CC-102: Anatomy and Physiology

UNIT-3: System II

3.4 Nervous system: organization, central nervous system- Brain, spinal cord, autonomic nervous system. Concept of nerve- muscle physiology: Neuromuscular junction and transmission.

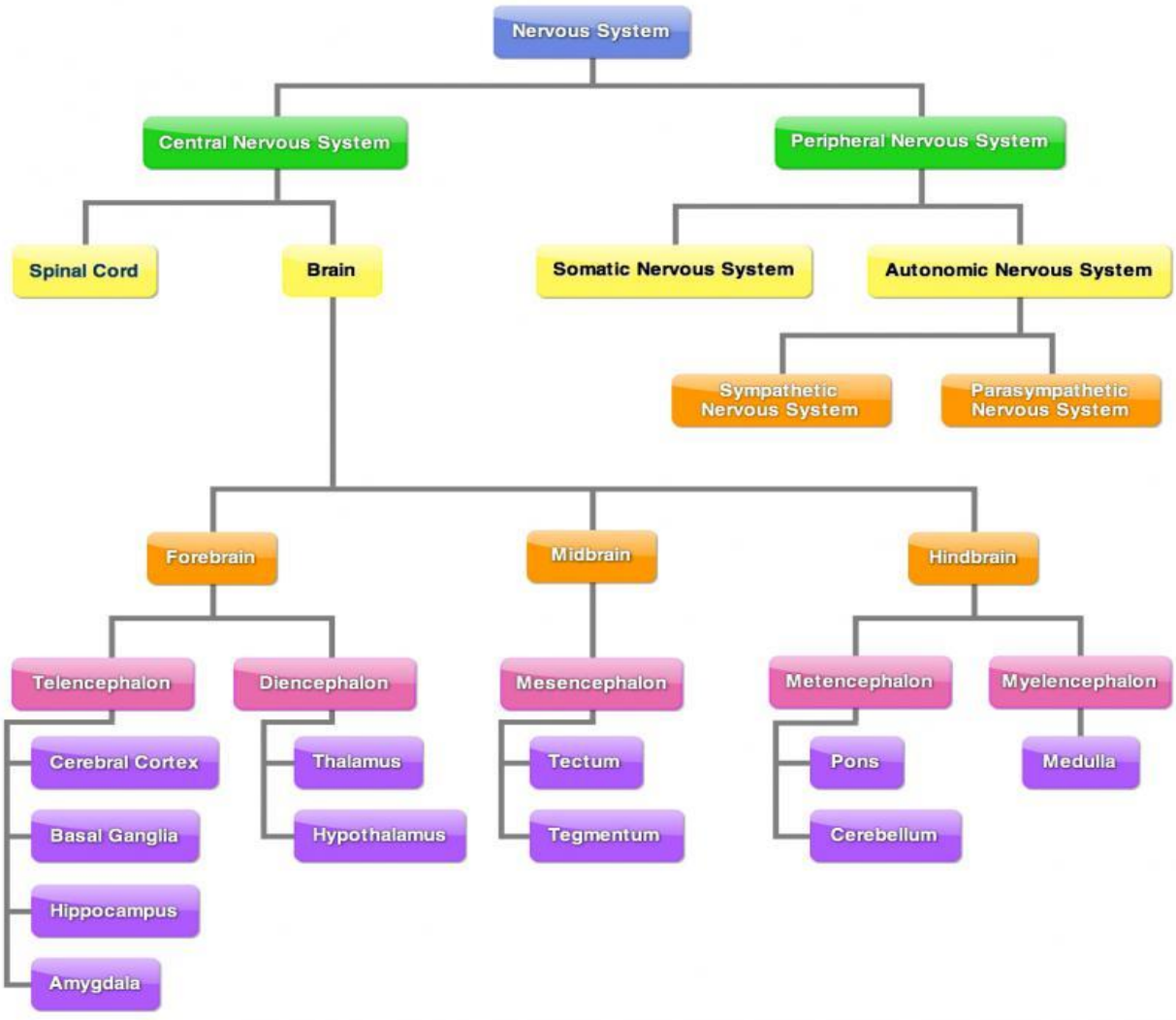
❖ Nervous system:

The nervous system is the network of nerve cells and fibres which transmits nerve impulses between parts of the body. The nervous system is a highly complex system of an animal that coordinates its actions and sensory information by transmitting signals to and from different parts of the body.

It controls and coordinates all essential functions of the body including all other body systems allowing the body to maintain homeostasis or its delicate balance.

The Nervous System is divided into Two Main Divisions: Central Nervous System (CNS) and the Peripheral Nervous System (PNS)

❖ Organization of nervous system:



❖ The central nervous system:

The central nervous system consists of the brain and spinal cord. It is referred to as "central" because it combines information from the entire body and coordinates activity across the whole organism.

❖ Brain:

The human brain is the central organ of the human nervous system, and with the spinal cord makes up the central nervous system. The brain consists of the cerebrum, the brainstem and the cerebellum. It controls most of the activities of the body, processing, integrating, and coordinating the information it receives from the sense organs, and making decisions as to the instructions sent to the rest of the body. The brain is contained in, and protected by, the skull bones of the head. The brain is the most complex organ in the human body.

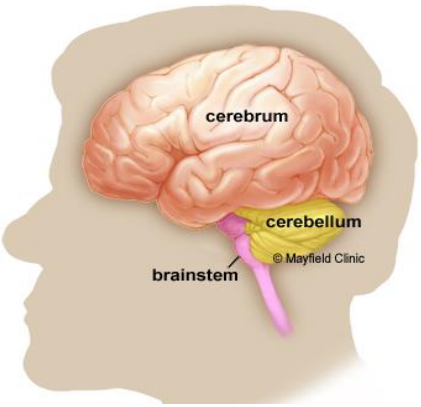
In total, around 100 billion neurons and 1,000 billion glial (support) cells make up the human brain. Our brain uses around 20 percent of our body's total energy. The brain is the central control module of the body and coordinates activity. From physical motion to the secretion of hormones, the creation of memories, and the sensation of emotion.

The brain is composed of the cerebrum, cerebellum, and brainstem.

Cerebrum: is the largest part of the brain and is composed of right and left hemispheres. It performs higher functions like interpreting touch, vision and hearing, as well as speech, reasoning, emotions, learning, and fine control of movement.

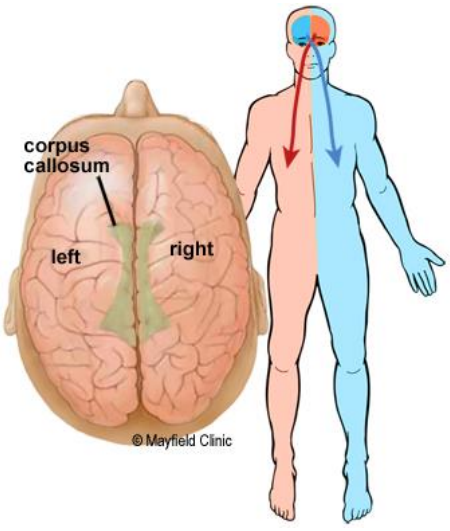
Cerebellum: is located under the cerebrum. Its function is to coordinate muscle movements, maintain posture, and balance.

Brainstem: acts as a relay center connecting the cerebrum and cerebellum to the spinal cord. It performs many automatic functions such as breathing, heart rate, body temperature, wake and sleep cycles, digestion, sneezing, coughing, vomiting, and swallowing.



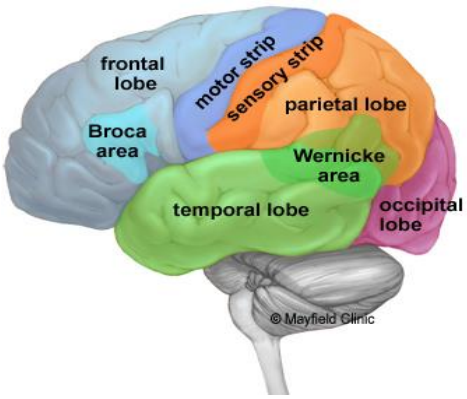
- **Right brain – left brain**

The cerebrum is divided into two halves: the right and left hemispheres. They are joined by a bundle of fibers called the corpus callosum that transmits messages from one side to the other. Each hemisphere controls the opposite side of the body. If a stroke occurs on the right side of the brain, your left arm or leg may be weak or paralyzed.



Not all functions of the hemispheres are shared. In general, the left hemisphere controls speech, comprehension, arithmetic, and writing. The right hemisphere controls creativity, spatial ability, artistic, and musical skills. The left hemisphere is dominant in hand use and language in about 92% of people.

- **Lobes of the brain (Function of Brain)**



The cerebral hemispheres have distinct fissures, which divide the brain into lobes. Each hemisphere has 4 lobes: frontal, temporal, parietal, and occipital (Fig. 3). Each lobe may be divided, once again, into areas that serve very specific functions. It's important to understand that each lobe of the brain does not function alone. There are very complex relationships between the lobes of the brain and between the right and left hemispheres.

Frontal lobe:

- Personality, behavior, emotions
- Judgment, planning, problem solving
- Speech: speaking and writing (Broca's area)
- Body movement (motor strip)
- Intelligence, concentration, self-awareness

Parietal lobe:

- Interprets language, words
- Sense of touch, pain, temperature (sensory strip)
- Interprets signals from vision, hearing, motor, sensory and memory
- Spatial and visual perception

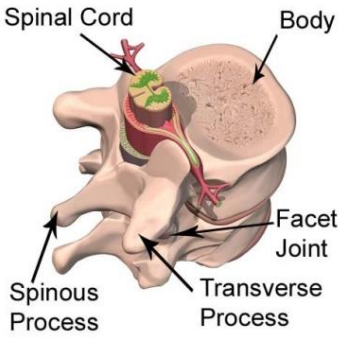
Occipital lobe:

- Interprets vision (color, light, movement)

Temporal lobe:

- Understanding language (Wernicke's area)
- Memory
- Hearing
- Sequencing and organization

❖ Spinal cord



Spinal cord the cylindrical bundle of nerve fibres and associated tissue which is enclosed in the spine or vertebrae (back bones) and connects nearly all parts of the body to the brain, with which it forms the central nervous system.

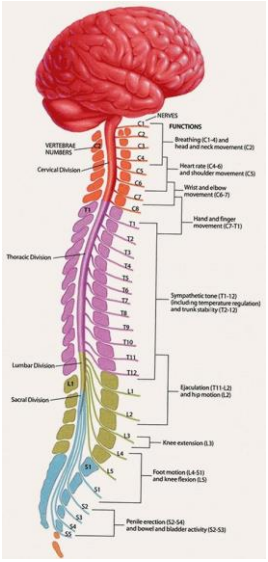
The spinal cord is a long, thin, tubular structure made up of nervous tissue, which extends from the medulla oblongata in the brainstem to the lumbar region of the vertebral column. It encloses the central canal of the spinal cord, which contains cerebrospinal fluid.

Functions:

The spinal cord works a bit like a telephone switchboard operator, helping the brain communicate with different parts of the body, and vice versa. Its three major roles are:

i. To relay messages from the brain to different parts of the body (usually a muscle) in order to perform an action
ii. To pass along messages from sensory receptors (found all over the body) to the brain
iii. To coordinate reflexes (quick responses to outside stimuli) that don't go through the brain and are managed by the spinal cord alone

The spinal cord is organized into five major regions consisting of a total of 33 segments (two of these segments are fused, so it is usually described as having 31 segments). Each segment contains nerves connected to different parts of the body.



i. **The cervical region** is connected to the head, neck, upper body, arms, and hands.
ii. **The thoracic region** is connected to the hands, fingers, chest, and abdominal muscles.
iii. **The lumbar region** is connected to the hips, knee, ankles, and toe muscles.
iv. **The sacral region** is connected to the legs, toes, bladder, and anal muscles.
v. **The coccygeal region** is connected to the skin around the coccyx.

❖ Autonomic nervous system:

The autonomic nervous system (ANS) is a division of the peripheral nervous system that supplies smooth muscle and glands, and thus influences the function of internal organs. **The autonomic nervous system is a control system that acts largely unconsciously and regulates bodily functions such as the heart rate, digestion, respiratory rate, pupillary response, urination, and sexual arousal.** This system is the primary mechanism in control of the fight-or-flight response.

Structure:

The autonomic nervous system is divided into the sympathetic nervous system and parasympathetic nervous system. The sympathetic division emerges from the spinal cord in the thoracic and lumbar areas, terminating around L2-3. The parasympathetic division has craniosacral "outflow", meaning that the neurons begin at the cranial nerves (specifically the oculomotor nerve, facial nerve, glossopharyngeal nerve and vagus nerve) and sacral (S2-S4) spinal cord.

- **Sympathetic nervous system:**

Promotes a fight-or-flight response, corresponds with arousal and energy generation, and inhibits digestion.

- Diverts blood flow away from the gastro-intestinal (GI) tract and skin via vasoconstriction
- Blood flow to skeletal muscles and the lungs is enhanced (by as much as 1200% in the case of skeletal muscles)
- Dilates bronchioles of the lung through circulating epinephrine, which allows for greater alveolar oxygen exchange
- Increases heart rate and the contractility of cardiac cells (myocytes), thereby providing a mechanism for enhanced blood flow to skeletal muscles
- Dilates pupils and relaxes the ciliary muscle to the lens, allowing more light to enter the eye and enhances far vision
- Provides vasodilation for the coronary vessels of the heart
- Constricts all the intestinal sphincters and the urinary sphincter
- Inhibits peristalsis
- Stimulates orgasm

- **Parasympathetic nervous system**:

The parasympathetic nervous system has been said to promote a "rest and digest" response, promotes calming of the nerves return to regular function, and enhancing digestion. Functions of nerves within the parasympathetic nervous system include.

- Dilating blood vessels leading to the GI tract, increasing the blood flow.
- Constricting the bronchiolar diameter when the need for oxygen has diminished
- Dedicated cardiac branches of the vagus and thoracic spinal accessory nerves impart parasympathetic control of the heart (myocardium)
- Constriction of the pupil and contraction of the ciliary muscles, facilitating accommodation and allowing for closer vision
- Stimulating salivary gland secretion, and accelerates peristalsis, mediating digestion of food and, indirectly, the absorption of nutrients
- Sexual. Nerves of the peripheral nervous system are involved in the erection of genital tissues via the pelvic splanchnic nerves 2–4. They are also responsible for stimulating sexual arousal.

- Some typical actions of the sympathetic and parasympathetic nervous systems are listed below.

Target organ/system	Parasympathetic	Sympathetic
Digestive system	Increase peristalsis and amount of secretion by digestive glands	Decrease activity of digestive system
Liver	No effect	Causes glucose to be release to blood
Lungs	Constricts bronchioles	Dilates bronchioles
Urinary bladder/ Urethra	Relaxes sphincter	Constricts sphincter
Kidneys	No effects	Decrease urine output
Heart	Decreases rate	Increase rate
Blood vessels	No effect on most blood vessels	Constricts blood vessels in viscera; increase BP
Salivary and Lacrimal glands	Stimulates; increases production of saliva and tears	Inhibits; result in dry mouth and dry eyes
Eye (iris)	Stimulates constrictor muscles; constrict pupils	Stimulate dilator muscle; dilates pupils
Eye (ciliary muscles)	Stimulates to increase bulging of lens for close vision	Inhibits; decrease bulging of lens; prepares for distant vision
Adrenal Medulla	No effect	Stimulate medulla cells to secrete epinephrine and norepinephrine
Sweat gland of skin	No effect	Stimulate to produce perspiration

❖ Concept of nerve:

Nerve is a bundle of fibers that uses electrical and chemical signals to transmit sensory and motor information from one body part to another. The fibrous portions of a nerve are covered by a sheath called myelin and/or a membrane called neurilemma. Nerves are a collection of neurons, which are the individual nerve cells.

The nerve is composed of different types of axons, and it is through these axons that the electrochemical nerve impulses (mentioned above) are transmitted. Nerves are found in the peripheral nervous system. Each nerve is covered by three layers, starting with the inner endoneurium, which covers the nerve fibres; the middle layer called the perineurium, and the outer layer over the perineurium, called the epineurium. There are even blood vessels found within a nerve.

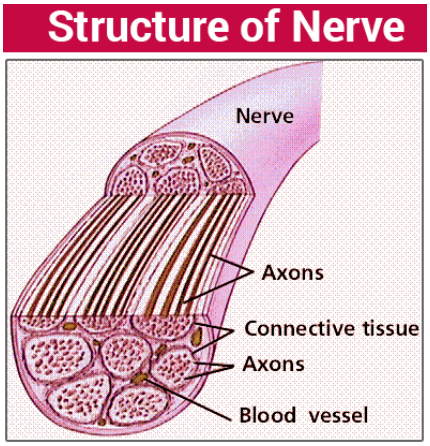
What is a Nerve?

A nerve is a cable like structure within the body designed to conduct nerve impulses that relay information from one part of the body to another.

A typical nerve is made up of a bundle of fibres which are wrapped around layers of tissue and fat and they stretch throughout the body. These nerves transmit information along the axons to the respective organs. These are the basic elements that constitute a nerve.

Nerves are a part of the nervous system. They are primarily involved in control and the coordination of all the parts of the body.

The nervous system not only sends and receives messages but also processes them into chemical signals called impulses in the human body. A wide network of nerves is spread throughout our body which also runs through the brain, the spinal cord and many organs.



Structure of a Nerve:

Nerves are the organs that make up the peripheral nervous system. It consists of a cordlike structure with multiple nerve fibres (also called axons) wrapped in layers of tissue and fat. This axon has layers of connective tissue around it. This connective tissue is called the **endoneurium**. This entire nerve is further enclosed in another layer of connective tissue called the epineurium.

- **Types of Nerves:**

There are three types of nerves in the human body which are classified based on their functions. These are the sensory nerves, motor nerves and mixed nerves.

- **Sensory Nerves**

These are the nerves that send messages to the brain or the spinal cord from the sense organs. These are enclosed in the form of a bundle like structures or nerve fibres in the peripheral nervous system. They carry information from the PNS to the CNS (Central nervous System).

- **Motor Nerves**

Motor nerves are those nerves those that carry the messages in the form of a response from the brain or the spinal cord to other parts of the body such as the muscles and glands. They are responsible for carrying the information from the CNS to the PNS.

- **Mixed Nerves**

Mixed nerves are the nerves that perform both the action of sensory nerves as well as a motor nerve. They transform electrical impulses from the central nervous system to the muscles of the body. Generally, the mixed nerves transmit impulses at the rate of 120 metres per second or 432 kilometres per hour.

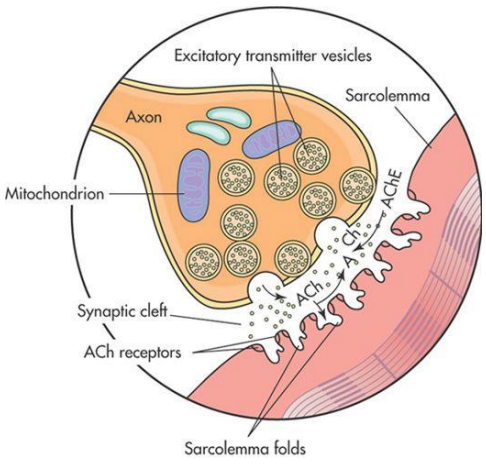
- **Function of Nerves:**
  - The main function of nerves to conduct an electrochemical impulse and convey information. These impulses are carried by the individual neurons that make up the nerve.
  - These impulses travel from one neuron to another by crossing a synapse. The messages are converted from electrical to chemical and then back to electrical.
  - The sensory nerves carry information from the receptor to the central nervous system where the information gets processed.
  - The motor nerves, on the other hand, carry information from the central nervous system to the muscles.
- **Nerve Disorders:**

The nerve disorders include: Pain, Muscle Malfunction, Changes in sensation, Changes in the senses, Vertigo, Dysarthria, Sleeping problems, Mental disability.

❖ Neuromuscular junction:

Neuromuscular junction (or Myoneural junction) is a chemical synapse formed by the contact between a motor neuron and a muscle fiber. It is at the neuromuscular junction that a motor neuron is able to transmit a signal to the muscle fiber, causing muscle contraction and thus is necessary for movement.

At this point, each axon of the motor neuron will divide into branches called axon terminals. Towards the end of the axon terminal, closest to the muscle fiber, the tip of the axon terminal enlarges and becomes known as the synaptic end bulb. Here in this junction motor neuron is called Pre synaptic cell and Muscle fiber is called post synaptic cell. The muscular component is a region of the muscle fiber referred to as the motor end plate. Between the synaptic end bulbs of the neuron and the cell membrane of the muscle fiber (the sarcolemma) lies a space known as the synaptic cleft, which is the final component of the neuromuscular junction.



❖ Neuromuscular transmission:

Neuromuscular transmission is the mechanism whereby motor nerve impulses initiate muscle contraction. Neuromuscular transmission involves the transmission of action potential from the motor neuron's axon to the muscle fiber.

- **Steps in neuromuscular transmission:**

  1) Nerve action potential.
  2) Calcium entry into the presynaptic terminus.
  3) Release of Ach quanta.
  4) Diffusion of Ach across cleft.
  5) Combination of Ach with post-synaptic receptors and Ach breakdown via esterase.
  6) Opening of Na+/K+ channels (cation channels).
  7) Postsynaptic membrane depolarization (EPP).
  8) Muscle action potential.