Introduction to The Nervous System Physiology

The nervous system comprises all neural tissue in the body. It functions as the **master control and communication system**, coordinating rapid responses to internal and external stimuli. Despite accounting for only about **3 percent of total body weight**, it is vital for maintaining homeostasis, regulating bodily functions, and enabling interaction with the environment.

Neurons (nerve cells) and supporting glial cells communicate through **electrical impulses and chemical neurotransmitters**. These signals are **rapid, specific, and usually lead to immediate physiological responses**.

Major Functions of the Nervous System

The nervous system performs three main, overlapping functions:

1. Sensory Function (Receiving Stimuli)

- Specialized **sensory receptors** detect changes in the **internal** (e.g., blood pressure, pH) and **external** (e.g., temperature, light, pain) environments.
- These receptors generate signals that are transmitted via **afferent (sensory) neurons** to the **central nervous system (CNS)**.
- This gathered data is referred to as **sensory input**.

2. Integrative Function (Deciding About Stimuli)

- The CNS processes and interprets the sensory input.
- This step involves **integration**, where information is:
  - Used to initiate **immediate motor responses**
  - **Stored in memory** for future use
  - Utilized in **higher cognitive functions** like reasoning, learning, and emotion

3. Motor Function (Reacting to Stimuli)

- After processing, the CNS sends instructions via **efferent (motor) neurons** to **effector organs**.
- Effectors include **muscles** (for contraction) and **glands** (for secretion).
- The outcome is a **motor response** that may be voluntary or involuntary depending on the system involved.

Divisions of the Nervous System

The nervous system is broadly categorized into two main divisions:

1. Central Nervous System (CNS)

- Composed of the **brain** and **spinal cord**
- Acts as the **integration and control center**
- Responsible for interpreting sensory input and formulating motor output

2. Peripheral Nervous System (PNS)

- Includes **cranial nerves** and **spinal nerves**
- Connects the CNS to the limbs and organs
- Subdivided into:

a. **Somatic Nervous System (SNS)**

- Controls **voluntary movements**
- Innervates **skeletal muscles**

b. **Autonomic Nervous System (ANS)**

- Regulates **involuntary functions** such as heart rate, digestion, and glandular activity
- Subdivided into:
  - **Sympathetic Division** : Prepares the body for "fight or flight"
  - **Parasympathetic Division** : Promotes "rest and digest" activities

Sensory Physiology

Types of Sensory Receptors

- **Mechanoreceptors** : Detect pressure, vibration, and touch
- **Thermoreceptors** : Detect temperature changes
- **Nociceptors** : Detect pain (physical or chemical damage)
- **Photoreceptors** : Detect light (in the retina of the eye)
- **Chemoreceptors** : Detect chemical stimuli (e.g., in taste buds or carotid bodies)

Signal Transmission

1. Receptors transduce stimuli into **electrical impulses**
2. Impulses are transmitted via **afferent neurons**
3. Signals reach the CNS where they are interpreted

Integrative Physiology

Role of the CNS in Integration

- The **spinal cord** handles simple reflexes and relays information to the brain
- The **brain** performs complex processing including memory, emotion, reasoning, and voluntary control
- The **thalamus** acts as a relay station
- The **cerebral cortex** is the main site of conscious perception, thought, and decision-making

Motor Physiology

Somatic Motor Control

- **Motor cortex** initiates voluntary movement
- **Upper motor neurons** send signals to **lower motor neurons** in the spinal cord
- Lower motor neurons stimulate **skeletal muscle contraction**

Autonomic Motor Control

- Involves two-neuron pathways (preganglionic and postganglionic neurons)
- Controls **smooth muscle, cardiac muscle, and glands**
- Balance between **sympathetic** and **parasympathetic** output regulates internal organ function

Neurotransmitters and Synaptic Physiology

- **Synapses** are the sites of communication between neurons or between neurons and effectors
- Electrical impulses trigger the release of **neurotransmitters** such as:
  - **Acetylcholine (ACh)** : Common in somatic and parasympathetic pathways
  - **Norepinephrine (NE)** : Major sympathetic neurotransmitter
  - **Dopamine, serotonin, GABA** : Modulate mood, behavior, cognition, and inhibition

Reflex Arcs

- A **reflex arc** is a simple neural circuit involving:
  1. **Receptor**
  2. **Sensory neuron**
  3. **Integration center** (spinal cord or brainstem)
  4. **Motor neuron**
  5. **Effector**
- Reflexes are rapid, involuntary, and protective

Example : Patellar tendon reflex or withdrawal from a hot surface

Clinical Correlation

Condition	Description
Stroke	Disruption of blood flow to brain leading to sensory and motor deficits
Parkinson's disease	Loss of dopamine-producing neurons causing motor impairment
Multiple sclerosis (MS)	Autoimmune demyelination affecting nerve conduction
Peripheral neuropathy	Nerve damage leading to numbness or weakness, often due to diabetes
Autonomic dysfunction	Abnormal regulation of involuntary functions such

Condition	Description
	as blood pressure and heart rate