepinephrine (NE) depending on the autonomic system (sympathetic or parasympathetic).

Locations of Autonomic Ganglia

1. Sympathetic Ganglia: Part of the Sympathetic Nervous System (SNS), Located near the spinal cord in a structure called the Sympathetic Chain, Controls "fight-or-flight" responses like increased heart rate and pupil dilation.

2. Parasympathetic Ganglia: Part of the Parasympathetic Nervous System (PNS), Located near the target organs like the heart or stomach, Responsible for "rest-and-digest" functions like reducing heart rate and increasing digestive activity.

Conclusion: The autonomic ganglion is a motor ganglion because it relays motor signals from the CNS to muscles and glands, It regulates involuntary functions such as blood pressure control, digestion, and heart rate, It is classified into sympathetic ganglia (activates emergency responses) and parasympathetic ganglia (controls resting and digestion functions).

Ganglion Cells in Dorsal Root Ganglia Do Not Receive Synapses

What Are Dorsal Root Ganglia (DRG)? Dorsal Root Ganglia (DRG) are clusters of sensory neuron cell bodies located along the dorsal roots of spinal nerves, near the spinal cord. These ganglia contain unipolar sensory neurons, which relay sensory signals from the body to the central nervous system (CNS).

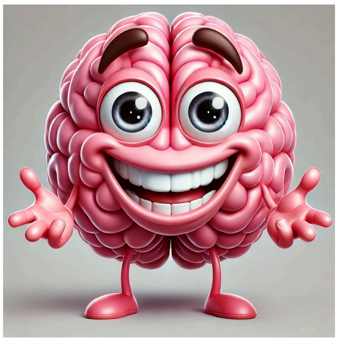
Why Don't Ganglion Cells in DRG Receive Synapses?

1. Nature of Unipolar Sensory Neurons, These neurons have a single process (axon-like structure) that splits into: Peripheral Process receives sensory input from skin, muscles, or organs and the Central Process sends the signal directly to the spinal cord without synapsing in the DRG.

This means the DRG does not act as a synaptic relay center, but rather a collection point for sensory neuron cell bodies.

2. Lack of Interneurons in DRG, Autonomic ganglia contain synapses because preganglionic neurons connect to postganglionic neurons, In contrast, DRG neurons do not need synapses within the ganglion since they directly transmit signals to the CNS.

3. The function of DRG serves as a storage center for sensory neuron cell bodies but does not process or relay signals between neurons via synapses, When sensory receptors in the skin or muscles are activated, the signal travels through the peripheral process to the DRG, then directly through the central process to the spinal cord without synapsing.



Conclusion: Ganglion cells in dorsal root ganglia do not receive synapses because sensory neurons in DRG bypass synaptic connections within the ganglion and directly send signals to the CNS, Unlike autonomic ganglia, which contain synapses between pre- and postganglionic neurons, DRG only functions as a collection of sensory neuron cell bodies without synaptic relay, this direct transmission allows for fast and efficient sensory processing, ensuring rapid responses to stimuli.

External Anatomy of the Spinal Cord

Location and Extension

The spinal cord runs through the vertebral canal, which protects it, It starts from the foramen magnum at the base of the skull, connecting to the medulla oblongata, It extends down to the second lumbar vertebra (L2) in adults.

Regions of the Spinal Cord

The spinal cord is divided into regions, each giving rise to spinal nerves, Total: 31 pairs of mixed spinal nerves (both sensory and motor fibers).

Region, Number of Spinal Nerves, Function

Cervical (Neck),8 pairs, Controls arms, shoulders, and diaphragm

Thoracic (Chest),12 pairs, Controls chest muscles, and organs

Lumbar (Lower Back),5 pairs, Controls lower body movement

Sacral (Pelvic Area),5 pairs, Controls pelvic organs and lower limbs

Coccygeal (Tailbone),1 pair, The lowest nerve, minimal function

Variations in Diameter

Cervical Enlargement: Located at C4 - T1, supplies the arms and shoulders.

Lumbar Enlargement: Located at T9 - T12, supplies the legs and pelvis.

These enlargements exist because they contain more neurons to support complex motor and sensory functions.

Inferior End of the Spinal Cord

1. Conus Medullaris: The tapered, cone-shaped end of the spinal cord, Located between L1 and L2, From here spinal nerves extend downward.

2. Cauda Equina: A bundle of spinal nerves extending below the conus medullaris, Named "horse's tail" due to its appearance, Provides sensation and movement to the pelvis and lower limbs.

General Features

Slightly flattened anteriorly and posteriorly, Adult spinal cord length: 42–45 cm, Protected by meninges and cerebrospinal fluid (CSF).

Conclusion

The spinal cord extends from the foramen magnum to L2 and consists of 31 pairs of mixed spinal nerves, It has two enlargements (cervical & lumbar) for controlling the arms and legs The conus medullaris marks its end, with the cauda equina extending downward, It is vital for transmitting sensory and motor information between the brain and the body.

The meninges are connective tissue membranes that surround and protect the brain and spinal cord. They consist of three layers:

1- Dura Mater (Outer Layer): The thickest and strongest layer of the meninges, Made of dense irregular connective tissue, making it tough and resistant to tearing, Continuous with

the epineurium of spinal nerves, connecting the CNS to the PNS, Extends from the foramen magnum to the second sacral vertebra (S2), Anchored to the coccyx by the filum terminal external, which prevents excessive movement of the spinal cord.

Functions:

1. Protects the brain and spinal cord from mechanical damage.

2. Forms a protective cavity for cerebrospinal fluid (CSF), which cushions and nourishes the CNS.

2- Arachnoid Mater (Middle Layer): A thin, web-like membrane just below the dura mater, Composed of delicate collagen and elastic fibers, giving it a spiderweb-like appearance, Adheres to the inner surface of the dura mater, forming a space called the subarachnoid space, which is filled with cerebrospinal fluid (CSF), The CSF in the subarachnoid space acts as a shock absorber and provides nutrients to the CNS.

3- Pia Mater (Inner Layer): The thinnest and most delicate layer of the meninges, A transparent, soft connective tissue membrane that tightly adheres to the surface of the brain and spinal cord, Extends downward to form the filum terminale, which anchors the spinal cord to the coccyx, Forms denticulate ligaments, which connect the spinal cord to the arachnoid and dura mater, preventing excessive movement within the vertebral column.

Comparison of the Three Layers

Layer	Location	Characteristics	Function
Dura Mater	Outer	Thick, tough, dense connective tissue	Protection & stability
Arachnoid Mater	Middle	Thin, web-like, contains CSF	Shock absorption & nutrient transport
Pia Mater	Inner	Delicate, adheres to brain & spinal cord	Nourishment & structural support

Importance of the Meninges

Protects the brain and spinal cord from injury, Maintains CNS stability within the skull and vertebral column, and Regulates cerebrospinal fluid (CSF) flow, providing nutrients and cushioning.

Conclusion: The meninges play a crucial role in protecting and stabilizing the CNS. Each layer contributes uniquely to mechanical protection, nutrient transport, and anchoring of the brain and spinal cord within their respective cavities.)

The meninges contain three important spaces, each with distinct functions and medical significance.

1- Epidural Space: Location Between the dura mater and the wall of the vertebral canal, Contents Fat tissue and blood vessels, which help cushion the spinal cord, Medical Importance Used for epidural anesthesia, where an anesthetic is injected into this space to numb the nerves passing through it, commonly used in childbirth and surgical procedures.

2- Subdural Space: Location Between the dura mater and arachnoid mater, Contents A small amount of serous fluid, reducing friction between the layers, Medical Importance Can be affected by subdural hematoma, where blood collects in this space due to ruptured blood vessels, causing pressure on the brain or spinal cord.

3- Subarachnoid Space: Location Between the arachnoid mater and pia mater, Contents Cerebrospinal fluid (CSF), which acts as a cushion and nutrient transporter, Large blood vessels that supply the brain and spinal cord, Medical Importance Lumbar puncture (spinal tap) is performed in this space to collect CSF for diagnostic testing, such as for meningitis, brain hemorrhage, or other neurological conditions.

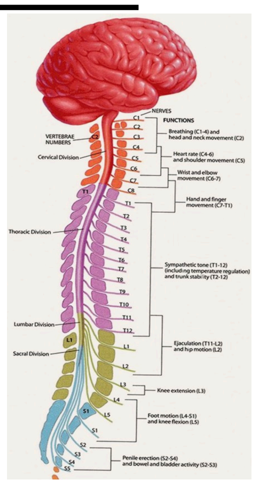
The lumbar puncture is typically done between L3 and L4 or L4 and L5, to avoid injuring the spinal cord, which ends at L1/L2, The supracristal line (an imaginary line between the highest points of the iliac crests) helps locate the ideal puncture site.

Comparison of the Three Spaces

Space	**Location**	**Contents**	**Medical Significance**
Epidural	Between dura mater and vertebral wall	Fat and blood vessels	Epidural anesthesia
Subdural	Between dura mater and arachnoid mater	Serous fluid	Subdural hematoma
Subarachnoid	Between arachnoid mater and pia mater	CSF and blood vessels	Lumbar puncture

Conclusion: These spaces play critical roles in protecting the CNS and facilitating medical procedures. The epidural space is used for anesthesia, the subdural space is important in brain injuries, and the subarachnoid space is crucial for CSF circulation and diagnostic testing.

Spinal Cord Segments



1- Relationship Between Spinal Cord Segments and Vertebrae

The spinal cord segments do not align perfectly with their corresponding vertebrae, and the difference increases as we go downward, This happens because the spinal cord is shorter than the vertebral column, causing spinal nerve roots to be longer at lower levels, For example, the T12 spinal cord segment is not at T12 vertebra but rather at L5 vertebra.

2- Length of Nerve Roots

As we move downward, spinal nerve roots become longer due to the discrepancy

between spinal cord segments and vertebral levels, This results in the formation of the Cauda Equina, a collection of nerve roots extending below the Conus Medullaris (the tapered end of the spinal cord).

3- Exit of Spinal Nerves from the Vertebral Column

Each spinal nerve exits through the intervertebral foramen below its corresponding vertebra, Except in the Cervical Vertebrae The first seven cervical nerves (C1 - C7) exit above their corresponding vertebrae, The C8 spinal nerve exits below the C7 vertebra because there are only 7 cervical vertebrae but 8 cervical spinal nerves, From T1 downward, spinal nerves exit below their corresponding vertebrae.

4- Spinal Cord Segment and Vertebral Level Correspondence, Due to the mismatch between spinal cord segments and vertebrae, spinal segments are positioned as follows:

Spinal Cord Segment	Corresponding Vertebral Level
C7	At C7 vertebra
C8	At C7-T1 level
T3	At T3 vertebra
T5	At T5 vertebra
T9	At T12 vertebra
T10	At L1-L2 vertebrae
T11	At L3-L4 vertebrae
T12	At L5 vertebra
L1	At S1 vertebra (end of spinal cord)

Medical Importance of This Difference

Lumbar puncture (spinal tap) is performed at L3-L4 or L4-L5 to avoid injuring the spinal cord, which ends at L1-L2 Understanding this is crucial for diagnosing spinal cord injuries, as a lesion at a certain vertebral level may affect a different spinal cord segment.

Conclusion: The spinal cord segments do not directly align with their vertebral counterparts, creating longer nerve roots at lower levels and forming the Cauda Equina. This anatomical knowledge is critical for medical procedures and diagnosing spinal injuries.

Herniated Disc / Ruptured Disc / Slipped Disc

1- Definition: occurs when the gelatinous nucleus pulposus protrudes or leaks through the annulus fibrosus of an intervertebral disc, This happens due to excessive pressure or degeneration, leading to a tear in the annulus fibrosus and the escape of the nucleus pulposus.

2- Common Direction of Herniation: The posterolateral direction is the most common because The annulus fibrosus is thinner and weaker in this region and The posterior longitudinal ligament does not cover the entire disc, allowing the nucleus pulposus to protrude.

3- Most Common Locations 95% of herniated discs occur at: L4/L5 and L5/S1, These levels bear the highest amount of stress and movement, making them more susceptible to herniation.

4- Symptoms depend on the location and direction of herniation and include:

1. Pain: Localized back pain or radiating leg pain (sciatica).

2. Numbness & Tingling: Due to nerve compression.

3. Muscle Weakness: If motor nerves are affected.

4. Loss of bowel or bladder control (in severe cases like Cauda Equina Syndrome).

5- Diagnosis: MRI (Magnetic Resonance Imaging) is the best imaging method and a CT Scan is used if MRI is unavailable Clinical Examination: Includes tests like the Straight Leg Raise Test for sciatica detection.

6- Treatment Options

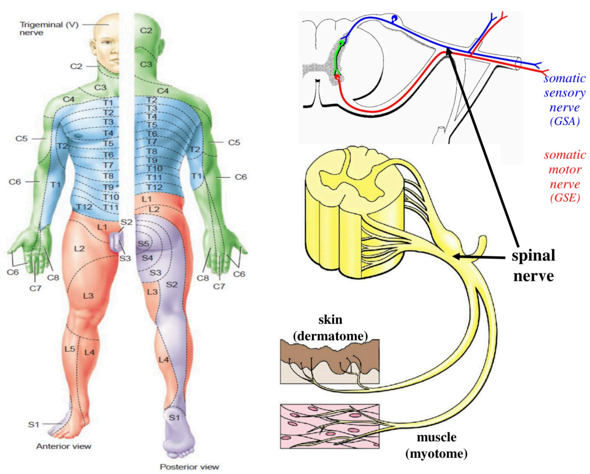
1. Conservative Treatment: Relative rest, avoiding aggravating movements, Physical therapy to strengthen muscles and relieve spinal pressure, NSAIDs (e.g., ibuprofen) for pain relief, and Epidural steroid injections for inflammation reduction.

2. Surgical Treatment (For severe cases): Discectomy Removing the herniated portion of the disc or Spinal Fusion Used in cases of spinal instability.

Conclusion: A herniated disc is a common spinal disorder, primarily affecting the lower lumbar region (L4/L5, L5/S1). Understanding its causes, symptoms, and treatments is essential for effective management and prevention of complications.

The image shows a diagram of a spinal nerve and its distribution to the skin and muscles. The diagram shows:

1-A diagram of the human body showing the division of the body into sensory (dermatomes)



and motor (myotomes) areas corresponding to the spinal nerve roots. Each number indicates the level of the vertebra in the spine from which the spinal nerve originates. This helps to locate nerve injury based on the affected area.

2-A detailed diagram of the spinal nerve, showing its sensory (GSA) and motor (GSE) components. It shows how the sensory nerve (GSA) enters the spinal cord from the skin (dermatome), and how the motor nerve (GSE) exits the spinal cord to the muscles (myotome). It also shows the dorsal root ganglion (sensory ganglion) containing the cell bodies of the sensory neurons.

In short, the image illustrates the anatomical relationship between spinal nerves, skin, and muscles, and how sensory and motor signals are transmitted between the central nervous system and the extremities. It is a useful tool for understanding peripheral neurology and diagnosing neurological diseases.

The image is a table and illustrations related to common lumbar disc problems. The table shows the relationship between the affected lumbar disc, the nerve root involved, the percentage of occurrence, motor weakness, sensory changes, and affected reflexes. The illustrations demonstrate clinical tests to assess the function of the L5 and S1 lumbar nerves, as well as a depiction of the anatomical effects of these problems on movement. In short, the image is a diagnostic tool to help identify lumbar disc problems based on symptoms.

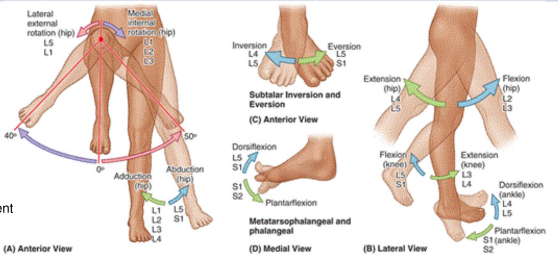
Common lumbar disc problems

Disc	Root	Percentage	Motor weakness	Sensory changes	Reflex affected
L3-L4	L4	3-10%	Knee extension (Quadriceps femoris	Anteriomedial leg (saphenous)	Knee jerk
L4-L5	L5	40-45%	Big toe dorsifelxion (EHL) and TA	Big toe , anteriolateral leg (Common P)	Hamstring jerk
L5-S1	S1	45-50%	Foot planter flextion (Gastrocnemius)	Lateral border of foot (sural)	Ankle jerk

Important myotomes of lower limb

❑**Test L5**: by asking the patient to stand on his heels

❑**Test S1**: by asking the patient to stand on his tiptoes



For the L5 nerve:

Muscle Strength Testing: This assesses the strength of the leg and foot muscles innervated by the L5 nerve. This includes Hip flexion The patient is asked to bend their knee and lift their leg against resistance; Knee extension The patient is asked to straighten their leg against resistance; Dorsiflexion The patient is asked to lift their foot upwards against resistance; Great toe abduction The patient is asked to move their big toe away from the other toes.

Sensory Testing: This assesses sensation in the skin area innervated by the L5 nerve, which includes the outer part of the leg and foot, particularly the lateral aspect of the thigh. A pin or monofilament is used to test the sensation of touch, pinprick, and temperature (hot and cold).

Reflex Testing: This assesses the patellar (knee-jerk) and ankle reflexes. Decreased or absent reflexes may indicate a problem with the L5 nerve.

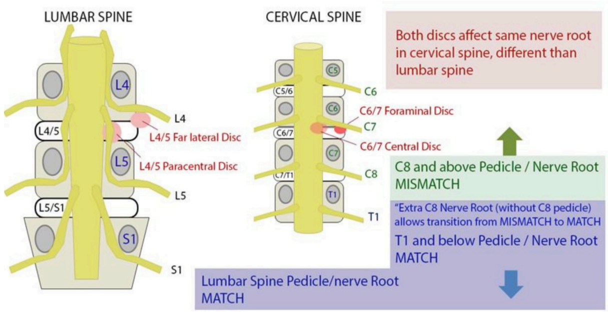
For the S1 nerve:

Muscle Strength Testing: This assesses the strength of the leg and foot muscles innervated by the S1 nerve. This includes; Knee flexion: The patient is asked to bend their knee against resistance; Plantarflexion: The patient is asked to push their foot downwards against resistance; Great toe abduction: The patient is asked to move their big toe away from the other toes.

Sensory Testing: This assesses sensation in the skin area innervated by the S1 nerve, which includes the back of the leg and foot, particularly the outer aspect of the foot and ankle.

Reflex Testing: This primarily assesses the ankle reflex (specifically the plantar reflex). Decreased or absent reflexes may indicate a problem with the S1 nerve.

The image is a medical diagram comparing the relationship between spinal nerve roots and intervertebral discs in the lumbar and cervical spine. It highlights a key difference in how nerve root compression occurs in these two regions.



Lumbar Spine: This section shows a simplified diagram of the lumbar spine (L4-S1). It illustrates the location of the L4/L5, and L5/S1 intervertebral discs and their relationship to the corresponding nerve roots (L4, L5, and S1). The labels "Far lateral Disc" and "Paracentral Disc" indicate different locations of disc herniation within the lumbar spine. The key takeaway here is that in the lumbar spine, the nerve root exiting at a given vertebral level is compressed by the disc above that level. For example, the L5 nerve root is compressed by the L4/5 disc.

Cervical Spine: This section shows a simplified diagram of the cervical spine (C3-T1). It illustrates the location of the C6/7 intervertebral discs (both foraminal and central herniations) and their relationship to the corresponding nerve roots. The key difference highlighted is that in the cervical spine, the nerve root exiting at a given vertebral level is compressed by the disc at the same level. For example, the C7 nerve root is compressed by the C6/7 disc.

The Main Point: The diagram emphasizes the anatomical difference in how nerve root compression occurs between the lumbar and cervical spine. This is crucial for accurate diagnosis and treatment of spinal nerve compression (radiculopathy). The text "Both discs affect same nerve root in the cervical spine, different than lumbar spine" directly points out this key distinction. The "MISMATCH" and "MATCH" labels further emphasize the difference in the pedicle/nerve root relationship between the cervical and lumbar regions. The note about the extra C8 nerve root explains a transitional anatomical variation.

Major Symptoms of Disc Herniation

1- Low Back Pain: One of the primary symptoms of disc herniation; The pain can be localized or radiating due to nerve compression, Pain Radiation Pathway: Gluteal region (buttocks)-Back of the thigh -Back of the leg.

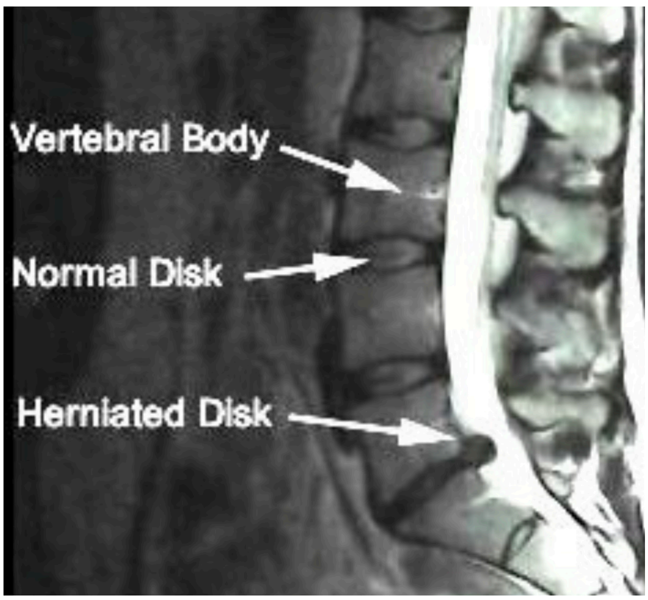
2- Role of Spinal Nerves in Pain: Each spinal nerve gives off a meningeal branch, which carries sensation from the dura mater, Irritation of these branches leads to widespread pain.

3- Dura Mater Sensitivity to Stretch, The dura mater is highly sensitive to stretching or compression, When compressed by a herniated disc, it can cause severe and diffuse pain.

4- Diffuse Pain Due to Overlapping Dermatomes: Each spinal nerve supplies a specific dermatome, Due to overlapping nerve distributions, pain may be widespread and difficult to pinpoint.

5- Straight Leg Raise (SLR) Test: Used to detect sciatic nerve irritation caused by disc herniation, Procedure: The patient lies flat on their back, The examiner slowly lifts the affected leg while keeping it straight, If pain radiates down the leg between 30-70Â° of elevation, it suggests nerve compression due to a herniated disc.

Disc herniation symptoms vary based on nerve involvement, but low back pain, nerve irritation, and positive SLR test are key indicators.



The image shows a sagittal (side) view Magnetic Resonance Imaging (MRI) scan of the lumbar spine (lower back). The image is displayed on a tablet or similar device. Arrows and labels point out key anatomical features:

Vertebral Bodies: These are the bony segments of the spine. The image shows several vertebral bodies stacked on top of each other.

Normal Disk: This label points to an intervertebral disc that appears normal in size and shape. Intervertebral discs are cushions of

cartilage that sit between the vertebrae, providing shock absorption and flexibility.

Herniated Disk: This label points to an intervertebral disc that is bulging or protruding beyond its normal boundaries. This is a herniated disc, also known as a slipped disc or ruptured disc. The herniation is visible as a displacement of the disc material.

MRI is commonly used to aid in making the diagnosis of a herniated disc and standard diagnostic tool for identifying herniated discs.

Cross Section of the Spinal Cord

1- Anterior Median Fissure: A wide groove located on the ventral (anterior) side of the spinal cord; Divides the spinal cord into right and left halves and allows nerve fibers to pass through.

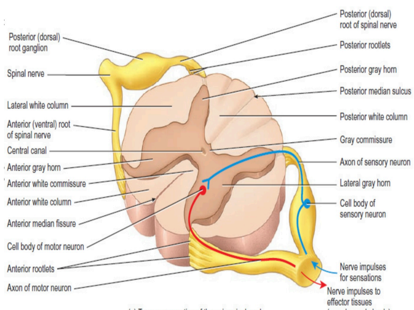
2- Posterior Median Sulcus: A narrow groove on the dorsal (posterior) side of the spinal cord that helps define the boundary between the right and left parts of the posterior white matter.

3- Gray Matter: Composed of neuron cell bodies, dendrites, and unmyelinated axons; Divided into Horns:

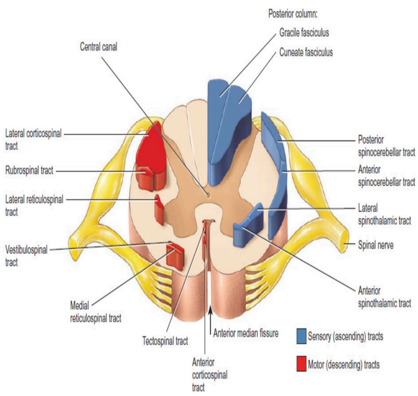
1. Posterior (Dorsal) Horn: Contains sensory neuron cell bodies and receives sensory input from afferent nerve fibers.

2. Anterior (Ventral) Horn: Contains motor neuron cell bodies and sends signals to skeletal muscles through efferent nerve fibers.

3. Lateral Horn: Found in the thoracic and upper lumbar regions, Contains autonomic motor neurons that control: Cardiac muscle-smooth muscle glands.



(a) Transverse section of thoracic spinal cord



Cross Section of Spinal Cord

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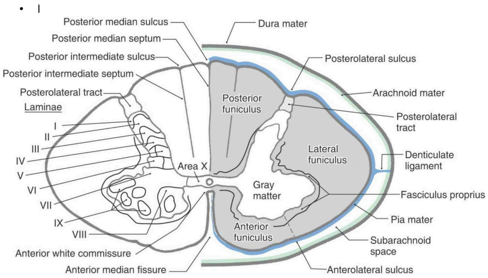

Medicine is not just a profession; it is a lifelong commitment to resilience and dedication. In every moment of fatigue or challenge, remember that your hands make a difference, your knowledge brings hope, and your determination saves lives. Do not stop at obstacles let them be stepping stones to excellence. A strong doctor is not one who never feels tired, but one who keeps going despite everything