UNIT 23 MIND AND BODY

Structure

23.1 INTRODUCTION

Do you know that one of the most complex systems in the world lies within your own head? Over centuries, the brain has been compared to various man made machines. The most recent, of course, is the computer. Though the activities of the computer are fast, they are limited, in the sense that the computer works according to a programme given to it, by a human being. No machine can rival the brain, with its billions of nerve cells intricately connected so as to give it the ability to receive, store, recall and process information and to think new thoughts. Scientists are working very hard to create what may be called, intelligent computers, but that is another story.

If we look through the history of human civilisation, the mind and its mental processes have always been a fascinating and controversial subject among philosophers. Until fairly recently, we did not know or understand much about the nature of the mind or its relationship with bodify functions. There was controversy even regarding the relationship between the mind which was considered spiritual, and the brain, which was thought to be material.

In this Unit, we expose you to an elementary scientific description of the Mind-Body relationship and to a physical description of the human nervous system and its working. There is special emphasis on the brain which is the seat of all thoughts we think and our response to people, events and most importantly to ourselves. In addition, we will look at all the other parts of the nervous system that carry messages to, and from the brain and the spinal cord to the rest of the body.

Some other parts of our body that are important for understanding behaviour are certain glands that put out chemicals called hormones which play a part in regulating body function. What you study in this unit would provide a foundation for a further study in unit 24, of human behaviour and the development of the mind from infancy onwards.

Objectives

After studying this unit you should be able to :

- describe the structure and functions of a nerve cell,
- describe the general organisation and major parts of the human nervous system and its working,
- identify the parts of the brain and describe how human senses, reactions and bodily functions are associated with different parts of the brain,
- recognise and define a reflex reaction,
- realise that hormones and the nervous system work closely together to coordinate the internal functions of the body and also affect an individual's behaviour,
- realise that this is a vast subject and your knowledge is only rudimentary.

3.2 MIND-BODY QUESTION

ı the Vedic times, in India, philosophers held the belief that man consisted of *atma* (soul), *anas* (mind), *indriyan* (sense organs) and *sarira* (body). The *sarira* was taken to be the ase for the *indriyan* which were located in its various parts. *Manas* was one of the 11 gans thought to be present in the body and, it was considered to be the organ for memory, nowledge and feeling etc. The *atma* was capable of knowing, feeling and action but without the *manas*, *indriyan* and *sarira*, it could not function. In later times, Yoga and Tantra came to view the brain and the nerves as the organs of the soul. The mind, however, ıad always been regarded as of great importance and all activities such as hearing, seeing, esiring and believing were assigned to it.

ly the 19th century, scientific explanations for the functions of the body were available, sed on concrete observations and experiments. Mental processes were seen to be linked to ivity in the brain. It was recognised that the mind cannot exist without the body. Our rception about the world, its sights, sounds and smells is entirely determined by our ısory system, i.e., the eyes, ears, nose, skin etc., and the brain.

'ou can perhaps see that our description of ancient and philosophical views about the mind d mental processes is too brief to do justice to the philosophers. But our purpose is not to into details of what people have thought about mental processes in the course of ousands of years of human history. Our purpose is to give you, again briefly, what is cientifically known at present about the human mind and behaviour.

he entire functioning of the human body is coordinated by the nervous system which nsists of the **brain,** the **spinal cord** and the **peripheral nerves.** The working of the brain nained a mystery for a long time. Even today, there is a good deal we do not know about w the brain works, although a lot of information has been pieced together from observing haviour of patients that suffer from diseases related to tumours or other physical defects in brain. However, the properties of individual nerve cells that make up the brain and the of the nervous system are well understood now. From these properties we can attempt to ıain the operations of the entire nervous system.

...[illegible] for medical students to dissect cadavers. The internal systems of the human body thus became known.

23.3 FUNCTIONAL UNIT OF THE NERVOUS SYSTEM — NEURON

The human brain is composed of more than one hundred billion (100,000,000,000 or 10^{11}) cells called '**neurons**'. This number which is comparable to the number of stars in the Milky Way, gives us an idea about the size of the neurons also — because 10^{11} of them fit in a space which slightly more than a litre of water can occupy. Since these neurons are the functional units of the whole nervous system, let us become familiar with some of their basic features. You can see some typical neurons in Fig. 23.1.

Neurons can be categorised into the following kinds according to their functions :

a) Motor neurons	:	send signals from the nervous system to muscles and glands.
b) Sensory neurons	:	carry signals from the receptor cells in sense organs in the body to the nervous system. For example, signals generated by touch or smell or hearing etc.
c) Inter neurons or association neurons	:	process the sensory information received from other neurons, and convey messages. For example, when an insect bites, the fingers are given a command to scratch at that point. Most of the brain's neurons fall in this category.

The neurons are specialised to carry information from one part of the body to another. These messages are referred to as **nerve impulses**. The nerve impulse occurs in response to some stimulus or event which excites them.

Notice in Fig. 23.1 that in every neuron, the portion of the cell with the nucleus is called the **cell body**. The thread like extensions of the cell that brings information from other types of

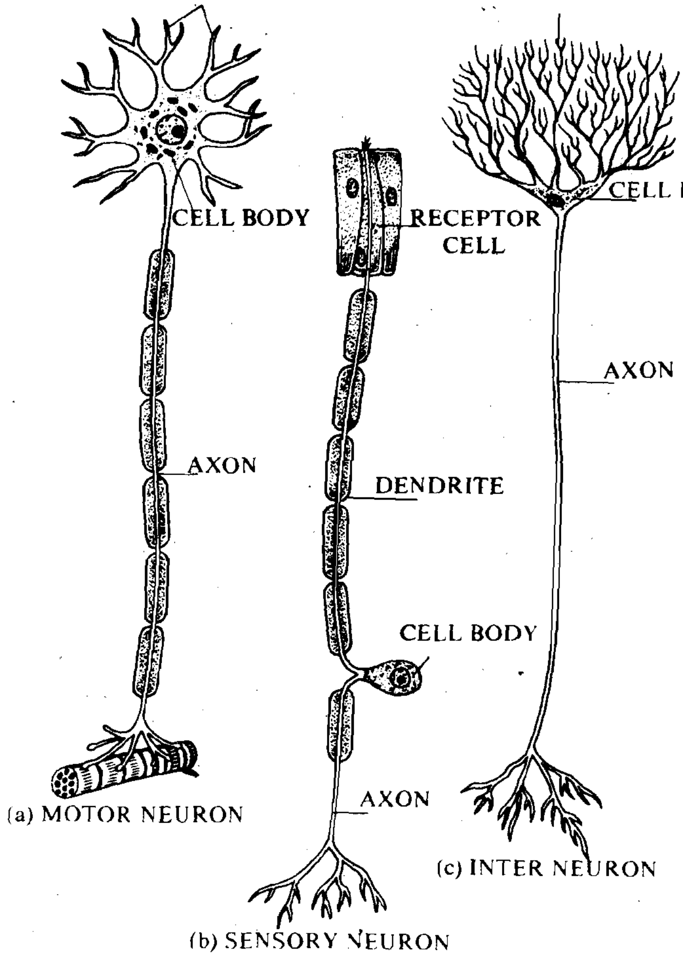

Fig. 23.1: Some typical neurons. Note the branched dendrites and long single axon that branches only at its tip. Although all neurons have the same three parts namely the cell body the axon and dendrites each is specialised according to its function. The specialisation is dependent on the location of the neuron in relation tothe central nervous system.

cells or external environment are called **dendrites**; while only one extension that takes messages from the cell body to other neurons, muscles or glands is called the **axon.** These extensions may be covered by a fatty sheath which helps in conduction of the messages, which are in the form of **electro-chemical codes** or **impulses**.

The axons of some neurons in the human body are a metre or more in length, for example, the one that goes from the spinal cord to the tip of the toe. Other axons may be less than a millimeter long. The axon divides into a number of small fibres that end in '**terminals**'. These terminals connect with other cells. This connection is in the form of a gap called the **synapse** (see Fig. 23.2). The synapse is a point where information jumps from the axon to another cell body or dendrite. Although the signals travel on the axon in the form of electrical impulses, this impulse is not strong enough to leap across the synapse. Therefore, a special chemical called **neurotransmitter** is released by the axon terminals. The molecules of this chemical combine with the target cells in a specific way just as a particular key fits a lock. This arrangement then either excites the target cells causing them to produce further signals or induces them to stop sending signals. The neurotransmitter is then broken down or reused by the cell that released it.

A neuron in the brain may be connected to several thousand other neurons through such synapses. Therefore if the human brain has 10^{11} cells then it has at least 10^{14} synapses. The diversity of interconnection in the brain seems limitless.

Fibres carrying messages are bundled together like wires in a cable and these are called **nerves**. Messages travel so fast in the system of nerves that a human being takes only a tenth of a second to react to an external event. If you are going on a bicycle and have to apply the breaks to avoid an accident, you will take a tenth of a second to do so. Speed limits for motor vehicles have something to do with this human limitation.

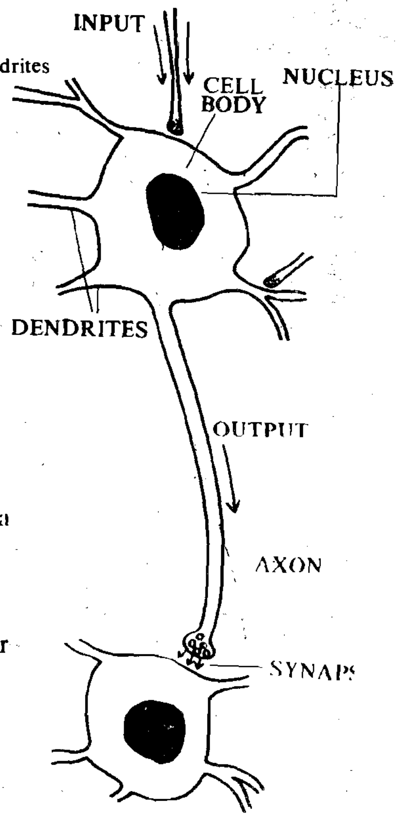

Fig. 23.2: Structure of a neuron showing synapse.

Insight

SAQ 1

Fill in the blanks with suitable words from those given below :

i) In a neuron, ... carries messages away from the cell body, while .... carries messages towards the cell body.

ii) The gap between the ends of an .... and the dendrite of the next cell is called a ....

iii) .... take messages from sense organs to central nervous system.

iv) .... take messages away from the central nervous systems to muscles and ....

v) Messages jumps from one nerve cell to another by means of ....

(glands, motor neurons, dendrite, synapse, sensory neurons, axon, neurotransmitters, axon)

You have studied the structure and functions of individual neurons. Let us now see how these are organised in highly characteristic ways to form the nervous system in the body.

23.4 CENTRAL NERVOUS SYSTEM (CNS)

The nervous system can be divided into two major components : the central nervous system (CNS for short) comprising the brain and the spinal cord, which you will be studying now and the peripheral nervous system (PNS for short) comprising individual nerves passing to all parts of the body. These you will study in Section 23.5. The general organisation of the nervous system can be seen in Fig. 23.3.

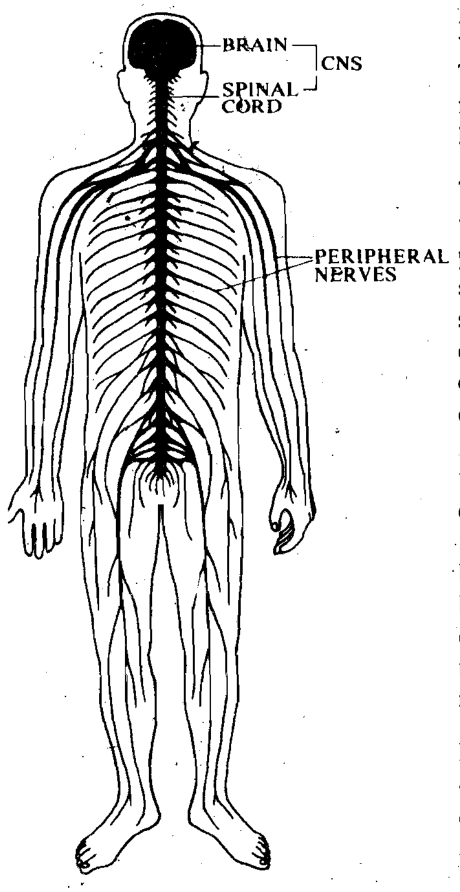

Fig. 23.3: Nervous system of man showing central nervous system and peripheral nerves.

23.4.1 Brain

The centre piece of the nervous system is the brain which is possibly the most organised form of matter known. It is unlike any other organ of the body, as it alone can receive, handle and analyse information and issue necessary commands.

The human brain containing billions of neurons with their axons and dendrites, is soft matter which has a folded appearance. Since the brain is a delicate organ, it is extremely well protected by three tough membranes and floats in a special fluid which helps to absorb shocks. The whole organ is then enclosed in a bony skull. (Fig. 23.4). The brain is very well supplied with oxygen, which is carried by blood. In fact, 75% of the body requirement of oxygen is used by the brain. Four inter-connected arteries carry blood to the brain so that even if two are blocked there are still two alternate passages. These four arteries are connected to millions of blood vessels called **capillaries** which reach every part of the brain. If the flow of blood is interrupted for even 10 seconds, we become unconscious and an interruption of a few minutes may cause permanent damage to the brain cells. These damaged brain cells cannot be replaced as the number of neurons in the brain does not increase after the age of five years. In fact, some neurons die every day. But, fortunately, we have them in such large numbers that it does not make too much of a difference. This slow but permanent loss of neurons is thought to be responsible for the loss of mental ability in old age. Because the loss of neurons is irreplaceable, diseases like poliomyelitis that destroy neurons, lead to muscular disability, called paralysis as muscles connected to the destroyed neurons do not receive any messages.

Even though the total number of neurons decrease, as one grows older, the number of connections amongst them in the brain increase. It is thought that learning involves the establishment of new connections or circuits in the brain and once they are established, they are relatively permanent. Persons with larger heads are not necessarily more intelligent, but persons with more and complex interconnections are.

Let us now have a brief overview of the major regions and structures of the brain. It would be best to read this section without trying to memorise all the new terms. You could refer back to them as needed. The major regions of the brain are shown in Fig. 23.4 and Fig. 23.5. These are **forebrain, midbrain** and **hindbrain**. The forebrain itself has many parts which we will now describe.

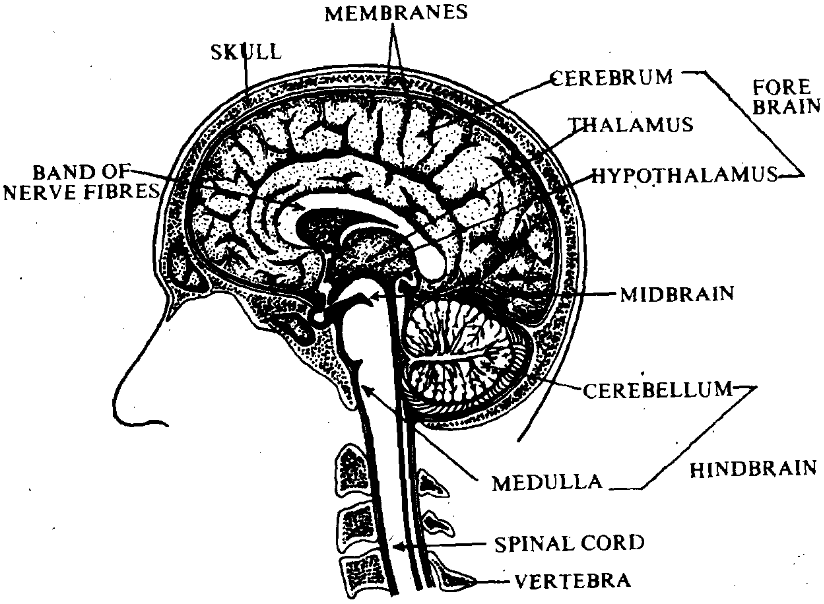

Fig. 23.4: The human brain cut in the medial plane showing its major divisions, encased in the bony cranium and the spinal cord encased in the vertebral column.

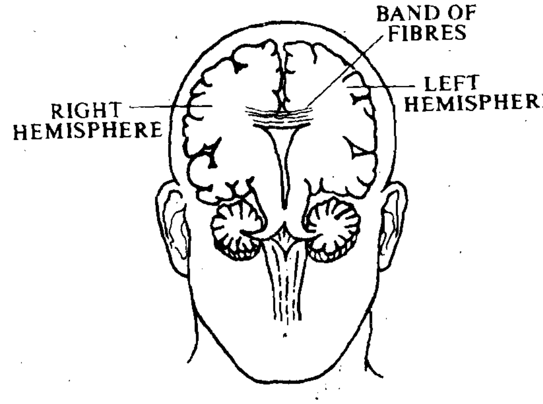

Fig. 23.5: Frontal view of brain showing the band of nerve fibres connecting the two cerebral hemispheres.

Forebrain

The largest part of the brain that you see in Fig. 23.4 is the **cerebrum.** It consists of two halves or hemispheres joined together by a band of nerve fibres (see Fig. 23.5). Interestingly the crossing over of nerve fibres here causes the right half to control the actions of the left side of the body and vice versa. The outer surface of the cerebrum is the **cerebral cortex.** It is often referred to as the 'grey matter' because of its colour. It is profusely supplied with blood vessels.

The cortex was explored in a very fascinating way, particularly by a Canadian neuro-surgeon, Wilder Penfield. Since 1900's it was known that the brain contained no pain ceptors and hence it could be operated upon, without making the person unconscious. ith local anesthesia, the top of the skull could be removed like a cap to expose the cortex. Penfield did exactly this and he stimulated different parts of the cortex, one by one, by uching them with an electric wire or probe. He was amazed to observe the reactions of the atients. On touching one part of the cortex with the probe, the patients could see, hear or nell or feel! Patients could revive old memories. Some reported hearing the sound of a articular song; one woman felt as if her daughter was in the room talking to her; another erson could actually recollect the smell of flowers! Stimulation of other regions caused **notor responses** such as the movement of an arm or leg.

In Fig. 23.6, you see a sideview of the cerebral cortex where some functions associated with specific portions have been shown.

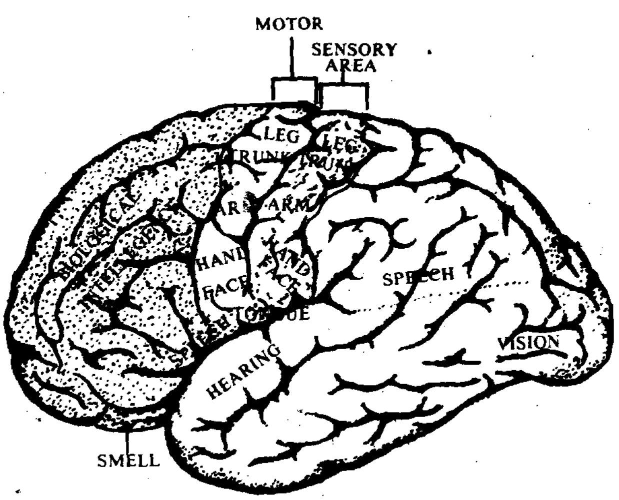

Fig. 23.6: Sideview of human cerebral cortex showing functions assigned to several areas.

An interesting feature of the brain is a kind of division of labour among the two [illegible] of the cortex. The left half of our brain deals with information logically and is [illegible] for linguistic ability, mathematical and scientific problem solving skills, while [illegible] is responsible for artistic, musical, perceptual and intuitive abilities (see Fig. [illegible]). Generally analytical processes are associated [illegible] h the left and the synthesizing [illegible] with the right hemispheres. In science both aspects are involved, so both [illegible] role. In executing a piece of art, the left has to be involved for detailed work [illegible] overall view and appreciation. So this division of labour is not rigid. Now it [illegible] that the right and left half of the brain play a complementary role in language, [illegible] etc

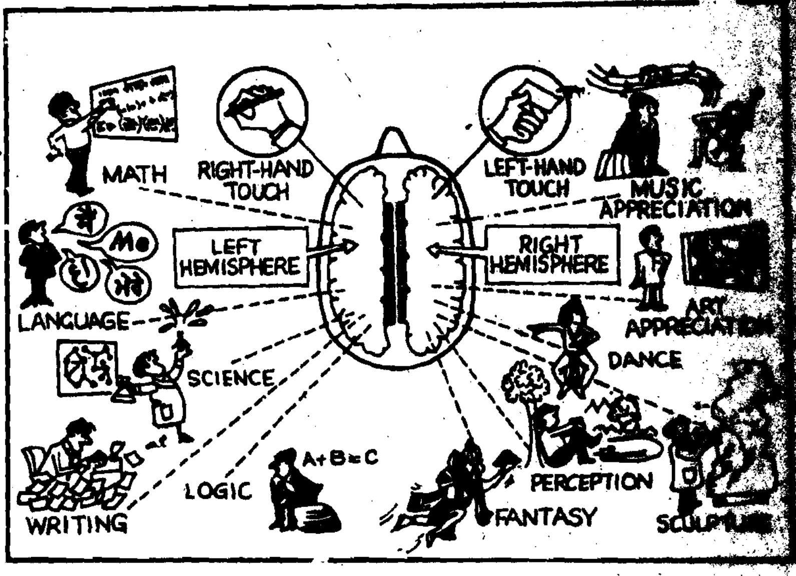

Fig. 23.7: Division of labour in the brain.

Among other parts shown in Fig. 23.4 you will notice the thalamus which is a [illegible] for sensory signals on their way to the cerebral cortex and also for signals [illegible] it. The part below it called the **hypothalamus**, ensures that all the [illegible] various functions of the body are in balance and all bodily processes function [illegible] optimum. For example, it continuously monitors the blood. If there is too little [illegible] of carbon dioxide present in the blood, the hypothalamus reduces or increases [illegible] rate. If your body temperature rises, it causes sweating to occur. It controls [illegible] and also plays a major role in the control of sleep, sexual behaviour and emotions.

Midbrain

The midbrain is a small but important part of the brain. It receives inputs from [illegible] organs, every part of the body and filters sensory information or decides which [illegible] should reach the concerned regions of the brain. The midbrain plays a role in [illegible] and damage to it results in coma or permanent sleep.

Hindbrain

The hindbrain consists of the **cerebellum** and **brain stem** (refer Fig. 23.4). The [illegible] like the cerebrum is divided into two halves and lies underneath the back of the [illegible] is primarily concerned with coordination of movements. It receives and integrates information from all senses and regulates all muscles so as to produce fine [illegible] movements rather than jerky uncoordinated ones. Another function of the cerebellum involves the maintenance of balance. Impulses from the eyes and ears inform the [illegible] of your position in your surroundings. The cerebellum then sends messages to [illegible] are responsible for your posture to maintain balance. You may not even be aware of [illegible] cerebellum's functions, as none of the activities it controls are voluntary. The [illegible] portion of the brain that connects it to the spinal cord. The lower part called the [illegible] helps regulate respiration, blood pressure, vomitting and other involuntary [illegible] damage to the medulla could easily lead to death.

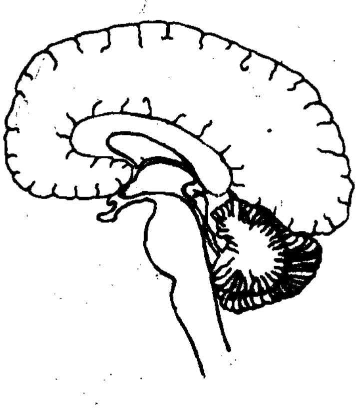

Fig. 23.8

SAQ [illegible]

In t[illegible] outline of the sideview of the human head (Fig. 23.8): show [illegible] cerebrum, cerebellum, thalamus, hypothalamus and midbrain are situated. [illegible] one function of each of the above stated parts of the brain.

....

....

....

....

23.4.2 Spinal Cord

The spinal cord extends downwards from the brain stem through the protecting bony rings called vertebrae down the centre of the backbone, to the bottom of the back. Its core is H-shaped in cross section (Fig. 23.9) and is composed of several kinds of neurons. The surrounding matter is mostly long cables of axon fibres. The cord, too, is covered like the brain with three membranes and contains fluid between the membranes.

There are 31 pairs of spinal nerves, that branch off from the spinal cord throughout its length, between the bones of the spine. These nerves carry sensory signals upto the brain and motor signals down from the brain to various parts of the body.

23.5 PERIPHERAL NERVOUS SYSTEM (PNS)

Except for the brain and the spinal cord, the rest of the network of nerves and neurons is included in the peripheral nervous system, or **PNS** for short. This system links the brain and spinal cord to the rest of the body. Any message that is sent to the brain or from it to the rest of body, travels along the **peripheral nerves.** The PNS consists of 12 pairs of individual nerves called **cranial nerves,** originating from the brain hence called cranical nerves (from cranium, the skull) and the 31 pairs of spinal nerves that branch off from the spinal cord. Each spinal nerve splits into three components soon after leaving the spinal cord. One branch passes to the skin and muscles of the front of the body; a second branch leads to the skin and muscles of the back; the third branch reaches the internal organs.

The first two branches carry sensory information to the brain, and carry motor signals from the brain to the muscles and glands. The third branch forms the "**autonomic system**" which governs actions of the internal organs that are mostly involuntary. If you look at Fig. 23.3 again, you would be able to appreciate the vast network of nerves that make up the peripheral nervous system.

23.5.1 Reflexes

It is of interest to know, that all sensory information does not have to go to the brain before we can react to a stimulus. Our responses to certain stimuli are simple, unvaried and quick. For instance, if a finger is too close to a burning match, **receptor cells** on the skin send the information on a nerve to the spinal cord, and a '**reflex action**' is taken to move the finger away from the fire. Such '**reflex circuits**' are well distributed and one is shown in Fig. 23.9.

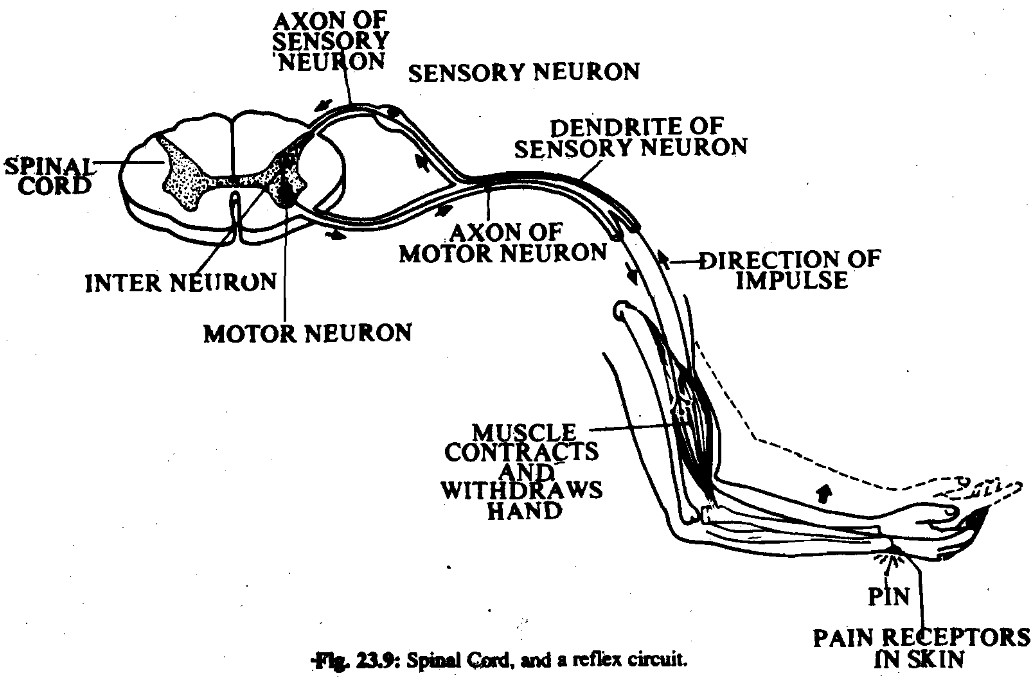

Fig. 23.9: Spinal Cord, and a reflex circuit.

Now let us see what happens when a pin pricks the finger.

1 The pin prick is the stimulus which activates a receptor cell at that point.

2 A nerve impulse is transmitted away from the skin along a sensory neuron to the spinal cord.

3 The impulse is now passed through the inter neuron to the motor neuron and finally passes to the muscle which pulls the hand back from the painful event.

The brain is not normally involved in such simple reflex actions. Only after the event, is the brain informed and we become conscious of what has happened. The time gap between the stimulus and the response is about 1/15th of a second and this is often crucial for survival. For instance, a person who is driving a car has to apply his brakes to avoid a sudden collision with another car. His reflex action timing is important if he has to avoid the accident. Similarly, the reflexes of an airplane pilot have to be fast to avoid disaster. Human capacity to handle equipment and machines is limited by the time taken by one's reflexes.

Part of a routine physical examination involves testing a person's reflexes. The condition of the nervous system, particularly the functioning of the synapses, may be determined by examining reflexes. In case of injury to some portion of the nervous system, testing certain reflexes may indicate the location and extent of the injury. Also, an anesthesiologist may try to initiate a reflex to ascertain the effect of an anesthetic.

Simple reflexes have these important qualities:

- they are inherited and not learnt. Therefore, not forgotten,
- they are not normally under our control, therefore, they are automatic, though some reflexes can be controlled by will power,
- for any given stimulus the response is always the same.

SAQ 3

Put the following in correct order for a simple reflex circuit. Indicate this order by putting 1 2,... etc., in the boxes given against each statement. We have done one for you as an example.

a) message travels through motor neuron ☐

b) message travels through sensory neuron ☐

c) muscle is stimulated to contract ☐

d) receptor cell or organ is stimulated $\boxed{1}$

e) message travels through inter neuron ☐

23.5.2 Autonomic System

The autonomic nervous system gets its name from the fact that it relates to autonomous or self-regulatory activities such as digestion and circulation, which continue even when we are asleep or unconscious. Impulses from the brain and spinal cord travelling along the **autonomic nerves**, cause blood vessels to dilate or contract, digestion to slow or speed up, body temperature to rise or fall, all according to the changing requirements. The autonomic system consists of two sets of nerves:

- The **sympathetic nerves** which stimulate the body to react in a situation of stress or danger by increasing the blood pressure, heart beat rate, breathing and flow of blood to the muscles, and by decreasing the flow of blood to the digestive organs and kidneys. All these reactions are a preparation for a sudden expenditure of energy in either fighting or fleeing.

- The **parasympathetic nerves** which prepare the body for relaxed functions. The autonomic nervous system does, however, interact with conscious nervous activity. For example, it is well known that anxiety and mental tension can affect digestion, they even cause peptic ulcers or high blood pressure. A child's dislike for school may make him sick every morning, without his being conscious of the connection. Under certain conditions, with lot of practice, some people have found it possible to consciously control heart beat, or blood pressure, or body temperature or breathing rate and oxygen intake; others may regulate the feeling of pain or even correct malfunction of an organ. But these are extraordinary and exceptional abilities developed with tremendous expenditure of time and effort.

SAQ 4

Tick mark the correct statements.

The autonomic nervous system:

i) interacts with conscious nervous activity to affect the body functions

ii) controls activities that are voluntary

iii) controls activities that are involuntary and self- regulatory

iv) activates the body in a situation of stress

v) all of the above.

23.6 HORMONAL SYSTEM

Most of us are not even aware that another system works constantly, along with the nervous system and the muscles, to direct our bodily functions. The system depends on chemical substances called **hormones** that are released by special glands called **endocrine glands.** These glands have no opening or ducts but release their secretions directly into the blood stream as it passes through their tissues. You can see their location in the body in Fig. 23.10

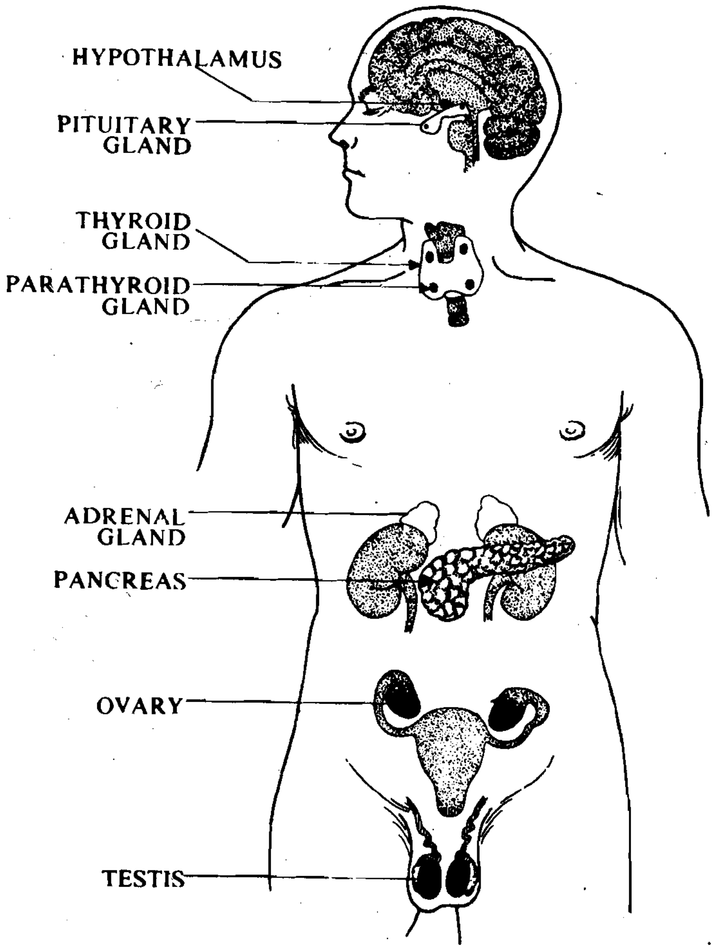

Fig. 23.10: Location of some endocrine glands. The figure shows both ovaries and testes for convenience.

Each hormone acts on a certain organ in a specific way. Many of the effects of hormones are long term changes, for example, the changes that take place in the body during growth and sexual maturity. However, some of the changes may be quick like the ones that occur when the heart rate and breathing rate is increased or decreased.

A list of some of the major endocrine glands along with the hormones they secrete is given in Table 23.1. You are not expected to remember each of them. The information is provided, in case, you are curious to know more about these glands.

You can see that these hormones are vital for the proper functioning of the body. They regulate the chemical reactions in the body and consequently play a critical role in maintaining normal physical conditions or homeostasis. If hormones are to serve a regulatory function, they must be produced at the proper time, in proper amounts. This is controlled by the brain, receiving information from all parts of the body and giving appropriate signals to the glands. This feedback system is very much like a thermostat that controls temperature in a machine. Any break in this feedback system leads to severe consequences. For example, the thyroid gland produces thyroxine which controls the metabolic rate in the body. Oversecretion tends to make a person thin, overactive and anxious while undersecretion makes him over-weight and sluggish. Thyroxine deficiency, in fact, causes mental as well as physical retardation which can be prevented if the deficiency is discovered sufficiently early and the right amount of the hormone is given.

The hormones work in close coordination with our nervous system. For example, in a situation of danger or fear, the sense organs convey the information to the central nervous system and the autonomic system is activated within seconds. The adrenal glands are also activated to release a hormone called adrenaline. When adrenaline reaches the alimentary canal and the skin, their blood vessels contract, diverting the blood supply to the muscles; the pupils of the eyes are dilated and glucose is released in the blood to speed up the rate of breathing. All these changes help a person who requires increased activity such as running away or fighting. You would be able to identify all these actions with those initiated by the autonomic nervous system that you have studied in sub-section 23.5.2.

Table 23.1

Some major Endocrine Glands and their Functions

Glands	Hormones	Functions
Hypothalamus	Group of releasing or inhibiting factors	Stimulates or inhibits pituitary
Pituitary	Antidiuretic (ADH)	Inhibits urine production
	Oxytocin	Causes utrine contractions in delivery and production of milk
	Growth hormone	Causes growth of bones, muscles and glands
	Adrenocorticotropic hormone (ACTH)	Regulates adrenal gland
	Thyroid stimulating hormone (TSH)	Stimulates thyroid
	Gonadotrophines	Stimulates ovaries or testes
Parathyroid	Parathormone	Increases blood calcium level
Thyroid	Thyroxine	Increases metabolic rate
	Calcitonin	Lowers blood calcium level
Adrenal medulla	Adrenalin	Increases heart and respiration rates, blood sugar level etc.
	Noradrenalin	Raises blood pressure, acts as neurotransmitter
Adrenal cortex	Group of hormones	Affects sugar and salt metabolism and response to stress.
	Sex hormones	Early development of sex organs
Pancreas	Insulin	Enables body to metabolise sugars, regulates storage of fats
	Glucagon	Increases level of sugar in blood
Ovaries	Estrogen	Regulates functions of uterus, promotes secondary sexual characters
	Progesterone	Promotes growth of female reproductive tissue, maintains pregnancy
Testes	Testosterone	Promotes growth of male sex characteristics

Nervous control evokes these reactions very rapidly in the time of danger; hormones provide a backup that maintains the response after the initial shock is over. This explains the state of 'nervous energy' that remains even after the final exam or a performance is over.

Often we see that in combination with the nervous system, hormones can change the behaviour of a person. Some of the abnormal behaviours shown by an individual may well be due to over or under secretion of certain hormones. Today, the science of biochemistry has made it possible to synthesise hormones, which can be administered to the body by means of injections or given orally, if the glands are unable to produce the right amount needed at different times. The most common example is that of insulin, which has made diabetic people live a longer and normal life.

SAQ 5

Tick mark the correct alternative from the words given in each parenthesis.

i) The effect of hormones is (slower/faster) than nervous action.

ii) Hormones are (vital/unimportant) for the proper functioning of our body.

iii) Hormones (cannot/can) be supplemented externally if the body is not able to produce them in adequate amounts.

[illegible] SUMMARY

[illegible] you have learnt that :

- [illegible] the functional unit of the nervous system. It receives signals in the form of [illegible] impulses through the dendrites and sends impulses via the axons. Impulses are [illegible] across the synapse by means of special chemicals which may be called [illegible]. Billions of neural inter-connection in the brain allow complicated [illegible] produce learning, memory and intelligence.
- [illegible] system is divided into the Central Nervous System, consisting of the brain [illegible] cord; and the Peripheral Nervous System, consisting of all the nerves in the [illegible] structure and functions of the nervous system are summarised in the table [illegible].

The Human Nervous System

[illegible]	Functions
[illegible]	
[illegible]	Centre of thought, memory, intelligence, initiates voluntary actions; interprets sensations; controls emotions.
[illegible]	Associated with forebrain and hindbrain, receives and filters sensory information before sending it to the forebrain.
[illegible]	Relays messages between brain and spinal cord, controls involuntary functions like respiration. Coordinates equilibrium and movement.
[illegible]	Carries information between brain and peripheral nervous system. Part of reflex circuits.
[illegible]	Take messages from sense organs to CNS. Voluntary control of muscles.
[illegible]	Involuntary control of internal organs. Respond to emergencies, increase heart rate, d[illegible]e pupils, increase blood pressure etc.

- [illegible] is an automatic nervous reaction that does not involve the brain. The simplest [illegible] involves a sensory neuron, an inter neuron and a motor neuron connected [illegible] in the spinal cord.
- [illegible] nervous system is a highly integrated system capable of coordinating and [illegible] many nerve impulses to achieve an enormous range and choice of responses.
- [illegible] glands and the hormones secreted by them are vital for the normal [illegible] and mental existence and growth of an individual. Some of these hormones work [illegible] coordination with the nervous system to affect behaviour.

[illegible] TERMINAL QUESTIONS

[illegible] at Figure 23.9 and answer the following questions:

[illegible] many cell bodies are drawn? Name them.

....

....

....

....

[illegible] many synapses are shown?

....

....

2 People who suffer damage to the cerebral hemisphere are mentally impaired but alive, people who suffer damage to the brain stem, especially medulla, almost always die within a short time. What aspect of brain functioning do you think accounts for this difference?

....

....

....

....

....

3 Keeping in mind the properties of simple reflexes, explain briefly whether coughing is a reflex or voluntary action.

....

....

....

....

....

4 Describe briefly the differences between coordination by hormones and coordination by the nervous system. You should write your answers keeping in mind:

a) The route of conduction of messages,

b) The speed of conduction, and

c) The speed and duration of response.

....

....

....

....

....

....

....

....

5 Tick the correct statements in the boxes provided alongside the statements.

i) The right half of the cerebral cortex controls the left side of the body and vice versa. ☐

ii) Only the left hemisphere of the cerebral cortex is specialised for language. ☐

iii) Motor areas of the brain control the voluntary muscle activity. ☐

iv) The central nervous system consists of the brain and spinal cord. ☐

v) The millions of possible inter-connections between the nerve cells in the brain are responsible for complicated actions, learning, memory and intelligence. ☐

vi) Hormones secreted by endocrine glands work as a separate system of coordination. ☐

23.9 ANSWERS

Self-Assessment Questions

1) i) axon, dendrite
   ii) axon, synapse
   iii) sensory neurons
   iv) motor neurons, glands
   v) neurotransmitters

2) Compare the labelling with Fig. 23.4.

Cerebrum	—	thinking, speech, taste and other complex responses
Cerebellum	—	coordination of movements; maintains balance of body
Thalamus	—	relay centre for incoming sensory messages to the cortex
Hypothalamus	—	controls thirst, hunger etc., maintains homeostasis
Midbrain	—	decides which stimuli should reach the concerned parts of the brain.

3) a) — 4
b) — 2
c) — 5
d) — 1
e) — 3

4) Correct statements are (i), (iii) and (iv).

5) a) slower
b) vital
c) can

Terminal Questions

1) a) 4 cell bodies
i) of pain receptor cell
ii) of sensory neuron
iii) inter neuron
iv) motor neuron

b) 4 synapses
i) between pain receptor and dendrite of sensory neuron
ii) between axon of sensory neuron and cell body of inter neuron
iii) between axon of inter neuron and cell body of motor neuron
iv) between axon of motor neuron and muscle cell

2) Damage to cerebral hemisphere affects voluntary actions, while damage to medulla disrupts body functions that are vital to life like heart beat, breathing, blood pressure. These functions are involuntary and must go on if life has to be sustained.

3) It can be both. You can cough deliberately but normally it is a reflex action.
i) because it is an involuntary response when the throat is irritated or if food accidentally goes into the windpipe.
ii) The response to such situations is always the same. One does not forget them.

4) a) messages travel along nerves and nerve fibres while hormones are secreted directly into the blood which takes them to the target organ.
b) Messages are conducted much faster by nervous system within a second while action of hormones is slower-from a few minutes to days.
c) The response for nervous impulses is immediate while for hormones, the response may be over years.

5) True statements are: (i), (iii), (iv) and (v).