Unit - III

chapter ... 7

ORGANIZATION AND FUNCTION OF AUTONOMIC NERVOUS SYSTEM

♦ LEARNING OBJECTIVES ♦

After completing this unit, reader should be able to:

- Describe organization of autonomic nervous system.
- Know pre and postganglionic transmission in autonomic nervous system.
- Understand functions of autonomic nervous system.

7.1 INTRODUCTION

Nervous system comprising all the neurons, plays an important role in our physiological system communicating with each and every organ and integrating all the physiological functions.

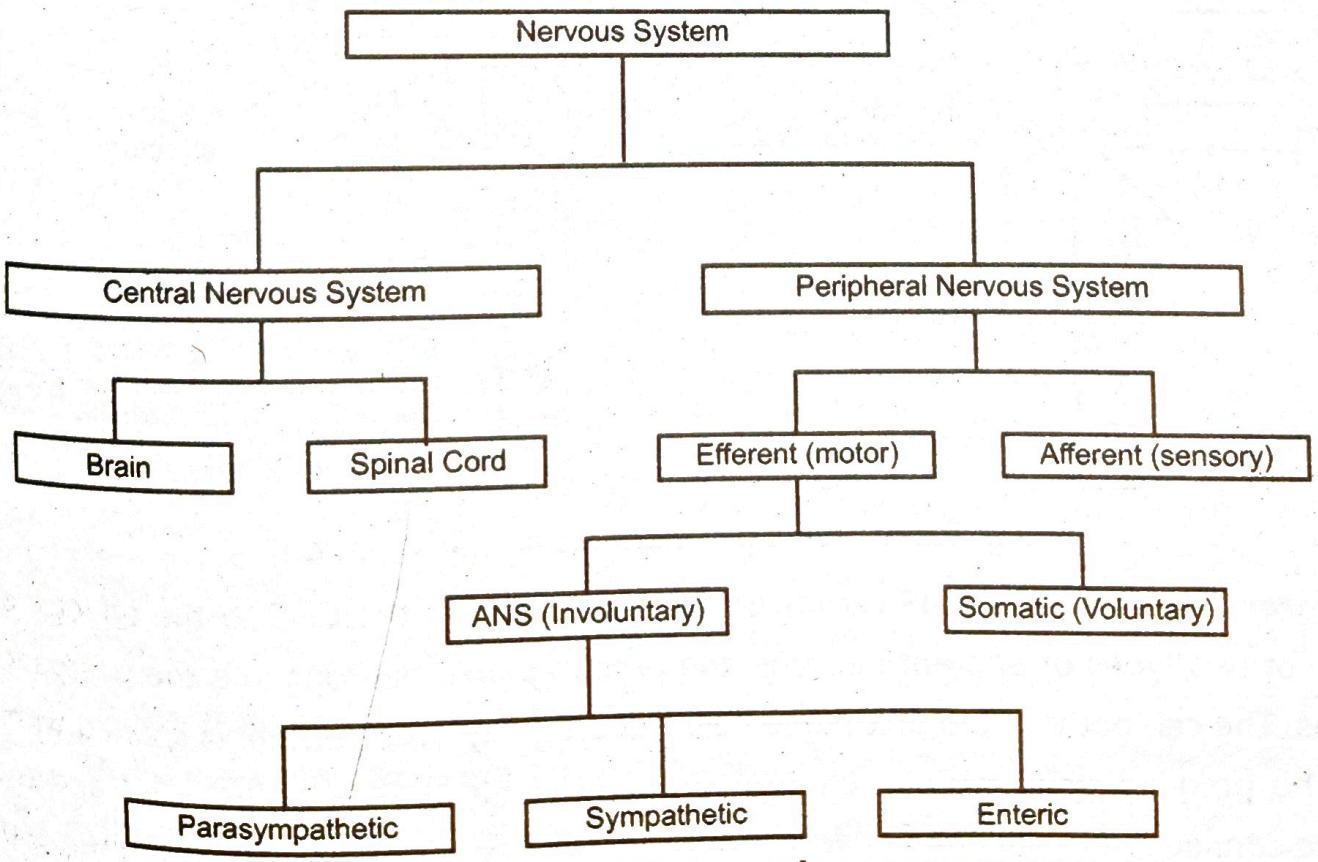

Fig. 7.1: Organization of Autonomic nervous system

The nervous system can be divided into two components such as:

- Central nervous system.
- Peripheral nervous system.

Central nervous system includes brain and spinal cord whereas peripheral nervous system is divided in to afferent and efferent divisions. The peripheral nervous system (PNS) is made up of nerves, and inside the nerves are neurons that conduct action potentials between the CNS and peripheral organ. Based on the direction in which they conduct impulses, neurons of the peripheral nervous system (PNS) are classified as a sensory (afferent) and motor (efferent) neuron.

1. Sensory division neurons conduct action potentials (impulse) toward the CNS.
2. Motor division neurons conduct action potentials away from the CNS.

Both divisions have branches that allow the CNS to voluntarily (consciously) or involuntarily (subconsciously) monitor and control the certain tissues and organs.

Afferent neurons: The afferent neurons (fibres) of the ANS are important in the reflex regulation of this system (for example, by sensing pressure in the carotid sinus and aortic arch) and in signaling the CNS to influence the efferent branch of the system to respond.

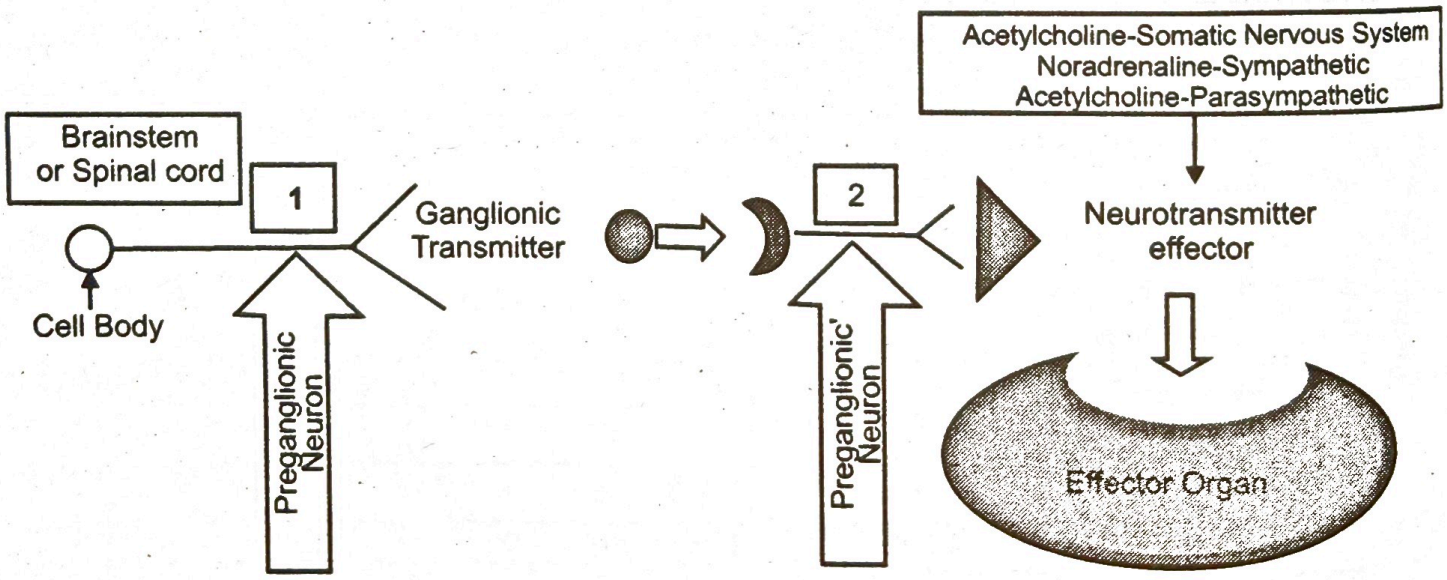

Fig. 7.2: Pre and postganglionic transmission

Efferent neurons: The ANS carries nerve impulses from the CNS to the effector organs by way of two types of efferent neurons: the preganglionic neurons and the postganglionic neurons. The cell body of the first nerve cell, the preganglionic neuron, is located within the CNS. The preganglionic neurons emerge from the brainstem or spinal cord and make a synaptic connection in ganglia (an aggregation of nerve cell bodies located in the peripheral nervous system). The ganglia function as relay stations between the preganglionic neuron

and the second nerve cell, the postganglionic neuron. The cell body of the postganglionic neuron originates in the ganglion. It is generally non-myelinated and terminates on effector organs, such as smooth muscles of the viscera, cardiac muscle, and the exocrine glands. The efferent division is further divided into:

- Somatic nervous system.
- Autonomic nervous system.

The efferent somatic nervous system differs from the ANS in that a single myelinated motor neuron, originating in the CNS, travels directly to skeletal muscle without the mediation of ganglia. As noted earlier, the somatic nervous system is under voluntary control, The motor neuron (efferent neuron) conduct impulses out to the skeletal muscles (effectors), which produce required response movements.

As autonomic nervous system (ANS) also called as involuntary nervous system, many of the functions are independent and automated.

The autonomic neural network allows the brain to involuntarily (subconsciously or unconsciously) monitor changes in the internal environment and control the activities of the viscera (The internal organs of the body, specifically those within the chest (as the heart or lungs) or abdomen (as the liver, pancreas or intestines).

- Activity of the ANS is regulated by hypothalamus and brainstem.
- Input is sent to the ANS control centers from higher levels of the brain (cerebral cortex and limbic system) and sensory receptors embedded in the viscera. Autonomic sensory neurons conduct signals from the visceral receptors to the CNS.
- Using the sensory input, the ANS control centers develop appropriate responses (reflexes), which are then relayed to autonomic motor neurons.
- Autonomic motor neurons carry signals out of the CNS to the heart, glands and smooth muscle. Each pathway to an effector location consists of two neurons.
- Functionally and anatomically, the motor neurons divided into the sympathetic and parasympathetic nervous systems.
- The sympathetic nervous system promotes activities that help the body cope with stress (fight or flight responses).
- In contrast, the parasympathetic nervous system promotes activities that support the body while at rest (digestion and reproduction).

These two divisions have antagonistic (opposing) effects on the internal organs. They innervate and maintain the homeostasis in the body.

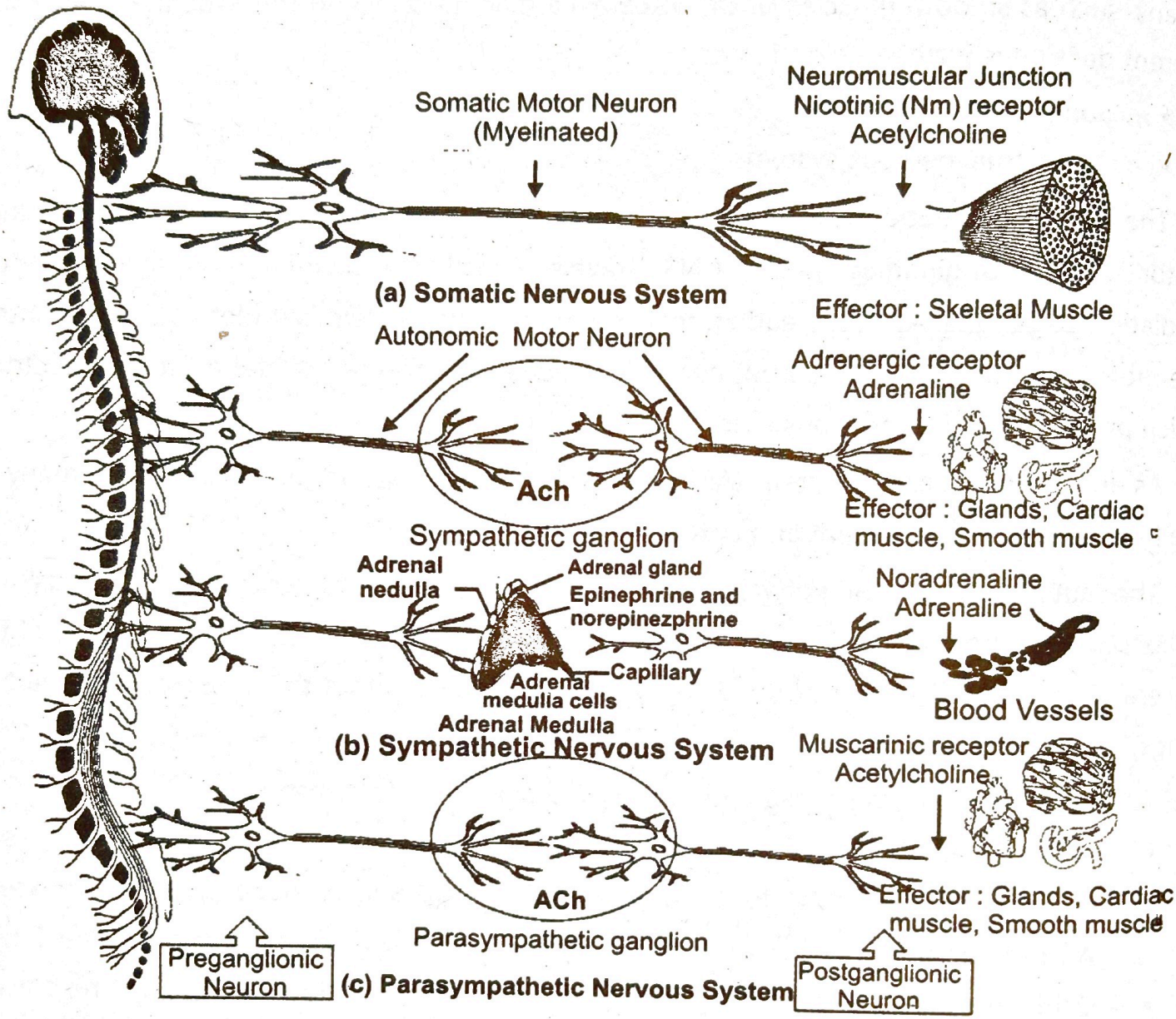

Fig. 7.3: Motor neuron pathways

Table 7.1: Difference between origin, fibers occurrence and location of ganglia in Autonomic nervous system

Division	Origin of Fibres	Length of Fibres	Location of Ganglia
Sympathetic	Thoracolumbar region of the spinal cord	Short preganglionic and long postganglionic	Close to spinal cord
Parasympathetic	Brain and sacral spinal cord (craniosacral	Long preganglionic and short postganglionic	In visceral effector organ

Sympathetic Nervous System: Sympathetic fibres have their reflex centers in the spinal cord, in segments T_1 to L_2, so the sympathetic nervous system is also called as thoracolumbar division.

The sympathetic nervous system is responsible for regulating many homeostatic mechanisms in living organisms. Fibres from the SNS innervate tissues in almost every organ system and provide physiological regulation over diverse body processes including pupil diameter, gut motility (movement), and urinary output.

The SNS is perhaps best known for mediating the neuronal and hormonal stress response commonly known as the fight-or-flight response, also known as sympatho-adrenal response of the body. This occurs as the preganglionic sympathetic fibres that end in the adrenal medulla secrete acetylcholine, which activates the secretion of **adrenaline** (epinephrine), and to a lesser extent **noradrenaline** (norepinephrine). Therefore, this response is mediated directly via impulses transmitted through the sympathetic nervous system, and also indirectly via catecholamines that are secreted from the adrenal medulla, and acts primarily on the cardiovascular system.

For example, the sympathetic nervous system can accelerate heart rate, widen bronchial passages, decrease motility of the large intestine, constrict blood vessels, increase peristalsis in the esophagus, cause pupillary dilation, and perspiration (sweating), and raise blood pressure.

The sympathetic nervous system uses chiefly epinephrine and norepinephrine as its neurotransmitter. These neurotransmitter acts on two types of receptors, the α (α_1, α_2), and β (β_1, β_2, β_3) adrenergic receptors. The SNS promotes a fight-or-flight response, corresponds with arousal and energy generation, and performs the following functions:

- 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 1,200% in the case of skeletal muscles).
- Dilates bronchioles of the lung, which allows for greater alveolar oxygen exchange.
- Increases heart rate and the contractility of cardiac cells (myocytes), thereby providing a mechanism for the enhanced blood flow to skeletal muscles.
- Dilates pupils and relaxes the ciliary muscle to the lens, allowing more light to enter the eye and far vision.
- Provides vasodilation for the coronary vessels of the heart.
- Constricts all the intestinal sphincters and the urinary sphincter.
- Inhibits peristalsis.
- Stimulates orgasm.

7.2 PARASYMPATHETIC NERVOUS SYSTEM

Parasympathetic reflex centers are associated with the nuclei of cranial nerves III, VII, IX and X and with spinal segments S2 and S3 (variably also S1 and S4). Therefore, the parasympathetic division of the ANS is sometimes called the craniosacral division. About 75% of parasympathetic fibres are brought with the vagus nerve. The PSNS is responsible for regulating the internal organs and glands, which occurs unconsciously. Its roles include stimulation of rest-and-digest activities that occur when the body is at rest, including sexual arousal, salivation, lacrimation (tears), urination, digestion, and defecation.

The parasympathetic nervous system uses chiefly acetylcholine (ACh) as its neurotransmitter, although peptides (such as cholecystokinin) may act on the PSNS as neurotransmitters. The ACh acts on two types of receptors, the **muscarinic** (M_1 to M_5) and **nicotinic** (N_M and N_N) cholinergic receptors.

Most transmission occurs in two stages. When stimulated, the preganglionic nerve releases ACh at the ganglion, which acts on nicotinic receptors of the postganglionic neurons. The postganglionic nerve then releases ACh to stimulate the muscarinic receptors of the target organ. PSNS promotes a rest-and-digest response, and performs the following functions:

- Dilates blood vessels leading to the GI tract, increasing blood flow.
- Constricts the bronchiolar diameter when the need for oxygen has diminished.
- Causes constriction of the pupil and contraction of the ciliary muscle to the lens, allowing for closer vision.
- Stimulates salivary gland secretion, and accelerates peristalsis.
- Stimulates sexual arousal.

Enteric nervous system: The enteric nervous system is the third division of the ANS. It is a collection of nerve fibres that innervate the gastrointestinal (GI) tract, pancreas, and gall bladder, and it constitutes the "brain of the gut." This system functions independently of the CNS and controls the motility, exocrine and endocrine secretions, and microcirculation of the GI tract. It is modulated by both the sympathetic and parasympathetic nervous systems.

Function of Autonomic nervous system: The autonomic nervous system plays an essential role in keeping the body's internal environment (temperature, salt concentration, blood sugar, oxygen and carbon dioxide level in blood, etc.) in proper balance, a condition called homeostasis.

QUESTION

1. Write about the organization of autonomic nervous system.

***