3

BIOLOGICAL BASES OF BEHAVIOUR

3.1 Introduction

We often wonder how do we behave in a wide variety of ways. Sometimes we feel happy; sometimes sad. Sometimes we take long time to act, whereas there are moments when we act very quickly. Earlier, it was believed that there is some inner spirit in all of us that controls our behaviour. Today, we know that our actions and bodily movements are controlled by our nervous system. Even awareness and understanding of ourselves and environment is done by our nervous system. In a way, our nervous system acts like an engine in the automobile that controls every movement and speed of the vehicle. Similarly all our actions and movements are controlled by our nervous system.

3.2 Objectives

After reading this lesson you will be able to :

- describe the cell as a unit of life;
- describe the structure and functions of a neuron;
- describe nervous system : the parts (central and peripheral nervous system), structure, and functions;
- describe specific areas of the brain and their related control of behaviour;
- describe endocrine glands and their functions;
- describe transmission of hereditary characteristics.

3.3 The cell as the basic unit of life

Have you seen a brick and then a building in the process of its construction ? The architect designs and the mason keeping brick by brick, the building comes into existence. In the same way, our body is also made up of cells. As the brick is the smallest unit in a building so is a cell—the small unit in a human body.

Each living being whether it be a plant, animal or human being, is made up of these small units, called cells. There are certain differences between the cells of different living beings as well as the cells in the different parts of the living organism. All cells contain a fluid called **cytoplasm and a nucleus, and** are enclosed in a cell membrane. Operations within the cells and the co-ordination among various cells make the being live. The life of all the living beings is, therefore, based upon the working of the cells.

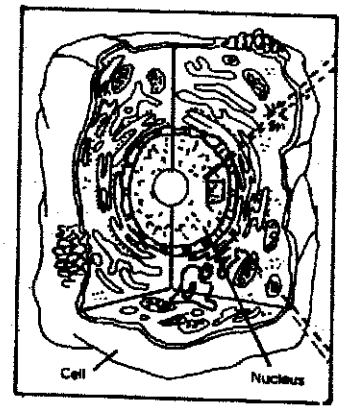

Fig. 3.1 The Cell

> The cells are thus, called the smallest unit of life.

Intext Questions 3.1

1. Fill in the blanks with appropriate word(s)

   (a) The cell contains cytoplasm and a nucleus enclosed in a cell____.

   (b) The cell is called _____of life.

   (c) The life is based upon the working of the _____.

3.4 The Neuron

The cells that compose the nervous system (central nervous system-CNS-, peripheral nervous system, somatic and autonomic nervous system) are known as *neurons* and *glia*. Only the neurons or nerve cells transmit information (impulses) from one location to another. Appreciating a sunset, enjoying the music, thinking of some loved one at distant place or solving a problem- all these acts reflect the co-ordinated actions of thousands or millions of neurons. These nerve cells collect information from the environment by means of

receptors and then combine the information as well as make the action. The neurons also store information in terms of memory and generate our behaviour

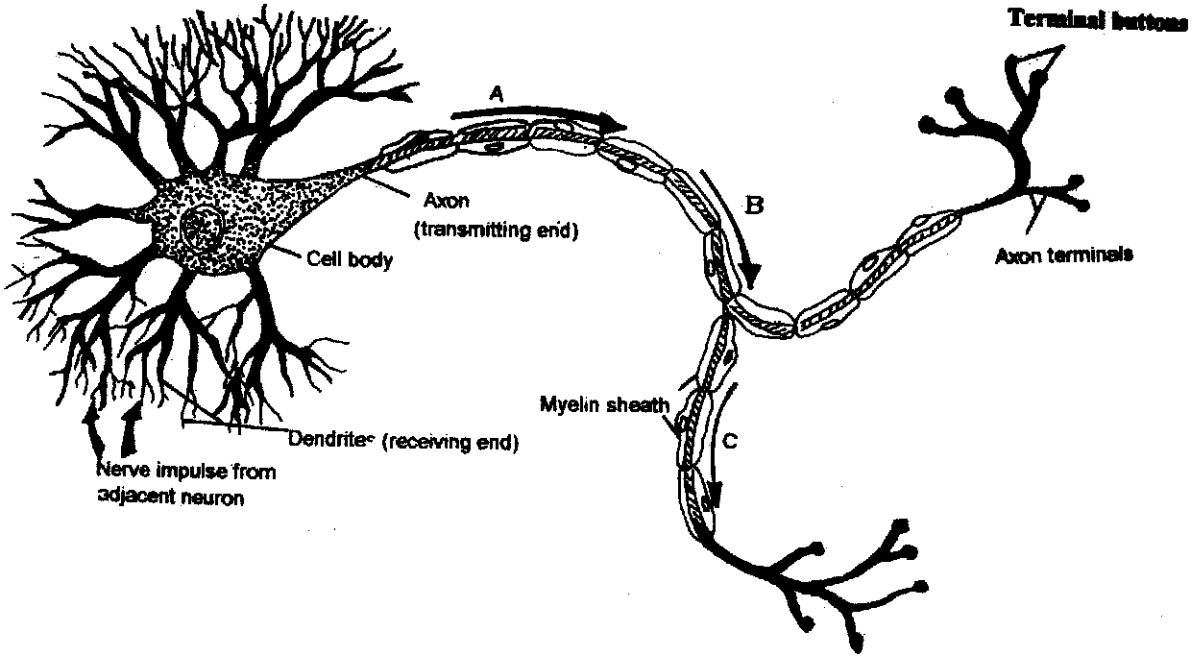

Fig. 3.2 Structure of a Neuron

Neurons make up half of the voulme of the brain . Glial cells are the other half of the nervous system. Neurons in the central nervous system are of various shapes and sizes, but most neurons may have features in common. There are three main structures of the neurons. They are the cell body (soma), the dendrites, and the axons.

(1) The **soma**, or the cell body, is the largest part of the neuron. It regulates and controls the metabolism and maintenance of the entire cell. The soma also receives impulses from other neurons. The cell body contains the nucleus that manufactures the chemicals used to transmit signals.

(2) The **dendrites**, are the branches that extend from the cell body and spread out in complex ways. The neurons receive much of their information through dendrites via synaptic connection from other neurons. The cell sending information releases a chemical that influences the activity of the receiving cell. Information passes from synaptic terminal to the dendrites or cell body, but does not go the other way.

(3) The **axon** is a long fibre that leads away from the cell body. The axons send signals to the dendrites of the other neurons or to muscles and glands. The axons make the neural pathways in the central nervous system. The axons are insulated by myelin sheath. Myelin sheath is made up of glial cells.

The nerve impulse

An information is carried through a series of electrical impulses that travel from one neuron to another. These are called nerve impulses. These impulses are sent to the specific areas of the brain where sensations take place. The axons or nerve fibres do not carry sensations like pain or cold. These sensations occur only when the information reaches the brain.

Synapse

The regions where impulses cross from one neuron to the other are called synapses. The synapses are thus junctions between the neurons. Through the gap at synapse (synaptic cleft) signals are transmitted from one neuron to another. The sending side of synapses is axon terminals whereas the receiving side of synapses is the tips of the branching dendrites. The chemical substances that facilitate the transmission of the signals are called neurotransmitters.

3.5 Types of Neurons

Depending upon the functions, the two major types of neurons are receptor and motor neurons.

(a) Receptor neurons

Receptor neurons bring information into the nervous system. Such information is brought through senses. You will learn more about the senses in the lesson on the "sensory processes". The major senses are, vision, hearing, touch, taste, and smell. The receptors are also classified in terms the specialised message from the different sense organs.

(b) Motor neurons

The motor neurons carry out the orders of our brain for muscular movements such as chewing, walking, writing and so on which are under our conscious control. The reflex actions are mediated by the spinal cord. Breathing, eye blinking and yawning are involuntary actions. These involuntary actions are controlled by the motor neurons.

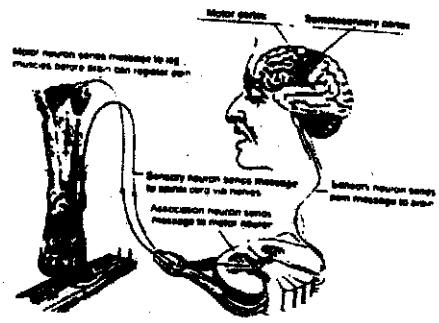

Fig. 3.3 Reflex Activity

Try this yourself

You can initiate an eyeblink reflex in a friend. For that you need orange peels . Hold the peel at about five or six inches from his/her eye and squeeze it into the eye. Your friend will exhibit as in voluntary reflexive blink of the eye.

Intext Questions 3.2

1. State whether the following statements are true or false

   (i) Only the neurons transmit information from one location to another. True/False

   (ii) Nerve cells collect information from environment by means of receptors. True/False

   (iii) Neurons do not store information. True/False

2. Fill in the blanks with appropriate words.

   (i) Neurons make up _____of the volume of the brain.

   (ii) The main structure of the neuron are _____, _____and _____.

   (iii) Neurons are of_____types. They are_____ and_____

3.5 Nervous System

The nervous system is made up of billions of neurons. This system is responsible for receiving, processing and sending of information. All the functions of the body are controlled by the nervous system. Nervous system consists of the central and the peripheral nervous systems.

The central nervous system consits of the *brain* and the *spinal cord*. The spinal cord is the narrow column that starts at the base of the back and extends up through the neck and into the base of the skull. The brain is surrounded by the protective skull. The central nervous system is responsible for sending nerve impulses and receiving the sensory information.

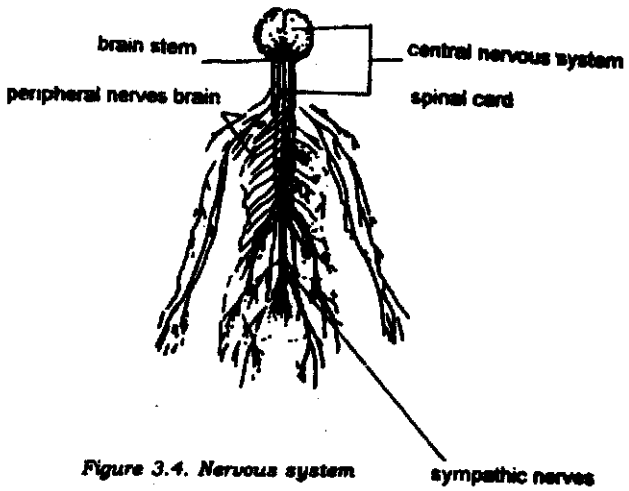

Figure 3.4. Nervous system

The peripheral nervous system consists of the group of neurons which transmit information between the central nervous system and the rest of the body. The peripheral nervous system is responsible for carrying nerve impulses to and from the body. The peripheral nervous system is further divided into two parts,

- *Somatic system* and
- *Autonomic system.*

The nerves in the **somatic system** connects the brain and spinal cord with voluntary muscles of the body. The somatic nervous system senses and acts upon the external world. It consists of both sensory and motor neurons. Sensory neurons transmit incoming signals to the central nervous system. These signals originate in the receptor cells, and are located in the sense organs such as eyes and ears. Motor neurons, whose cell bodies lie inside the spinal cord, transmit outgoing signals from the spinal cord. The somatic nervous system controls the skeletal muscles that help the movement of the body.

The neurons in the **autonomic nervous system** control the involuntary actions in the body such as the heart, stomach and liver. The autonomic nervous system is composed of the sympathetic and parasympathetic systems.

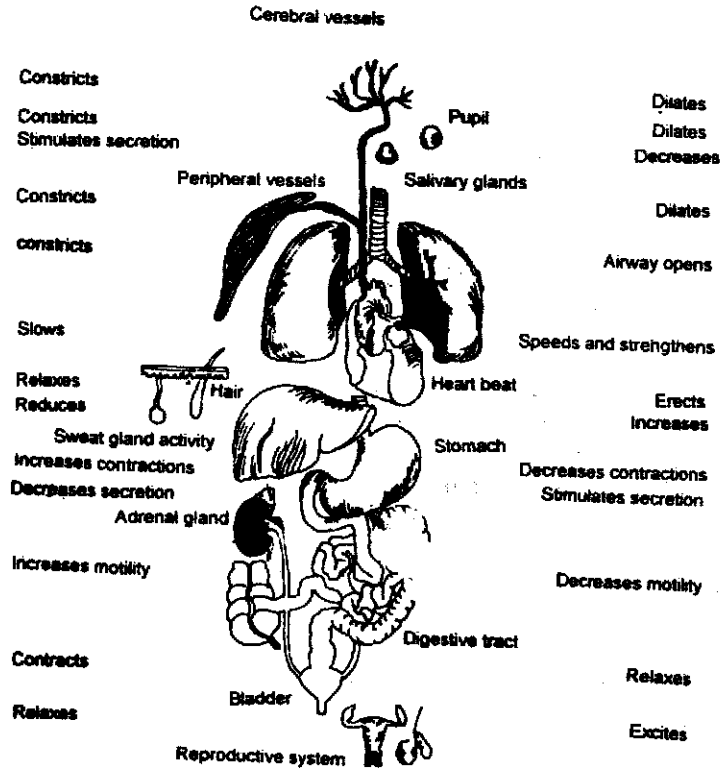

Figure 3.5. The Autonomic Nervous System

The **sympathetic nervous system** dominates in emergencies and in stressful situations. This system controls our emotions. It responds by increasing blood sugar level, heart rate, and blood pressure and slows the process of digestion. These changes enable us to cope with stressful situations. The **parasympathetic nervous system** dominates the activities in the relaxed situations. However, the two systems work together in many actions.

Intext Questions 3.3

Fill in the blanks with appropriate words :

(1) The nervous system is responsible for _____,_____and____ of information.

(2) The central nervous system consists of the _____and_____.

(3) The peripheral nervous system carries the _____to and from the body.

(4) The somatic system connects the _____and the _____.

(5) The autonomic nervous system consists of _____and ___.___ systems.

3.6 The Central Nervous System

The central nervous system consists of the brain and the spinal cord. You have learned that neurons in spinal cord can produce reflex actions. Other than such a reflex action, the spinal cord acts as a relay station. It sends information from sensory neurons in the body to the brain and it takes motor command back to the muscle. The severe injury in the spinal cord usually results in loss of sensations and paralysis at levels below the point of injury. It has two major components,

* Gray matter and

* White matter

The gray matter found near the center of the spinal cord processes the information and the white matter found in the outer layers which contains axons, transmit information to and fro from the brain.

If tea is brought to you in steel glass and you suddenly try to pick it up, do you realize how hot your fingers feel ?

The process which takes place is that the heat receptors in our skin are being stimulated and are firing nerve impulses. This incoming information from the receptors in our hand travels through neurons to our spinal cord where it enters the gray matter in the center of the cord. It travels in the white matter to your brain. The

brain analyzes this sensory information and initiates a voluntary movement in a response such as dropping the glass.

2. The brain

If you would like to get a feel for the physical structure of your brain you might try this stand infront of the mirror and draw an imaginary line across the front of your face running from left ear through both your eyebrows to your right ear.The bulk of your brain is located above this line.

Fig. 3.6 Mirror Figure of a boy with the imaginary line of the brain

The brain is the primary component of the nervous system, occupying the cranial cavity.It is surrounded by the skull for protection. The brain weighs an average of three pounds (about 1.4 kilograms). It comprises about 97% of the entire central nervous system. The brain is connected to the upper end of the spinal cord. The brain is divided into three parts: the cerebrum,

Do you know that

Our brain appears something like a walnut.

Our brains contains at least 15 billion nerve cells (neurons).

The cortex contains the "decision making centers" that influence what we do feel and think ?

The major psychological function of our brain is to process information.

the cerebellum, and

the brainstem leading to the spinal cord. The brainstem is also divided into the medulla oblongata, the midbrain, and the pons.

(a) Cerebral cortex and control of behaviour

The uppermost layer of the brain is called cerebral cortex (see Figure 3.7).The brain is divided into two halves

the left hemisphere and

right hemisphere, that resemble the halves of a walnut. Interesting fact is that each hemisphere processes about the opposite side of the body. For example when you write with your righthand, the motor information enabling your right hand to move comes from your

left hemisphere . The cortex consists of thick layer of densely packed neurons. It has large area to be fitted into the skull cavity and therefore it has a large number of turns and twists. The turns and twists make the structures like hills and valleys, which are called gyri (*singular gyrus*) and sulci (*singular sulcus*).

The brain has two basic functions :

cognitive functions (learning, memory, thinking, etc.)and

the regulation of physiology of the body.

(b) The Lobes of the cerebral cortex

The cerebral cortex on the basis of its structure and functions is divided into four lobes : *frontal, occipital, parietal and temporal lobes.* As we know that we are aware of our environment by means of our senses: vision, audition, smell, gestation (taste), cutaneous senses (touch, pain and temperature). Various centres in these lobes are responsible for our awareness of the environment and our responses to the changes in the environment.

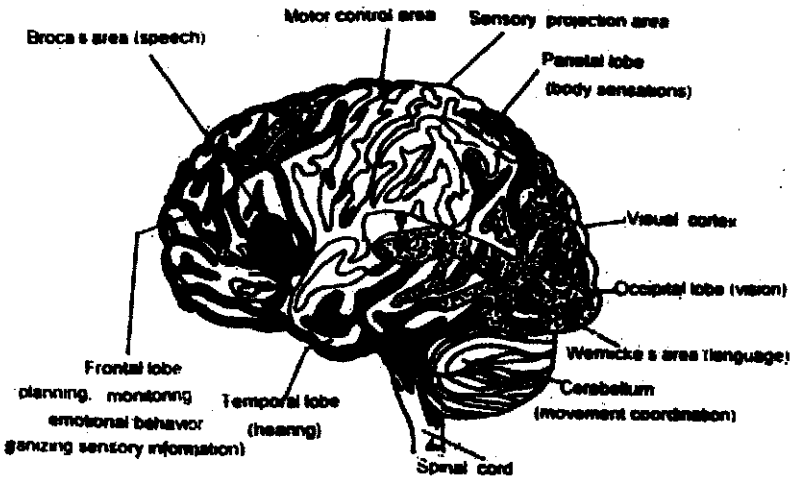

Figure 3.7 The physical structure of Brain

The visual information is received by the primary visual cortex located in the occipital lobe of the cerebral cortex. Any damage or disorder to eye, pathway or to the visual cortex results in the various visual disorders. Similarly, the auditory information is received by the primary auditory cortex located in the temporal lobes of the cerebral cortex. Any damage to our ears, auditory pathways, and to the auditory cortex results into the hearing problem. The information from body senses is received by the somatosensory cortex that is located in the parietal lobe.

Apart from the division of cerebral cortex in terms of the four lobes, there has been a division in term of the two cerebral hemispheres, *the right and left cerebral hemispheres.* Each hemisphere receives sensory information, and controls the muscular action of the opposite

side of the body. The two cerebral hemispheres play a crucial role in higher mental functions including language, processing and integration of sensory information, planning, decision making, and reasoning. Although both hemispheres contribute to behaviour in important ways, each hemisphere is specialised in its capabilities.

Clinical evidence suggested that damage to one hemisphere leads to disabilities different from those arising from damage to the other hemisphere. These differences strongly suggest that each hemisphere contributes certain specialised functions to overall human behaviour. Some of the most persuasive evidence on specialisation of the right and left cerebral hemisphere comes from the studies on split-brains. Accordingly, some division of labour between hemispheres does exist, with each side *dominant* (in more control of) in certain functions. In general, the left hemisphere is dominant for language, logic, complex motor behaviour. The right hemisphere is specialised for visual-spatial and other non-linguistic functions such as visual imagery, tactile perception, facial identification, appreciation of music non-verbal communication, etc.

Intext Questions 3.4

(A) State whether the following statements are true or false.

(1) The central nervous system consists of brain and the spinal cord. True/False

(2) The spinal cord has three components. True/False

(3) The brain is surrounded by the skull for protection. True/False

(4) The lower most layer of the brain is called the cerebral cortex. True/False

(B) Fill in the blanks with the appropriate words :

(1) The two major divisions of the nervous system are _____ and _____

(2) The network of neurons in the brain and spinal cord is called_____

(3) The outer covering of the cerebrum in which the higher mental processes are mediated is known as _____

(4) The two major divisions of the peripheral nervous system are _____ and _____ .

Do you know :

Brain Research techniques: Imaging through the living brain

Several techniques are used to know the functioning of our brain. These techniques are also used to find out if there is any thing wrong in the working of the brain. Some of the commonly used techniques in the living brain system are as follows:

CAT scan

In computerised axial tomograph CAT a weak x-ray beam is rotated about the person's head to produce images. A computer then plots the images on a display. The CAT scan differentiates and localises the extent and site of brain tumours, blood clots, and areas of cerebral damage.

PET scan

In position emission tomography (PET) a radio active glucose related substance is injected into the blood supply of the brain. The images of the brain are obtained by the consumption of the glucose in the brain. The motion picture in PET scan is generated by the computer.

NMR

In nuclear magnetic resonance (NMR) imaging technique, the brain is placed in an intense magnetic field. The changes in the magnetic properties of the cells are then recorded. From these recorded properties again the image is generated.

All of these techniques have their relative advantages and disadvantages, depending on physiological differences between the brain sites under study and on the kind of brain activity or pathology being investigated. Most of these techniques are used to locate any disorder in the brain.

3.7 THE ENDOCRINE SYSTEM

You must have heard about some diseases caused by high or low level of hormones in the body. For example, diabetes is caused by the low level of a hormone called insulin. Similarly the level of another hormone, thyroxin controls our behaviour. Hormones are chemicals secreted directly into our blood streams. The secretion of the hormones is done by endocrine glands. This system is a collection of ductless glands that control various body functions. The endocrine glands secrete chemicals that send signals by releasing hormones directly into the bloodstream. The endocrine glands and their major functions are shown in the Box. The location of these glands is shown in Figure: Some of the major glands are as follows :

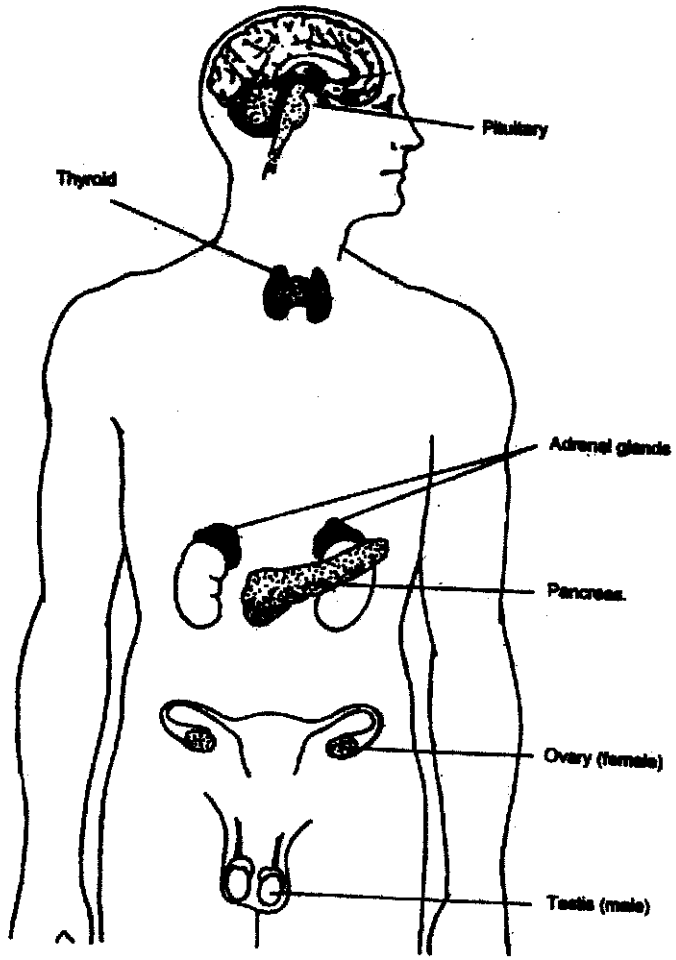

Figure 3.8: Endocrine system

The **pituitary gland** is reddish-grey, about the size of a pea, located in the brain . It is referred as the "master gland" because some of the hormones it releases stimulate and regulate the hormonal action of other endocrine glands.

The **thyroid gland,** located in the neck, releases a hormone that controls metabolism (transformation of food into energy). It also affects energy level and the mood.

The **adrenal glands** are located above the kidneys. These glands secrete adrenalin and other hormones during emergency situations.

The other endocrine gland, the **pancreas**, is located near the stomach. It produces insulin that controls blood sugar level.

The **gonads** control sexual development and behaviour. The male gonads (testes) are located in the testicles. These glands produce the hormone known as testosterone. The female gonads (the ovaries) produce the hormone known as estrogen. In both sexes (male and female) these hormones not only control the sex drive, but also regulate the development of secondary sex characteristics, like beards in men or breasts in women.

The endocrine glands and important functions

Gland	***Function***
Pituitary (Master gland)	*Growth : metabolism (transformation of food into energy); regulation of adrenal, thyroid, and gonadal hormone secretion; milk production in females*
Thyroid	*Control of growth, energy level and our mood*
Adrenal	*Adaptation to prolonged stress*
Pancreas	*Control of blood sugar level*
Gonads	*Reproduction primary and secondary sex characteristics; sex drive*

Intext questions 3.5

1. What are hormones ?

2. Fill in the blanks with appropriate words :

   (a) Pituitary gland is called_____gland.

   (b) The _____glands are located above the kidneys.

   (c) The pancreas is located near the _____.

3.8 Genetic influence on behaviour

We often talk about people inheriting certain characteristics. Neena has inherited her mother's blue eyes, or Ashok has inherited his father's curly hair. We expect tall parents to have tall children. The inheritance of such characteristics is called *heredity*. The branch of biology, that deals with how heredity works, is called genetics. *Behavioural genetics* in which the psychologists are particularly interested, is the study of inheritance of behavioural characteristics.

All living beings are unique as they differ from the members of other species (cat differs from dog and man differs from animals). An

organism's physical appearance and behaviour varies from individual to individual.The former is known as *genotype* and the later are termed as *phenotype*. Every individual's phenotype is the result of the interaction between its genotype and the environment. The physical development is in large part based upon the genes we inherit from our parents. It is largely believed that the genetic characteristics transmitted by genetic factors set limits on the behaviour capabilites of the organisms including human beings.

The present genetic theory is based upon the work of Gregory Mendel. Mendel showed that the characteristics of parents are passed on to their offspring through genes. These genes might produce visible characteristics in offsprings, or might be carried for possible transmission to another generation. The children of one set of parents do not inherit all the same characteristics.

The union of two cells, the egg from the mother and the sperm from the father is the beginning of new individual. These two cells like all other carry within them material that forms a definite number of rodlike units called chromosomes. These chromosomes carry heredity factors or genes. The cell nucleus that contains the chromosomes is made up of deoxyribonucleic acid (DNA) in combination with protein compounds. Chromosomes are pairs and each chromosome contains 1000 or so genes that also occur in pairs.

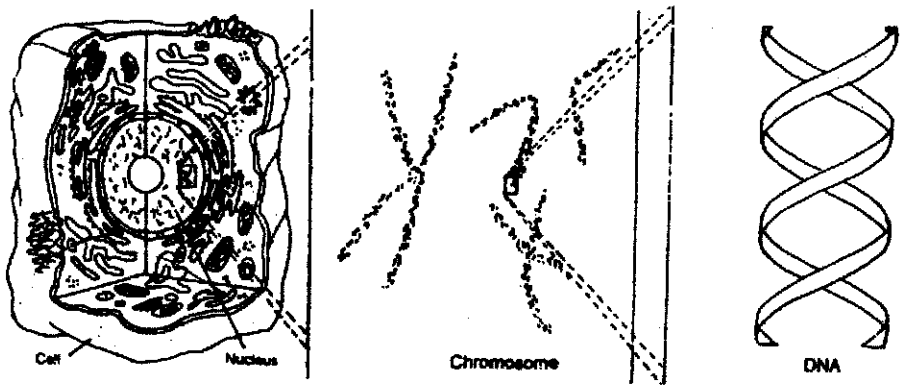

Figure 3.8 : Cell, Chromosome and DNA

The two members of a chromosome appear almost identical in size and shape when they are viewed under a microscope, except for the twenty third pair in the human male. This pair has one large member, called X and one small member, called Y. Every normal male has XY chromosome pair whereas female has XX pair. The normal human sperms are of two types, X and Y. If Y sperm fertilises an egg, the result will be XY and a male foetus will develop. If egg is fertilised by an X sperm, an XX individual or female foetus will develop.

The process of inheritance is based upon the process in which the offspring receives one of each gene pair from each parent. Some genes are dominant and some are recessive. An individual with

dominant gene for a particular characteristic displays that characteristic whether only one or both genes in the pair are dominant. If a gene is recessive, however, the characteristic associated with it does not show up unless both genes in the gene pair are recessive. In case only one gene in a pair is recessive, its effect will be masked by its dominant partner, but that recessive gene may still be passed on to the individual's offspring. Some characteristics are produced by a single gene or gene pair. Whereas multiple-factor inheritance involves the action of several genes.

The scientists working in the area of genetic engineering are attempting to find out the genetic code so as to manipulate the cell structure. The research is basically aimed to solve the problem of genetically transmitted diseases or behavioural abnormalities. Moreover, through genetic manipulation scientists are trying to control certain undesired behaviours and to facilitate the desired behaviour. The genetic manipulation has so far been tested widely in plant sciences and to some extent in animals. The human research on genetic manipulation is under strict control of ethical principles. These principles are against any intervention and manipulation of human being without following the guidelines and the consent of the person involved.

Intext Questions 3.6

1. What is heredity ?

2. What is genotype and phenotype ?

What you have Learnt

1. We study the functioning of our body and brain with the help of our brain itself. We receive sensation through our senses and we react by actions of our muscles and glands. Both sensation and control of our actions are mediated by our brain. Every organism including human being is made up of small units called cells These units are the unit of life.

2. The nervous system is made up of neurons, the basic unit of the system. Sensory neurons carry information from sense organs to the central nervous system. Motor neurons carry command from the brain to the glands and muscles of the body. All the neurons have cell body, dendrites (branch like extensions) and axons that carry information to other neurons. Synapses are junctions between axons of one neuron and the dendrites of the other.

3. The nervous system consists of the central nervous system (brain and spinal cord) and the peripheral nervous system. The peripheral system is further divided into somatic and autonomic nervous system. Somatic system is responsible for receiving the information through sensory receptors and for our actions through the glands and muscles. The autonomic nervous system consisting of the sympathetic and parasympathetic nervous system acts to mobilise in response to threats and then for returning the body to the normal state.

4. The cerebral cortex can be divided into four lobes: frontal, occipital, parietal and temporal. The occipital lobes are specialised for vision. The parietal lobes are involved in the sense of touch and the sensations from own body. The functions of frontal lobes include co-ordination of movement, planning, attention, social skills, etc. The temporal lobes are important in audition and language. The right and the left cerebral hemispheres are specialised for various higher order functions.

5. Modern day methods of studying brain, such as CAT scans, PET scans and NMR are enabling us to learn more about the structure and functions of our nervous system.

6. The endocrine system is a collection of ductless glands that control various bodily functions through the secretion of hormones.

7. Genetics is the study of how traits are inherited, or passed on, from parent to child. Studies in genetics suggest that a substantial portion of the variation among individuals on many psychological attributes such as intelligence and personality are heritable.

Terminal Exercise

1. Describe the structure and function of a neuron ?
2. What is nervous system ? Describe various components of the nervous system.
3. Describe the functions of central nervous system ?

4. What is cerebral cortex ? Describe main functions of cerebral cortex.
5. Describe the functions of endocrine system.
6. How are the behavioural characteristics transmitted from parent to their children ?

Key to Intext Questions

3.1 (i) Membrane

(ii) Smallest unit

(iii) Cells

3.2 1. (i) True

(ii) True

(iii) False

(2) (i) Half

(ii) Soma, dendrites and axons

(iii) Two, receptor and motor

3.3 (1) receiving, processing and sending

(2) brain and spinal cord

(3) nerve impulses

(4) brain, spinal cord

(5) sympathetic and parasympathetic

3.4 (A) (1) True

(2) False

(3) True

(4) False

(B) (1) Central nervous system and Peripheral nervous system.

(2) Central nervous system

(3) Cerebral cortex

(4) Somatic system and autonomic system

3.5 1. Harmones are chemicals secreted directly into on our blood streams.

(a) master

(b) adrenal

(c) stomach

3.6 (1) The inheritence of similar characteristics of from parents to children is known as heredity.

(2) When living being differ from other species it is known as genotype and when an organisims physical appearance and behaviour differs from individual to individual it is known as phenotype.

Hints to Terminal Exercise

(1) Consult-Section 3.4

(2) Consult-Section 3.5

(3) Consult-Section 3.6

(4) Consult-Section 3.6

(5) Consult-Section 3.7

(6) Consult-Section 3.8