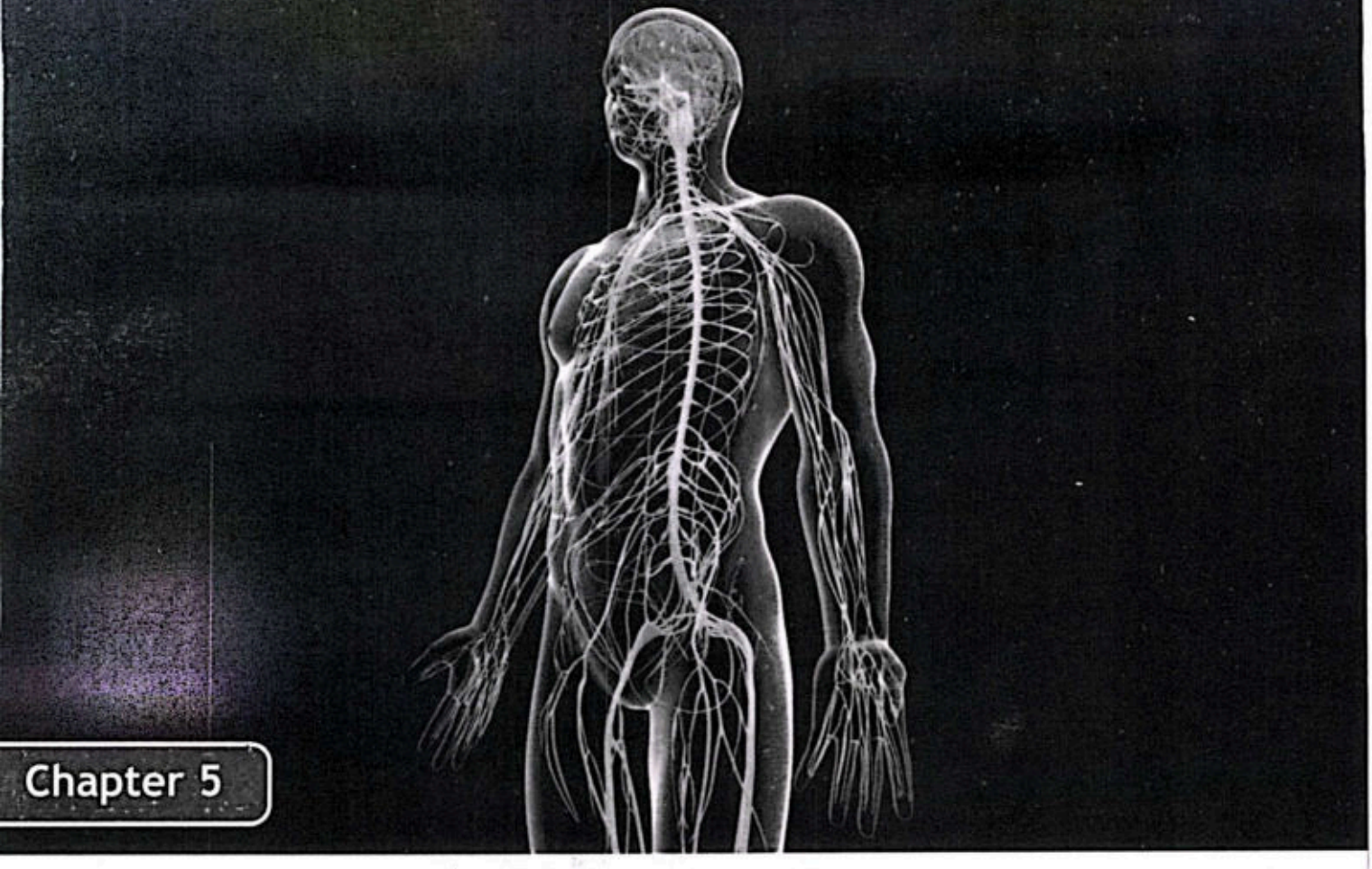


Chapter 5

NERVOUS SYSTEM

SLOs: After completing this lesson, the student will be able to:

1. [B-10-G-01] Describe the nervous system and its role.
2. [B-10-G-02] Describe central nervous system and peripheral nervous system.
3. [B-10-G-03] Outline the types of neuron with diagrams.
4. [B-10-G-04] Define stimulus with example.
5. [B-10-G-05] State the nerve impulses are electrical signals that travel across neuron.
6. [B-10-G-06] Define and sketch synapse.
7. [B-10-G-07] Introduce neurotransmitters.
8. [B-10-G-08] Explain through sketching a diagram the involvement of nervous system when a person accidently touches something painfully hot and withdraws their hands as a reflex.
9. [B-10-G-09] Explain the endocrine system.
10. [B-10-G-10] Identify major endocrine glands and hormones with their functions.

The body of a human is very complex. To ensure that different parts work together effectively there is a need of communication. The nervous system is made up of specialized cells that allow body to communicate. They carry information from one part of the body to another. The nervous system regulates complicated processes like thoughts and memory. It also plays an essential role in the things your body does without thinking, like blushing, sweating and blinking. The nervous system keeps track of what's going on inside and outside of your body and decides how to respond to any situation you are in.

5.1 NERVOUS SYSTEM AND ITS ROLE

Through the sense organs you receive information from the environment. The sense organs include eyes, ears, nose, tongue and skin. Information from the sense organs travels along a nerve to the brain. The brain interprets the message. You can see a picture, hear a sound, smell a rose, taste an apple or feel the cold winter air. The human body is made up of different organs. Each of these organs plays its role in carrying out the process that keeps us alive. The functions performed by each part of the body are coordinated. This coordination is brought about by the organ system called **nervous system.**

Do you know?

The study of the structure of nervous system is called neurology.

5.1.1 Role of Nervous System

Sensitivity is a main feature of all living organism. Any change in the environment of an organism is called **stimulus.** Reaction to the stimulus is known as **response.** The stimulus is received by a **receptor.** The structures that give responses are called **effectors.**

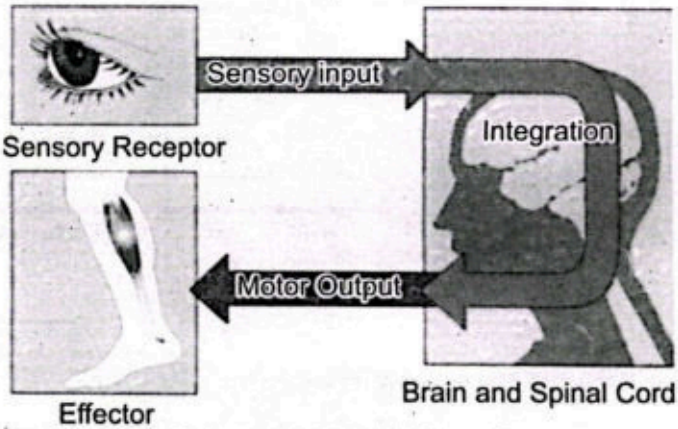


Fig. 5.1: Basic organization of nervous system

The basic organization of a nervous system has three interconnected functions: the sensory input, integration and motor output. Sensory input is triggered by stimuli, such as light or touch. **Sensory input** is the conduction of signals from sensory receptors, to **processing centres** the brain and the spinal cord or the central nervous system. **Integration** is interpretation of the sensory signals and the formulation of responses within processing centre.

Motor output is the conduction of signals from a processing centre to **effector cells,** such as muscle cells and gland cells. Information in the form of signals passes from receptors to processing centres and from there to effector. The electrical signals or nerve impulse travel along pathways of cells called **neurons.**

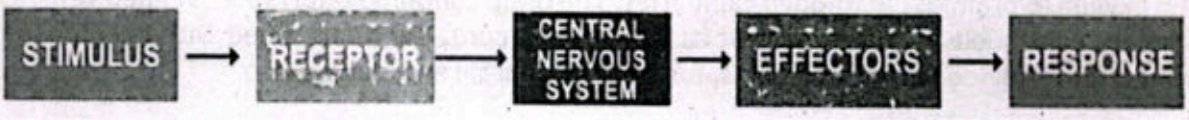


Fig. 5.2: Nervous co-ordination

The nervous system controls all the functions such as: heartbeat and blood pressure, breathing, muscle movements, thoughts, memory, learning and feelings, sleep, healing and aging, stress response, hormone regulation, digestion, sense of hunger and thirst, senses (response to what you see, hear, feel, touch and taste).

5.2 HUMAN NERVOUS SYSTEM

The human nervous system comprises of central nervous system and peripheral nervous system. The **central nervous system** consists of brain which narrows into a long tube called the **spinal cord**. The **peripheral nervous system** consists of cranial nerves from the brain and spinal nerves from the spinal cord. The structural and functional unit of nervous system is **neuron**. An outline of division of human nervous system is given below.

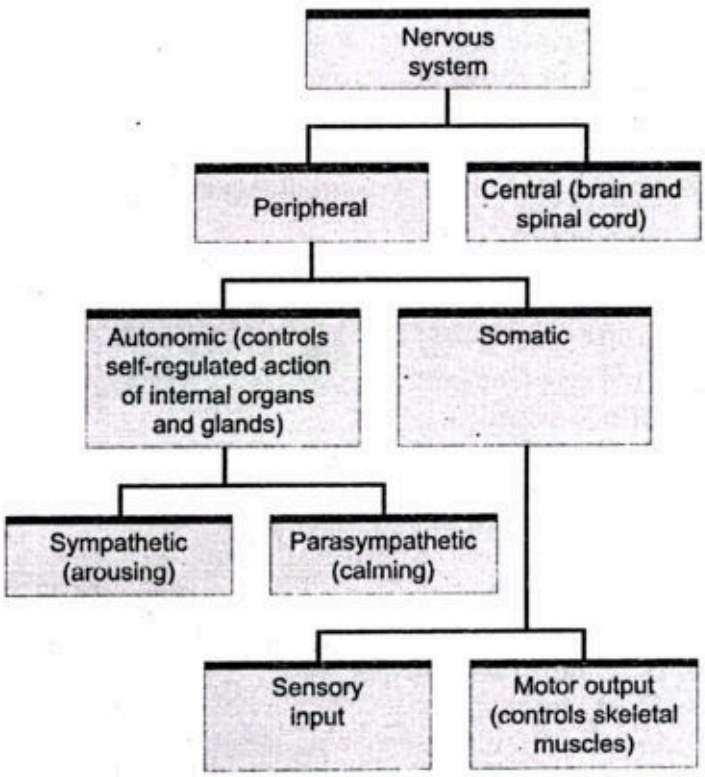


Fig. 5.3: The functional divisions of the human nervous system

5.2.1 Components of Central Nervous System

Here we will discuss the brain and spinal cord as the components of human nervous system.

Brain

It is enclosed within the cranium (skull). The brain and the spinal cord are covered with three protective membranes called **meninges**. Between the inner and middle layer there is a fluid, the cerebrospinal fluid, which helps to cushion the brain from shock. Meninges also provide nutrients and oxygen to brain tissue through capillaries. The brain contains hollow spaces called **ventricles** that are continuous with the central canal of spinal cord. These are filled with **cerebrospinal fluid**. Brain is divided in to three parts, forebrain, midbrain and hindbrain.

Forebrain

The forebrain consists of cerebrum, thalamus and hypothalamus. Cerebrum is the largest part of

the human brain. **Cerebrum** is the main centre of various sensations e.g., hearing, sight smell, memory voluntary action, intelligence, and reasoning. Cerebrum is divided into two **cerebral hemispheres**. Each cerebral hemisphere is divided into four major lobes. 1. frontal lobe 2. parietal lobe 3. temporal lobe 4. occipital lobe.

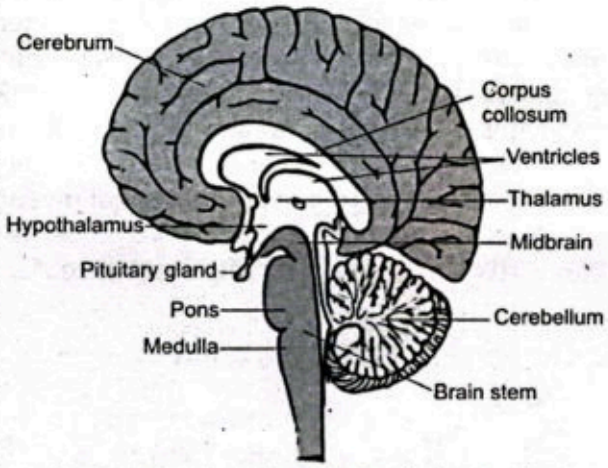


Fig. 5.4: Section through head showing brain

Occipital lobe is responsible for vision. **Temporal lobe** is concerned with hearing and smelling. **Frontal lobe** controls movement of skeletal muscles including movement involved in speech. **Parietal lobe** receives stimuli from skin and provides awareness of body position. The right and left hemispheres control the opposite sides of the body. The two hemispheres are connected by a bundle of nerve fibres called corpus callosum.

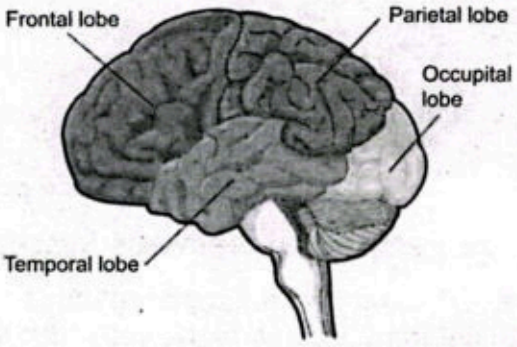


Fig. 5.5: Lobes of Forebrain

Thalamus is below the cerebrum. Thalamus receives nearly all impulses arriving from sensory areas of the body, before passing them to cerebrum. Thalamus is also involved in pain reception and consciousness.

Hypothalamus lies below thalamus. It regulates body temperature, appetite, water balance blood pressure, feeling of mood etc. It links nervous system and endocrine system as it regulates the secretion of pituitary gland. Just below the hypothalamus lies the **pituitary gland**. It is a very small gland about the size of a pea. It is an endocrine gland.

Midbrain

The midbrain is just a mass of tract below the cerebrum. The midbrain receives sensory information and sends it to the appropriate part of the forebrain. It also controls some auditory reflexes and posture.

Hindbrain

The hindbrain includes cerebellum, pons and medulla. **Cerebellum** is the second largest part of the brain. It controls balance and muscle coordination. **Medulla oblongata** is the last part of the brain, just above the spinal cord. Medulla controls involuntary processes of the body like heartbeat, blood pressure and respiration etc. Medulla also controls reflexes such as coughing, sneezing and vomiting etc. Information is passed through medulla between the spinal cord and rest of the brain. **Pons** is small lobe like structure lying just above the medulla. It assists medulla in controlling breathing process. It also serves as a connection between cerebellum and spinal cord.

Spinal Cord

The human spinal cord is an oval shaped hollow cylinder of nervous tissue. It runs from the base of the brain. It is protected by the vertebrae of the backbone. 31 pairs of nerves originate from

spinal cord. Each spinal nerve has a dorsal root of sensory neurons and ventral root of motor neuron. Therefore, all spinal nerves are mixed nerves. The spinal cord serves as a link between body parts and brain. It receives sensory information from the receptors and sends out motor commands to the effector. The spinal cord works as coordinator. It carries out the reflex actions. It also helps in better functioning of brain.

The cross section of the brain and spinal cord shows that the central nervous system has two distinct areas. **White matter** consists of myelinated fibres. **Grey matter** is mainly cell bodies and non-myelinated fibres. In spinal cord butterfly shaped grey matter is surrounded by white matter. While in brain, grey matter makes up the outer layer having some white matter in the centre.

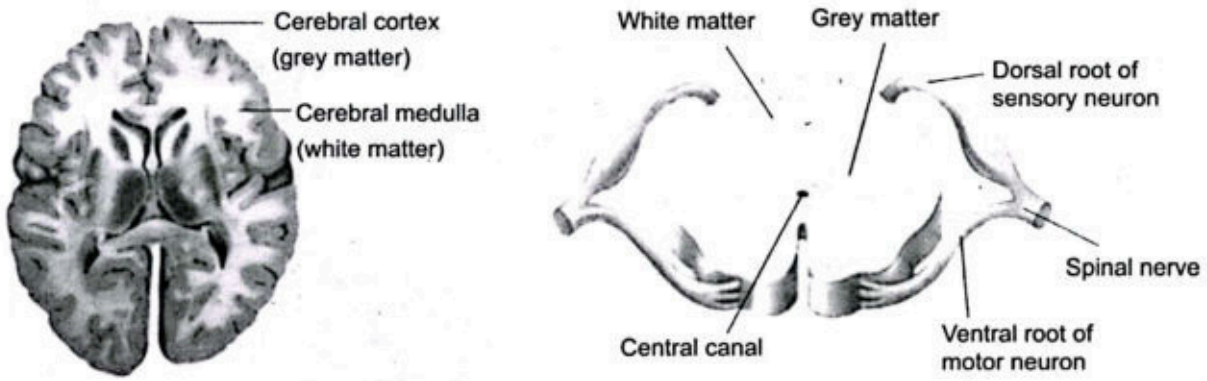


Fig. 5.6: Cross section view of brain and spinal cord

5.2.2 Peripheral Nervous System

The peripheral nervous system (PNS) is composed of nerves which link central nervous system with different body parts. Nerves which arise from brain are called **cranial nerves**. The nerves which arise from spinal cord are called **spinal nerves**. There are 12 pairs of cranial nerves and 31 pairs of spinal nerves in the human body. Some cranial nerves are sensory, some are motor and some are mixed. While, all spinal nerves are mixed nerves.

The peripheral nervous system can be divided into somatic and autonomic nervous system.

Somatic nervous system: Generally it consists of the cranial and spinal nerve fibers that connect the CNS to skin and skeletal muscles.

Autonomic nervous system: It includes those fibres that connect the CNS to the visceral organs, such as the heart, stomach, intestines and various glands. It is concerned with the unconscious activities. The autonomic nervous system is divided into sympathetic and parasympathetic nervous system.

Sympathetic system: It consists of only spinal nerves. It functions only in the state of emergency. It prepares the body to fight or flight response.

Parasympathetic system: It consists of few cranial and spinal nerves. It controls various autonomic nerves during the state of rest. In short it returns the body functions to normal after they have been altered by sympathetic stimulation.

5.3 NEURON

The structural and functional unit of nervous system is neuron. Neurons are long, thin delicate cells. A single neuron may extend from the spinal cord of man to the foot. Bundles of neuron fibres are called **nerves**. The portion of the neuron most resembling other cells is the **cell body**. The cell body contains a nucleus and cytoplasm. The long fibre of a neuron leading away from the cell body is the **axon**. An axon transmits impulses away from the cell body. The other end of the neuron is a highly branched structure called **dendrites**. Impulses move toward the cell body from the dendrites and from cell body to axon.

Long neuron fibres are covered by a fatty **myelin sheath.** Cells of myelin sheath are called **Schwann cells.** Small gaps between consecutive Schwann cells are called **nodes of Ranvier.** Both myelin sheath and the nodes of Ranvier are important in determining the speed with which impulses are conducted. Myelin sheath is an insulator so the membrane coated with this sheath does not conduct nerve impulse. In such a neuron, impulse jumps over the myelin going from node to node. These jumping or **saltatory impulses** increase the speed of nerve impulse.

5.3.1 Types of Neurons

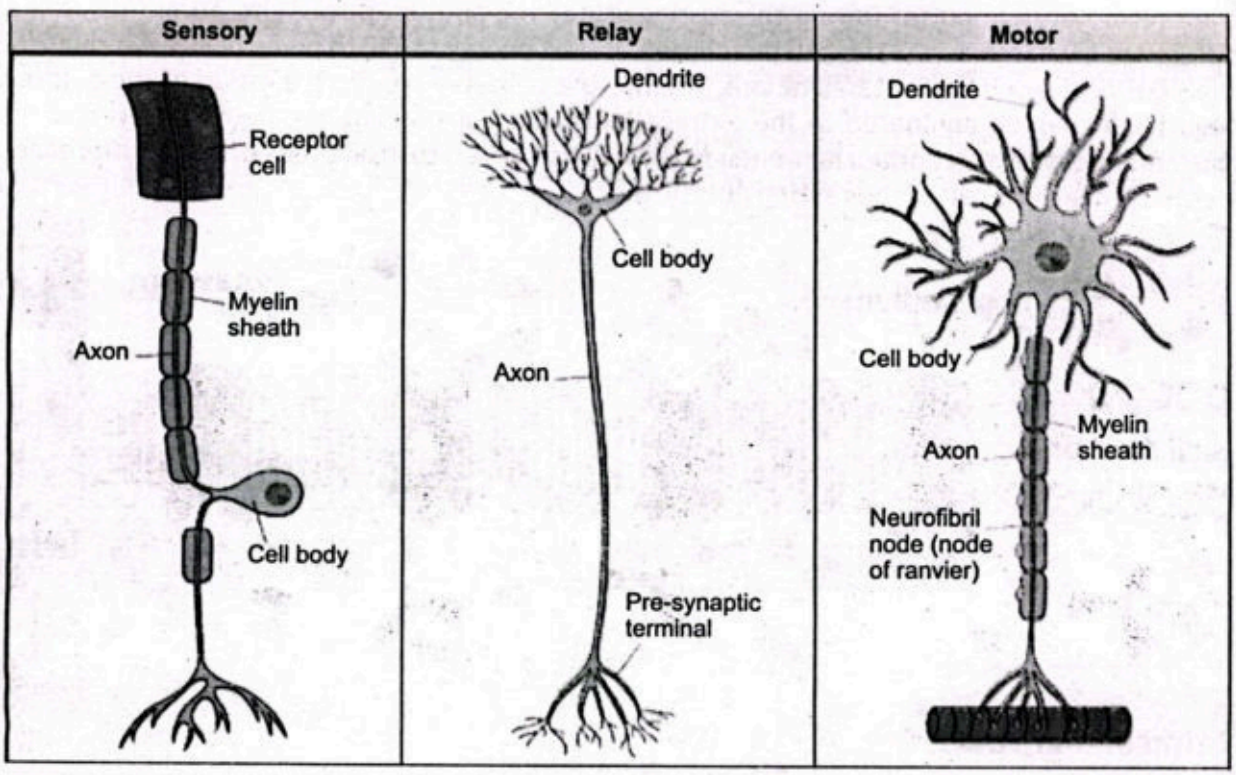


Fig. 5.7: Types of Neuron

The neurons differ in structure and in direction toward which they carry impulses.

Sensory Neurons: They carry sensory information from receptor to the brain and spinal cord. It has one dendrite and one axon.

Motor Neurons: They carry impulses from the brain and spinal cord to the effectors. They have many dendrites and one axon.

Interneurons: These are found in brain and spinal cord. They have many dendrites and axons. The interneuron carries impulses from sensory neuron to motor neuron.

5.4 STIMULUS

Any change or signal in the environment that can make an organism react is called a **stimulus.** (Plural: **stimuli**). Stimuli can be external or internal. External sensory stimuli generally activated by the external changes and include pain, touch, vision, smell, taste, sound, and balance. Internal stimulus is the type of stimulus that comes from inside of the body. One example is of hunger which makes our body get food as there is low energy in the body. Other example includes, level of glucose in the blood, blood pressure and homeostasis etc.

Fig. 5.8: Stimulus

5.5 NERVE IMPUSLES

Nerve impulses are electrical in nature. They result from a difference in electrical charge across the plasma membrane of a neuron. How does this difference in electrical charge come about? The answer involves ions, which are electrically charged atoms or molecules.

Resting Potential

When a neuron is not actively transmitting a nerve impulse, it is in a resting state, ready to transmit a nerve impulse. During the resting state, the **sodium-potassium pump** maintains a difference in charge across the cell membrane. It uses energy in ATP to pump positive sodium ions (Na^+) out of the cell and potassium ions (K^+) into the cell. As a result, the inside of the neuron is negatively charged compared to the extracellular fluid surrounding the neuron. This is due to many more positively charged ions outside the cell compared to inside the cell. This difference in electrical charge is called the **resting potential**.

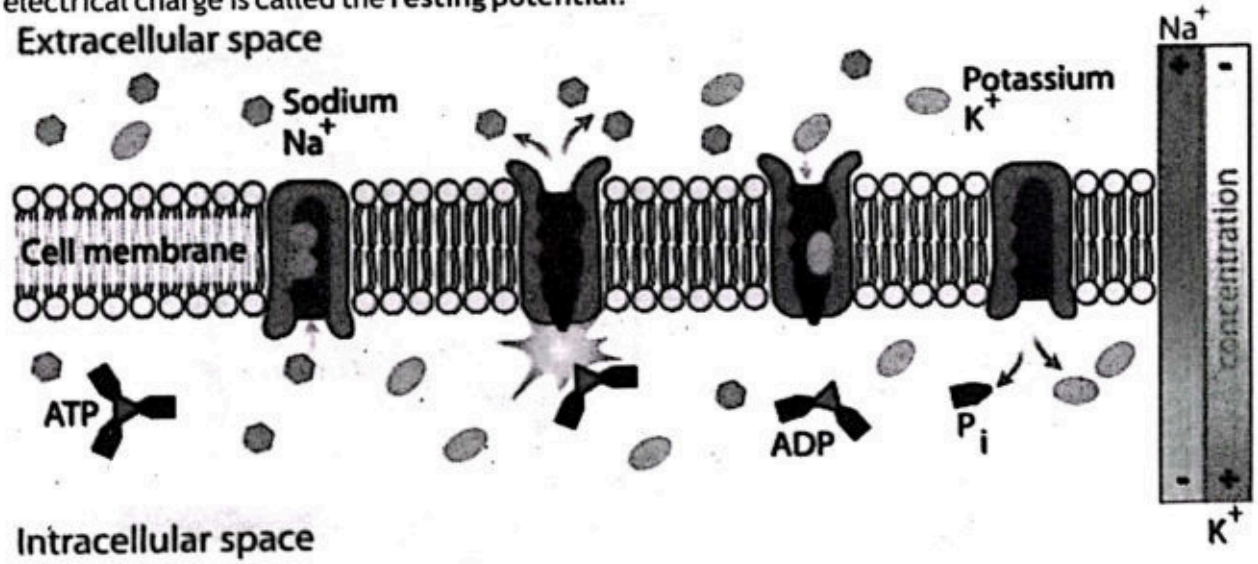


Fig. 5.9: The sodium-potassium pump maintains the resting potential of a neuron.

Action Potential

A **nerve impulse** is a sudden reversal of the electrical charge across the membrane of a resting neuron. The reversal of charge is called an **action potential**. It begins when the neuron receives a chemical signal from another cell. The signal causes gates in sodium ion channels to open, allowing positive sodium ions to flow back into the cell. As a result, the inside of the cell becomes positively charged compared to the outside of the cell. This reversal of charge ripples down the axon very rapidly as an electric current.

Do you Know?

An action potential speeds along an axon in milliseconds.

For your information

In neurons with myelin sheaths, ions flow across the membrane only at the nodes between sections of myelin. As a result, the action potential jumps along the axon membrane from node to node, rather than spreading smoothly along the entire membrane. This increases the speed at which it travels.

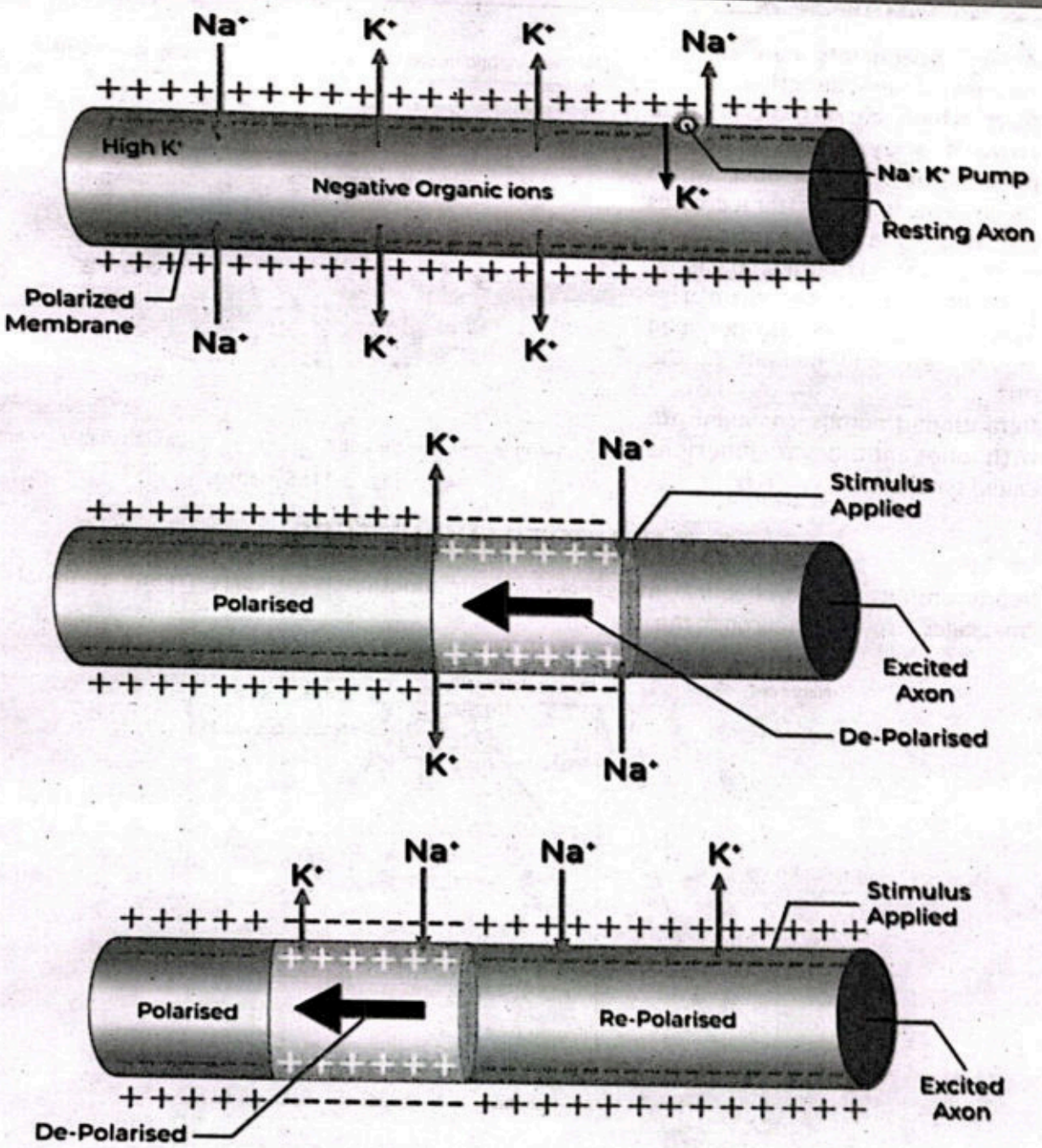


Fig. 5.10: Nerve impulse

5.6 SYNAPSE

The term 'synapse' comes from the Greek words '*syn*', which means 'together' and '*haptein*' meaning 'to clasp'. Action potential do not cease at the end of a single neuron. They are passed on to another excitable cell. The junction between two neurons is called a **synapse** (Sai-naps). Actually, the neurons are not in direct contact at a synapse. There is a gap called **synaptic cleft** between them. For an impulse to continue along a nerve pathway, it must cross this gap. The process of crossing the gap at a synapse is called **synaptic transmission.**

Action potentials can cross a synapse in one direction only. A fiber which carries an impulse toward a synapse is called **presynaptic fiber.** A fiber which receives the impulse after it crosses the synapse is a **postsynaptic fiber.** It serves as structural basis of communication between the neurons in the CNS and between muscle cells and neurons in the PNS.

Definition: Neurons communicate with one another at junctions called **synapses.**

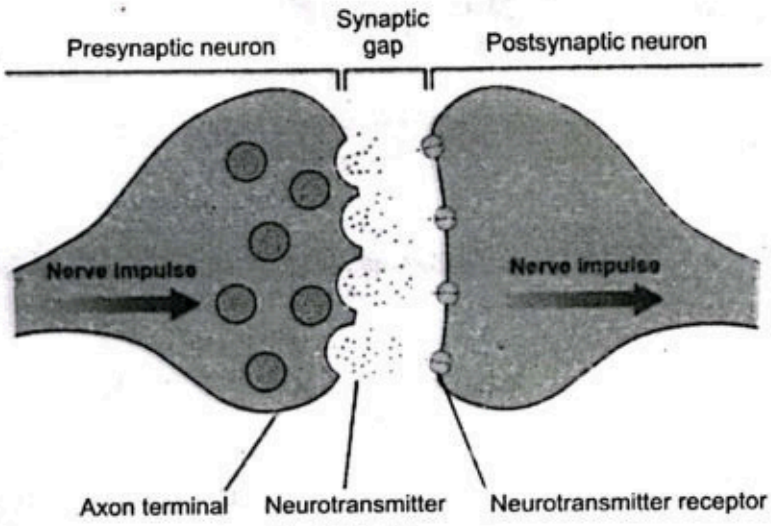


Fig. 5.11: Synapses

5.7 NEUROTRANSMITTERS

Neurotransmitters are chemical messengers. Their function is to carry chemical signals or "messages" from one neuron to the next target cell.

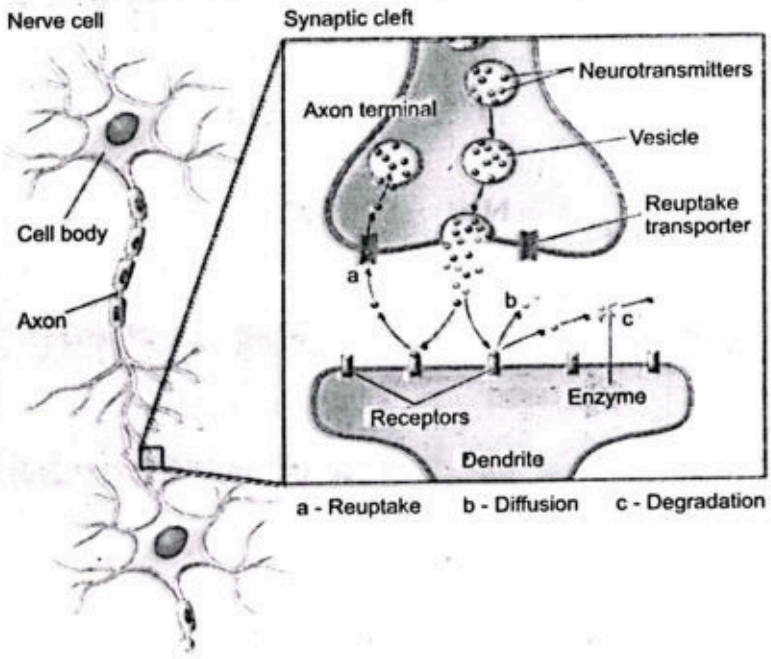


Fig. 5.12: Synaptic transmission

Neurotransmitters are located in the **axon terminal.** They are stored within thin-walled sacs called **synaptic vesicles.** Each vesicle can contain thousands of neurotransmitter molecules.

As a message or signal travels along a nerve cell, the electrical charge of the signal causes the vesicles of neurotransmitters to fuse with the nerve cell membrane at the very edge of the cell. The neurotransmitters, which now carry the message, are then released from the axon terminal into a fluid-filled space that's between one nerve cell and the next target cell.

Each type of neurotransmitter lands on and binds to a specific receptor on the target cell. After binding, the neurotransmitter then triggers a change or action in the target cell, like an electrical signal in another nerve cell, a muscle contraction or the release of hormones from a cell in a gland.

Examples of neurotransmitters are: epinephrine and norepinephrine, glycine and serotonin.

Do you know?

After neurotransmitters deliver their message, the molecules must be cleared from the synaptic cleft. They do this in one of three ways.

Neurotransmitters: a. Fade away (a process called diffusion). b. Are reabsorbed and reused by the nerve cell that released it (a process called reuptake). c. Are broken down by enzymes within the synapse so it can't be recognized or bind to the receptor cell (a process called degradation).

5.8 REFLEX ACTION

The actions performed by our bodies are voluntary and involuntary.

Voluntary actions are the responses by the will and may not be automatic or immediate. Example: Running, walking etc.

Involuntary actions are the actions that occur automatically and without our awareness.

Examples: Heartbeat, secretion of gastric glands, peristalsis, reflexes etc.

Reflex Action

Reflex actions are also called **reflexes**. Reflexes are the responses to external and internal environmental changes. The responses are immediate or automatic and without the intervention of will. Certain responses are without the help of the brain. In this case the spinal cord acts as the control centre. Such a response is a reflex, which involves no conscious control.

Example: The nervous pathway for a well-known reflex called the withdrawal of hand on touching hot object.

Sequence of events that occur when the hand touches a hot object:

1. The heat on the object stimulates nerve endings (receptor) in the skin.
2. Impulses are produced. The impulses travel along the sensory neuron to the spinal cord.
3. In the spinal cord, the impulses are transmitted first across a synapse to the interneuron and then across another synapse to the motor neuron.
4. Impulses leave the spinal cord along motor neuron to the effector.
5. The effector is the arm muscle which then contracts. This brings about a sudden withdrawal of the hand.

Other examples of **reflex actions** are sneezing, coughing, blushing, scratching, and the sudden blinking of the eye when a hand is waved in front of it.

Reflex Arc

In each of the examples mentioned above, there is a particular pathway by which the impulses can travel from the receptor to the effector. This nervous pathway is known as the **reflex arc.**

A reflex arc consists of: 1. sense organ. 2. sensory neuron. 3. interneuron of reflex centre (spinal cord or brain) 4. motor neuron. 5. effector (muscle or gland)

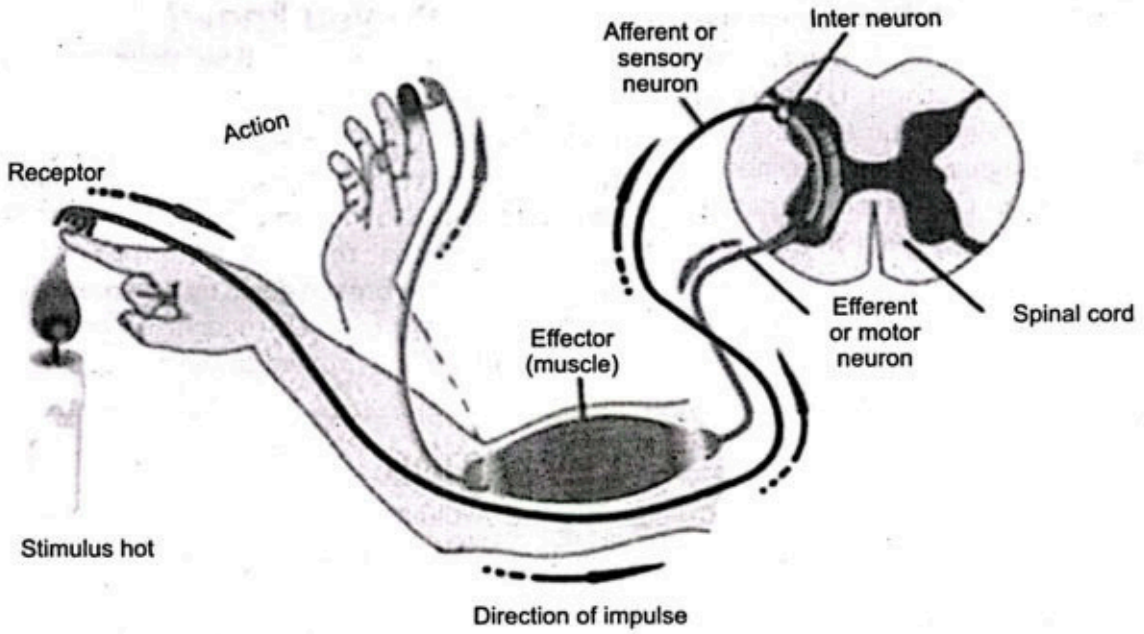


Fig. 5.13: Reflex arc

5.9 ENDOCRINE SYSTEM

Hormones are chemicals produced by the ductless endocrine glands. Small amounts of these chemicals are carried around the body in the blood. The organ on which a particular hormone acts is called **target organ.** Hormones speed up or slow down or alter the activities of these organs. **Hormones** are chemical messengers which regulate and control a number of activities of the body. The hormonal system is slower acting and regulates processes that occur over days or even month. Why it is beneficial for an animal to have two different systems for coordinating activities? Having two systems allow an animal to respond to two different types of stimuli - those requiring immediate action and those that depend on a long-term response.

The gland that secretes a substance out through a duct is called exocrine gland. The secretion is either inside the body or on a surface of the body.

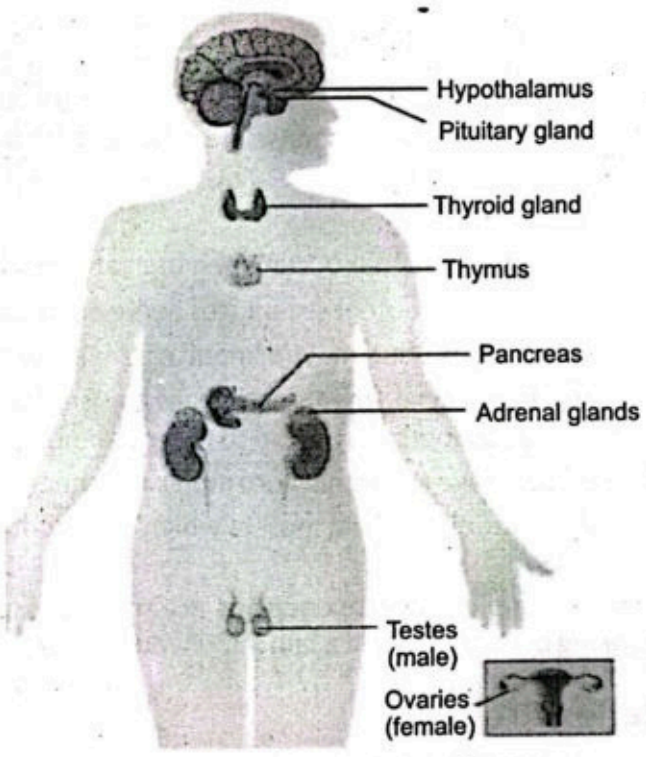


Fig. 5.14: Endocrine system in man

Following major endocrine glands are present is man:

1. Pituitary gland
2. Thyroid gland
3. Parathyroid glands
4. Pancreas
5. Adrenal glands
6. Gonads

5.9.1 Pituitary Glands

Pituitary gland is attached with the hypothalamus. It is about the size of a pea, and consists of two distinct lobes, the anterior and the posterior lobe. It is called master gland because it controls the activity of other endocrine glands.

Anterior Lobe

It mainly affects, regulates and maintains the development and functions of the endocrine glands. It is the larger one and secretes many hormones. **Thyroid stimulating hormones** control development and maintenance of the thyroid glands including production of thyroid hormone. **Growth hormone** or **somatotropic hormone** affects height of the individual. If less growth hormone is produced during childhood, the individual becomes **pituitary dwarf**. If too much growth hormone is produced the individual, is a **pituitary giant**. When there is overproduction of growth hormone in the adult a condition called **acromegaly** results. Since only the feet, hands and face can respond, these portions of the body become overly large. The other hormones of the anterior lobe influence gonads and adrenal glands.

Posterior lobe

It secretes two hormones, oxytocin and antidiuretic hormone.
Oxytocin: It causes powerful contractions of uterus during birth. It causes the ejection of milk.
Antidiuretic hormone. It causes reabsorption of water from the nephrons. It's under secretion results in large quantity of dilute urine. This disease is called diabetes insipidus.

5.9.2 Thyroid Gland

The thyroid gland is located in the neck and fits closely around and sides of trachea just below larynx. The thyroid gland has two lobes. The thyroid hormones are thyroxin and calcitonin.
Thyroxin regulates basic metabolism. It regulates process of growth especially maturation, mental and skeletal development in children. The deficiency of iodine in diet causes the disease goitre, which is the enlargement of thyroid gland itself. It is common in mountain areas due to lack of iodine in soil and water. **Calcitonin** is secreted when blood calcium level is high. It stimulates the deposition of extra calcium in bones.

5.9.3 Parathyroid Glands

Located on the thyroid glands are two pairs of very small structures called parathyroid glands. They secrete the hormone called **parathormone**. Parathormone has function opposite to the function of calcitonin. It controls the balance of calcium ions and phosphate in body.

5.9.4 Pancreas

It is present in the abdominal cavity near the stomach. It is an endocrine as well as exocrine gland. Within the pancreas are certain cells called **Islets of Langerhans**. The islets contain two special groups of cells called alpha and beta cells. Alpha cells secrete **glucagon** and beta cells secrete **insulin**.
Insulin: Insulin is secreted when the level of blood sugar rises, such as right after a meal. The most important effect of insulin is to facilitate glucose transport across cell membrane. Insulin also enhances the conversion of glucose to glycogen.
Glucagon: Glucagon has function opposite to the function of insulin. Its most important job is to increase glucose concentration by stimulating the liver to convert glycogen to glucose.
Diabetes Mellitus: Diabetes, is caused when beta cells do not produce enough insulin. When this happens, glucose accumulates in the blood and is excreted with urine. It requires treatment with regular injections of insulin or medicines prescribed by the physician.

Table 5.1: Hormones and their functions that are produced by the endocrine system.

Secreting gland(s)	Hormone	Function
adrenal	adrenaline	increases blood pressure, heart rate, and metabolism in reaction to stress
adrenal	aldosterone	controls the body's salt and water balance
adrenal	cortisol	plays a role in stress response
adrenal	dehydroepiandrosterone sulfate (DHEA-S)	aids in production of body odor and growth of body hair during puberty
ovary	estrogen	develop female sex characteristics; aids in sperm production
pituitary	follicle-stimulating hormone (FSH)	controls the production of eggs and sperm
pancreas	glucagon	helps increase levels of blood glucose (blood sugar)
pancreas	insulin	helps reduce the blood glucose levels
pituitary	luteinizing hormone (LH)	controls estrogen and testosterone production.
pineal	melatonin	controls sleep-wake cycles
pituitary	oxytocin	helps with lactation, childbirth, and mother-child bonding
parathyroid	parathyroid hormone	controls calcium levels in bones and blood
ovary	progesterone	helps prepare the body for pregnancy when an egg is fertilized
pituitary	prolactin	promotes breast-milk production
ovary, testes, adrenal	testosterone	contributes to body density in males and females as well as development of male sex characteristics
thyroid	thyroid hormone	helps control several body functions, including the rate of metabolism and energy levels

5.9.5 Adrenal Glands

The two adrenal glands rest on the top of kidneys. Each adrenal gland has two parts. Adrenal cortex and adrenal medulla. **Adrenal cortex** secretes several hormones collectively called **corticosteroids.**

Adrenal medulla produces hormones called adrenaline and nor-adrenaline. **Adrenaline** is secreted to meet emergency situation e.g., fight and flight. It is also secreted during fear and anxiety. Adrenaline increases the rate and intensity of heart beat, blood pressure and blood flow to the limbs. Such changes prepare the body to face any emergency situation. **Noradrenalin** raises blood pressure and is responsible for the constriction of blood vessel.

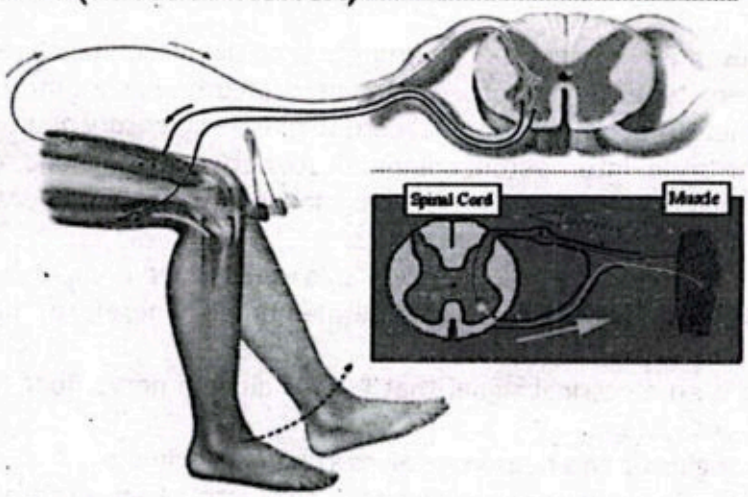
Gonads

The gonads are testes and ovaries. Their hormones are required for reproduction. The male hormone **testosterone** is secreted by the **testes** of males. It is responsible for the appearance of secondary sexual characters at puberty e.g., appearance of beard, coarseness of voice etc. The female hormone **oestrogen** (also known as estrogen) is secreted by the **ovaries.** Oestrogen also stimulates the development of secondary sexual characteristics.

Some examples of hormones and their functions that are produced by the endocrine system are given in table 5.1.

STEAM ACTIVITY 5.1

Knee Jerk Reflex (Patellar Reflex)



Procedure

Have a partner sit with his legs crossed so that his leg can swing freely. Hit his leg just below the knee with the side of your hand. **Do not use a hammer.** The leg will kick out immediately (if you hit the right place).

The knee jerk reflex (seen in the figure) is called a monosynaptic reflex because there is only one synapse in the circuit needed to complete the reflex. It only takes about 50 milliseconds between the tap and the start of the leg kick. That is fast. The tap below the knee causes the thigh muscle to stretch. Information is then sent to the spinal cord. After one synapse in the ventral horn of the spinal cord, the information is sent back out to the thigh muscle that then contracts.

SUMMARY

1. The nervous system's main function is to send messages from various parts of the body to the brain and from brain back out to the body to tell body what to do.
2. These messages regulate: Thoughts, memory, learning and feelings, Movements, balance, coordination, senses i.e., how the brain interprets what you see, hear, taste, touch and feel, wound healing, sleep, heartbeat, digestion etc.
3. The nervous system has two main parts: The brain and spinal cord make up the central nervous system. Peripheral nervous system is made up of a network of nerves. The nerves branch out from spinal cord. This system relays information from brain and spinal cord to the organs, arms, legs, fingers etc.
4. The brain and spinal cord are covered with three protective membranes called meninges.
5. Brain is divided into three parts, forebrain, midbrain, and hindbrain.
6. The forebrain consists of cerebrum, thalamus and hypothalamus.
7. The cerebral cortex is convoluted. The cerebrum receives sensory information and controls motor response. It is the center for speech, intelligence, memory etc. Taste, smell, sound and vision are interpreted by cerebrum.
8. The midbrain is a relay center between the forebrain and hindbrain.
9. The hindbrain is composed the cerebellum and medulla oblongata. The cerebellum analyzes cerebral impulses and controls posture and muscle tone. The medulla controls involuntary responses of internal organs.
10. The spinal cord connects the brain and the peripheral nervous system.
11. Spinal nerves bring information to the spinal cord from receptors and carry impulses to the effectors.
12. Nervous system uses nerve cells called neurons to send signals, or messages, all over the body. There are different types of neurons. Each type of neuron has a different function. Motor neurons take signals from brain and spinal cord to muscles. Sensory neurons take information from senses to the brain. Interneurons communicate between motor and sensory neurons.
13. A stimulus is defined as a chemical or physical change in the environment that triggers some sort of the behavioral change in a living organism.
14. A series of action potentials sweeping down an axon is a nerve impulse. A nerve impulse is generated by the flow of ions across the cell membrane. Therefore, a nerve impulse is an electrochemical reaction.
15. A nerve impulse is an electrical signal that travels along a nerve fiber to carry information through the nervous system.
16. A nerve impulse begins when a neuron receives a chemical stimulus.
17. The impulse travels down the axon membrane as an electrical action potential.
18. The impulse reaches the axon terminal, which releases neurotransmitters that carry the impulse to the next cell.
19. The impulse travels rapidly along the axon through a process of local depolarization and repolarization.
20. The impulse is received at synapses, which are junctions between neurons.
21. At the synapse, the neurotransmitters released by the presynaptic neuron can either excite or inhibit the postsynaptic neuron.
22. The impulse is formed by voltage-gated ion channels and ion pumps, which allow certain ions to pass through the cell membrane.
23. Neurons communicate with one another at junctions called synapses.

24. Neurotransmitters are the body's chemical messengers. They carry messages from one nerve cell across a space to the next nerve, muscle or gland cell.
25. A reflex act is a simple response which involves no conscious control. The path of an impulse in a reflex act is a reflex arc. A reflex arc involves receptors, sensory neurons, association neurons, motor neurons and effectors.
26. The endocrine system is a complex network of glands and organs. It uses hormones to control and coordinate the metabolism, energy level, reproduction, growth and development, and response to injury, stress, and mood.
27. The endocrine glands are: pituitary gland, thyroid gland, parathyroid glands, pancreas, adrenal glands, and gonads.
28. Pituitary gland is a small, pea-sized gland at the base of the brain below the hypothalamus. It releases eight hormones, some of which trigger other endocrine glands to release hormones.
29. Thyroid gland is a small, butterfly-shaped gland at the front of the neck under the skin. It releases hormones that help control metabolism.
30. Parathyroid glands are four pea-sized glands that are typically behind the thyroid. They release parathyroid hormone , which controls the level of calcium in the blood.
31. Adrenal glands are small, triangle-shaped glands on top of each of the two kidneys. They release several hormones that manage bodily processes, like metabolism, blood pressure and stress response.
32. Gonads are glands that produce hormones that are involved in reproduction and other functions of the body. Those hormones include estrogen, progesterone and testosterone.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

1. Reaction to any stimulus is called:

   A) receptor B) impulse C) responses D) effector

2. The unit of structure and function in the nervous system is:

   A) neuron B) muscle cell C) nephron D) cardiac cell

3. Thyroid gland has the ability to store:

   A) iodine B) chlorine C) fluorine D) zinc

4. Endocrine glands pour their secretion directly into:

   A) lymph B) blood C) organs D) muscles

5. Islet of Langerhans are parts of the:

   A) thyroid gland B) adrenal gland C) pancreas D) gonads

6. Nerve impulse is best described as:

   A) chemical B) electrical C) osmotic D) electrochemical

7. When a person is frightened, which substance increases the blood sugar level?

   A) adrenaline B) amylase C) glycogen D) insulin

8. Which part of the brain detects temperature changes in the blood?

A) cerebellum B) cerebral hemispheres C) hypothalamus D) medulla

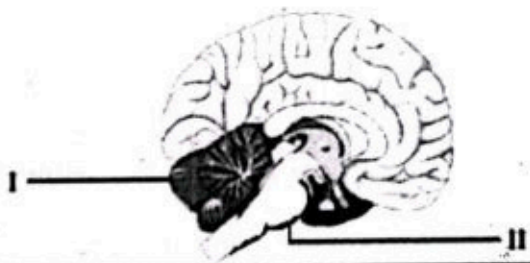
10. In contrast to nerve ls, the response produced by hormones takes longer because:

A) hormones are specific in their action.
B) hormones are transported through blood.
C) hormones are produced in small amounts.
D) the molecules of hormones are small in size.

11. Once released, neurotransmitter molecules typically produce signals in postsynaptic neurons by

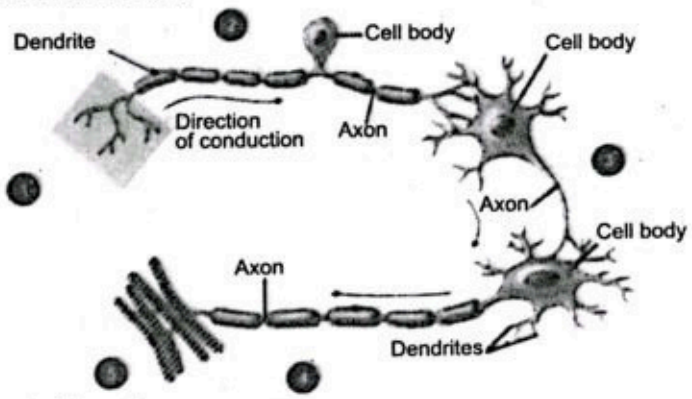
A) entering the postsynaptic neuron B) attaching to vesicles
C) binding to presynaptic receptors D) binding to postsynaptic receptors

12. The parts of brain represented by I and II are:



	I	II
A)	cerebellum	pons
B)	cerebrum	pons
C)	cerebellum	medulla oblongata
D)	cerebrum	medulla oblongata

13. The diagram shows Reflex arc.



The components of this reflex arc are:

	1	2	3	4	5
A)	Receptor	Sensory neuron	Motor neuron	Interneuron	Effector
B)	Sensory neuron	Motor neuron	Interneuron	Receptor	Effector
C)	Receptor	Effector	Sensory neuron	Interneuron	Motor neuron
D)	Receptor	Sensory neuron	Interneuron	Motor neuron	Effector

14. Four characters of a specific hormone are listed below

    i. Increased rate and intensity of heartbeat
    ii. Increased blood pressure
    iii. Decreased blood flow to skin & alimentary canal
    iv. Increased blood flow to limb

    Which is this hormone?

    A) adrenaline B) glucagon C) insulin D) testosterone

Section II: Short Answer Questions

1. What is nervous system?
2. What is the role of nervous system?
3. Differentiate between central nervous system and peripheral nervous system.
4. Name the parts of human brain.
5. Write two functions of cerebellum.
6. How are brain and spinal cord protected?
7. Describe peripheral nervous system.
8. What are the types of neuron? What are their functions?
9. Define stimulus with examples.
10. Define and sketch synapse.
11. How does an impulse cross a synapse?
12. What action or change do neurotransmitters transmit to the target cell?
13. What happens to neurotransmitters after they deliver their message?
14. How many different types of neurotransmitters are there?
15. What is a reflex action?
16. Name the endocrine glands of man.
17. Name the hormones secreted by each of the endocrine gland.
18. Differentiate between: cerebrum and cerebellum, sensory and motor neuron, voluntary and involuntary action, nerve impulse and hormonal transmission, endocrine glands and exocrine glands.

Section III: Extensive Answer Questions

1. Describe the nervous system and its role in human.
2. Draw a vertical section of human brain and label it. Write the functions of each part.
3. Draw, label cross section of human spinal cord and write its structure and function.
4. Outline the types of neuron with diagram.
5. Explain that nerve impulses are electrical that travel across neuron.
6. What are neurotransmitters?
7. Explain reflex action with diagram.
8. Identify the major endocrine hormones with their functions.