UNIT 2 BIOLOGICAL THEORIES

Structure

2.0 INTRODUCTION

By now, you must be clear about the thoughts and concepts explained by the school of behaviourism. The behavioural theories explained how behaviour can be shaped, modified and terminated with the help of learning. In this unit, you will come to know about several biological theories that explain human behaviour, that means the concept of behaviour will be explained with the help of biological processes. Biological psychology is the study of physiological, evolutionary and developmental mechanisms of behaviour. It is a sub-discipline of psychology that seeks to explain behaviour in terms of biological mechanisms. It not only acknowledges that biology influences behaviour, it also considers how behaviour and environment can influence biology. For example, the process of evolution demonstrates that an environmental influence over a long period of time can produce change in biology and consequently in behaviour.

All psychobiological accounts of behaviour use ‘reductionism’. Reductionism permits explanation of behaviour at the biological level. There are different levels of investigation even within the biological area. For example, it investigates the functions of the two hemispheres and also more specific areas (e.g. hippocampus) to explain behaviour. The discipline of biological psychology uses a wide range of information from other subjects to explain behaviour, such as, physiological psychology, behavioural genetics, neuropsychology etc. Therefore, it is a meeting place of many different schools of thought and diverse scientific research, all of which are used to provide an explanation for behaviour.

The knowledge base of the disciplines that contribute to biological psychology is dynamic and ever changing. Technological advances has permitted substantial amount of new research. Use of functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) to examine the processes of the brain in action are some of the examples.

In brief, biological psychology contributes to our understanding of behaviour much like a jigsaw puzzle. It puts pieces of information together from all other disciplines.

2.1 OBJECTIVES

This unit enable you:

- to understand the basic concepts of biological psychology;
- to recognize the role of genetics in human behaviour;
- to understand the role of evolution in human behaviour; and
- to explain the role of the brain in human behaviour.

2.2 BIOLOGICAL PERSPECTIVES

This field of psychology analyses the biological aspects of human behaviour. The nervous system controls the behaviour and the patterns of behaviour can be understood from the functioning of the brain. The technological advances in the field of neuroscience have shown that the brain is a continually changing organ. Its structure as well as its function keeps on changing. There is a constant flow and processing of information from the endogenous (originate from within the species) activity or sensory events (environmental). The information affects the neurons resulting in release of neurotransmitters which activates the receptors. This in turn activates the genes resulting in synthesis of new proteins, receptors and other membrane components and finally affects the morphological and physiological changes of neurons.

Perceptions, emotions, thought, consciousness and self consciousness are concerned with intimate and subjective entities of the mind that are elusive and difficult to grasp or measure. The field of Neuro sciences and cognitive neuro-sciences have tried to bridge the gap between brain and mind.

Since brain is a vital organ of human body, it is important for you to understand its function (neuroanatomy), brain activity, and genetics. Its structure needs to be studied in order to recognise the role of biological processes in human behaviour and psychological disorders. Let us deal first with the neuroanatomy.

2.3 NEURO ANATOMY

As mentioned earlier also that neuroanatomy refers to the different structures of brain and their functions which help out in the proper functioning and response amongst individuals. In a nut shell, the human brain looks like a walnut from inside. It has several lobes, knots, fluids and neurons

2.3.1 The Brain Structure

Basically, the brain is divided into the forebrain, the mid brain and the hind brain. The higher functions of human beings such as thought, speech and emotions are performed in the forebrain. The mid-brain controls sleep, alertness and pain. The hind brain takes care of respiration and heart rate. The spinal

cord receives sensory information from the rest of the body and sends commands to the muscles, controls balance and sense of physical space. The cerebellum helps in controlling body movements.

Further, the cerebrum is divided into the left and the right hemispheres and each hemisphere is divided into four lobes- the frontal, parietal, occipital and temporal lobes. The frontal lobe is related to functions of thinking, feeling, imagining and decision making. The parietal lobe controls information about bodily sensations, movement and spatial orientation. The occipital lobe controls visual information. The temporal lobe controls auditory information, memory and language. The limbic system comprises of the thalamus, striatum, hippocampus and amygdala and it lies underneath and deep within the forebrain. The limbic system plays a role in the processes of cognition, emotion, learning, memory and motivation. The orbito-frontal cortex and medial frontal cortex are involved in social cognitions, empathy (capacity to recognise feelings that are being experienced by other person), and theory of mind (ability to attribute mental states, dogmas, intents, needs for one's own self and for others).

The ventricular system is composed of four cavities that are filled with cerebral spinal fluid and projects into the cerebral cortex. When there is damage to the brain, the ventricles may enlarge and fill the space. Therefore enlargement of the ventricles is an indicator of damage to the brain.

The nervous system is made up of nerve cells (the neurons), glial cells, synapses (connections between neurons), and chemical messengers communicating information between neurons (neurotransmitters), multiple inter-neuronal connections and circuits.

Computerised tomography (CT) and magnetic resonance imaging (MRI) scans are the imaging techniques used to see brain structure. Electro-encephalography (EEG), positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) are used for visualizing brain functioning.

2.3.2 The Neurons

The nervous system is made up of nerve cells called neurons. The neurons are specialised cells for receiving, moving and processing information and relay messages from different parts of the body to and back from the higher centres of the nervous system. The neuron has a cell body and two types of fibres, dendrites and axon. The axon conducts nerve impulses to other neurones. The dendrites are shorter and have many branches.

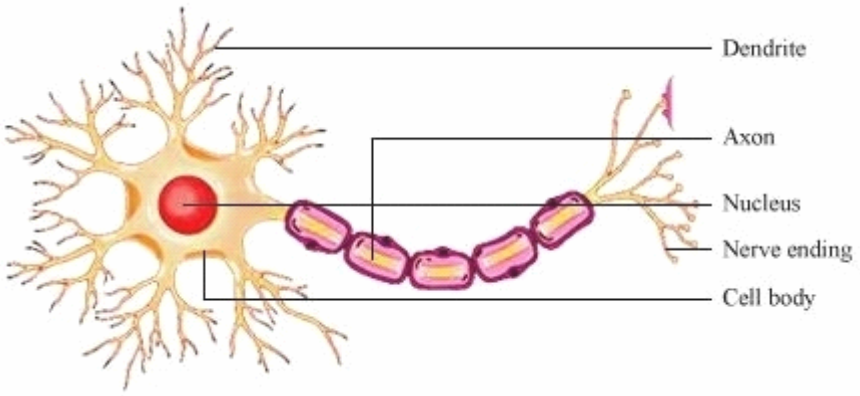

Fig. 2.1: Structure of a Neuron. (Source: http://the-works.net/tag/diagram-of-neuron)

Self Assessment Questions 1

State whether the following statements are True or False:

1) The ventricular system is composed of four cavities that are filled with cerebral spinal fluid. ( )

2) Neuroanatomy refers to the different structures of neuron and their functions. ( )

3) Reductionism helps in explanation of behaviour at the Psychological level. ( )

4) Computerised tomography (CT) and magnetic resonance imaging (MRI) scans are the imaging techniques used to see brain structure. ( )

2.3.3 Functions of the Neurons

Neurons carry messages between the brain and the body. They form an interconnected pathway and pass the messages through neural transmission and synaptic transmission. In neural transmission the information within the neuron moves in the form of an electrochemical impulse in an axon and is called an action potential, while synaptic transmission is the process by which information is transmitted from one neuron to another neuron through a synapse.

2.3.4 Synapse

Neurons are arranged in the form of chains and they do not touch each other. The space between the axon tips of a neuron and the dendrite or cell body of another neuron is called the synapse. When the neuron is stimulated, an electrical impulse travels along the axon to its tip called the synaptic knobs. The synaptic knobs contain tiny vessels called synaptic vesicles that contain neurotransmitters.

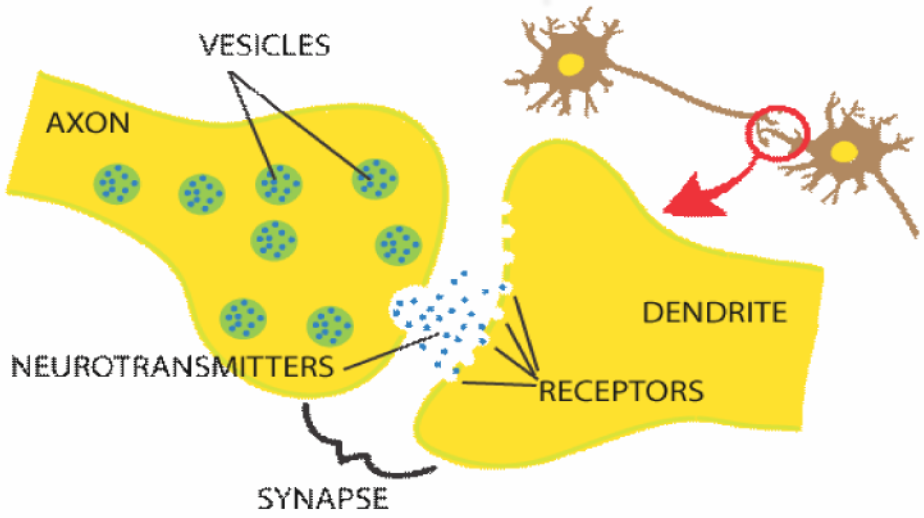

Fig. 2.2: Synapse. (Source: http://the-works.net/tag/synapse-diagram)

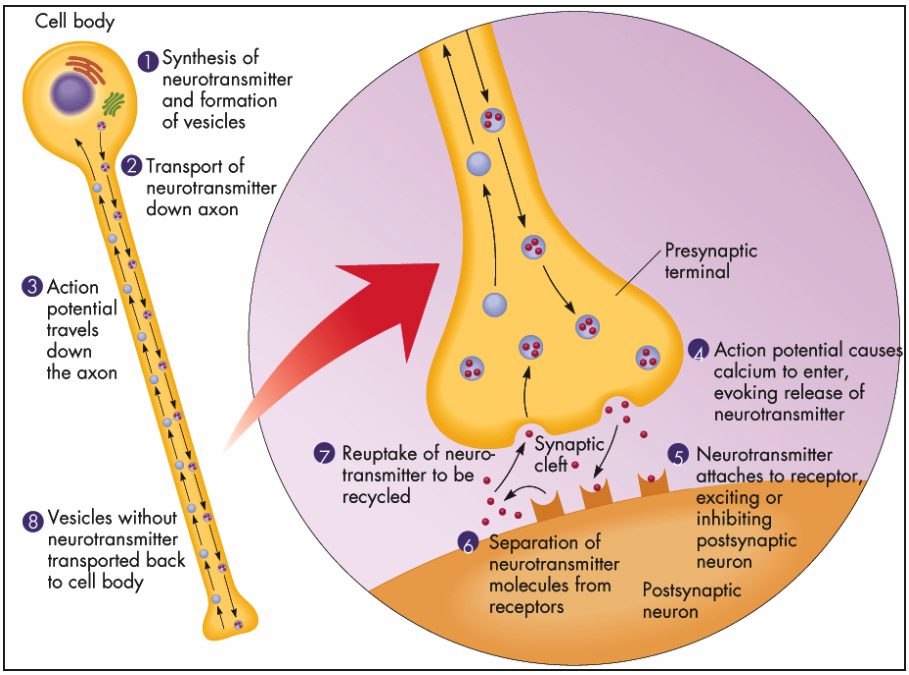

Fig. 2.3: Diagrammatic representation of changes taking place at the Synaptic Cleft. (Source: http://the-works.net/tag/synapse-diagram)

2.3.5 Neurotransmitters

The neurotransmitters are chemical substances which are stored in the synaptic vesicles and get released into synapse when electric signal reaches the synaptic knob. The neurotransmitters carry information across the synapse and have inhibitory (turn off) or excitatory (turn on) effect on the receiving neuron. If the effect is excitatory in nature then there is a change in the resting potential of the receiving neuron and the process of neural transmission occurs in this neuron. On the other hand, if the effect of the neurotransmitter is inhibitory, no action potential is generated in the receiving neuron and the message is not transmitted.

Some neurotransmitters are reabsorbed by the synaptic terminals from which they were released, this process is called reuptake. Reuptake prevents action and further production of the neurotransmitter. Whether a neuron will generate an action potential and pass the message to other neurons in its pathway depends on the balance between the excitatory and inhibitory synapses.

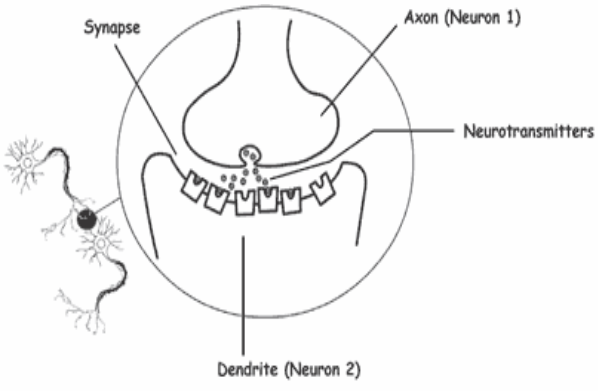

Fig. 2.4: Flow of neurotransmitters

(Source:http://www.drugabuse.gov/publications/brain-power/grades-4-/neurotransmission-module-3/background)

2.3.5.1 Neurotransmitters and Brain Functions

There are several types of neurotransmitters which operate in the brain and carry out different functions. Synaptic transmission in the brain can be altered through the use of drugs that increase or decrease the effectiveness of specific neurotransmitter. Some of the neurotransmitter can be mentioned as follows:

- Acetylcholine (ACh) usually has excitatory effect and is present mainly in the hippocampus. It plays an important role in the formation of new memories. Decreased ACh levels, caused by degeneration of the neurons that produce it, are associated with Alzheimer‘s disease.
- Gamma-aminobutyric acid (GABA) is a major inhibitory neurotransmitter. Anti-anxiety drugs work by activating the action of GABA.
- Serotonin plays a crucial role in the regulation of mood, appetite and sleep. Low levels of serotonin are associated with depression. Antidepressants work by inhibiting the reuptake of serotonin that increases the amount of serotonin in the brain.
- Norepinephrine is an excitatory neurotransmitter and influences mood states. Drugs like cocaine/amphetamines have their psychological effects by prolonging the action of norepinephrine and slowing its reuptake. Its deficiency causes depression.
- Dopamine when released in the brain produces intense feelings of pleasure. An excess of dopamine is thought to cause schizophrenia while its deficit leads to Parkinson‘s disease.

2.3.6 The Neural Network

The neurons (grey matter) are connected to other neurons through axons and dendrites (white matter) and communicate with each other by electrical, chemical and molecular exchanges. These exchanges are conceptualised as the biological substrate of thought, emotion, memory, judgements and feelings; these processes are affected in psychiatric disorders. Instructions are coded in the DNA of neurons for the synthesis and metabolism of these chemicals, molecular messengers and complex proteins. The dysfunction in neural command system may result in disruption of connections resulting in malfunction of the chemical balances and feedback loops. There may be mutations of implicated genes or abnormal regulation of their expression.

Self Assessment Questions 2

Fill in the Blanks:

1) The neurons (grey matter) are connected to other neurons through ..... and ..... .
2) Gamma-aminobutyric acid (GABA) is a major ..... neurotransmitter.
3) Neurotransmitters: are ..... which are stored in the ..... and get released into synapse when electric signal reaches the synaptic knob.
4) When the neuron is stimulated, an ..... travels along the axon to its tip.

2.4 GENES

Humans have 46 chromosomes, made up of 23 pairs in their body cells. There are 44 chromosomes called autosomes that are numbered from 1 to 22 according to size from the smallest to the largest as well as the two sex chromosomes: X and Y. Women's chromosomes are described as 46, XX. Men's chromosomes are described as 46, XY. A mother passes 23 chromosomes to her child through her egg and a father passes 23 chromosomes through his sperm

The chromosomes are made up of deoxyribonucleic acid (DNA). Each chromosome consists of two very long thin strands of DNA chains twisted into the shape of a double helix and are located in the nucleus (the 'control centre') of our body cells. The chromosomes can be conceptualized as long strings of genes. Since the chromosomes in the cell's nucleus come in pairs, the genes in the nucleus also come in pairs. Each gene in the cell contains a piece of genetic information which guides our growth, development and health. The genetic information contained in the DNA is in the form of a chemical code, called the genetic code

The DNA's genetic code is virtually identical across all living organisms and is like a recipe book for the body to make proteins and control how the genes work. We all have variations in the genetic code which is why we are all unique. Most variations are harmless. However, variations in the genetic information can sometimes make the gene faulty which means that a particular protein is not produced properly, produced in the wrong amounts or not produced at all. Variations that make the gene faulty are called mutations. These faulty genetic variations or mutations can result in genetic disorders, affecting growth, development and functioning of the body. In other cases, the variation in the genetic code may make a person more susceptible for developing a genetic disorder.

Different cell types, tissues and organs have specific roles and so produce specific proteins for that role. The genes are expressed or not expressed depends on whether they are turned on or off. The genes that contain the information to make the necessary proteins are therefore 'switched on' in these cells while the remaining genes are 'switched off'. For example, the genes that are 'switched on' in liver cells are different to those that are 'switched on' in brain cells because the cells have different roles and make different proteins.

The basic unit of genetics is the genome which is the complete set of instructions for the development of every cell in the body. The human genome is present in the nucleus of the trillions of cells in human body and consists of long molecules of DNA. Phenotype refers to the expression of the genes as a result of their interaction with the environment.

Strands of the DNA have the information needed by the cells to produce the protein which is the primary component of all organisms. An important function of the DNA is to replicate itself before cell division begins, so that every new cell has a copy of the instructions required for manufacturing the protein.

There are thirty two thousand genes in the human body, which are functional units of the DNA and carry the precise instructions for manufacturing a specific protein. Genes are microscopic bags of chemicals found on the chromosomes.

Genes are transferred/passed on through mutations, that is, alterations or changes caused from incorrect copying of instructions during cell replication and this may be inherited or acquired. Inherited mutations are caused due to mutations in the DNA of the reproductive cells (sperm and ovum) - when these mutated cells get passed to the child, the mutations would be found in all the cells in the child‘s body. Acquired mutations are changes in the DNA that occur throughout life due to sunlight or carcinogens. Inherited mutations play a role in diseases such as cystic fibrosis and sickle cell anemia and may predispose a person to cancer, mental illnesses, etc. However, our cells have the ability to repair many of these mutations. If the cells fail to do so, the mutations are passed to the future copies of the affected cell.

2.4.1 Models of Genetic Transmission

The chromosomes operate in pairs and each set has the same genes on it but in different combinations called alleles. Alleles refer to whether the combination of genes is dominant or recessive. The hair colour, texture, eye colour, etc., are decided by the combination of alleles inherited by the individual. A dominant allele always shows its effect irrespective of what the other allele in the pair is whereas a recessive allele expresses its effect only if it is paired with another allele of its own kind.

Genetic disorders have a dominant-recessive pattern of transmission. In dominant pattern of disease inheritance, if the person has a normal allele and a disease allele, he is likely to develop the disease because the disease allele is dominant. Since, this person carries a normal and a disease allele, his/her child has a 50 percent chance of inheriting the disease allele and thus a 50 percent chance of having the disease. In recessive pattern of disease inheritance where both parents carry one normal allele (N) and one disease allele (D), neither of them have the disease but both are carriers of it. The combination of alleles that they are likely to pass on to their children are NN, ND, DN or DD. Thus, each of their children has 1/4th chance of being normal (NN), 1/4th chance of developed the disease (DD) and 1/2 chance of being carriers of the disease (ND, DN).

Disease inheritance, sometimes, is complex and may not be explained by the dominant-recessive pattern of transmission. In such cases, the pattern is likely to be polygenic, that is, multiple genes may play a role in the expression of a characteristic. Diabetes, coronary heart disease, epilepsy, etc., are a result of such polygenic processes.

It has been suggested that genetic factors are involved in the manifestation of several traits such as subjective well being, political views, job satisfaction, religiosity etc.

2.4.2 Genes, Environment and Psychological Disorders

Researchers believe that an important aspect of genetic transmission is that what is inherited is only the predisposition and not the inevitability of having the disorder. It is the mutual influences of nature (biology) and the nurture (environment) on each other that determine expression of most of the psychological traits and disorders. For instance, the trait of extraversion is thought to be partially inherited. A child born with extraversion genes may generate positive reactions in people in his/her environment, which further strengthen this personality trait. It is also suggested that people tend to select

environments that are consistent with their inherited interests and capabilities and these environments in turn facilitate the expression of these characteristics.

The diathesis-stress model suggests that a person may carry some vulnerability or inherent risk to develop a particular disorder. This vulnerability can be biological - inheriting disordered genes, it may be psychological - a faulty personality trait, or may be social - a history of abuse or poor interpersonal relations. In addition to this, for the disorder to develop, one must experience some kind of stress or trigger. This stress could be biological - an accident or illness that changes the neurotransmitter balance, psychological - perceived loss of control, or social - a traumatic event. The full-blown disorder can develop only when the vulnerability to develop disorder combines with the stress.

A large study which demonstrates the diathesis-stress model involved biological parents with and without psychiatric disorders and their children. They were interviewed and ratings were obtained to determine the child‘s chances of developing psychiatric disorders. A significant factor here was the presence of maladaptive parental behaviour. It was found that children who developed psychiatric disorders tended to come from homes with maladaptive parental behaviours, irrespective of whether their parents had psychiatric disorders or not. Similarly, children of parents who had psychiatric disorders were found to develop the disorders only when there was a history of disturbed parental behaviour. Thus, the diathesis of parental psychiatric disorders produced a full blown illness only when combined with the stress of living with parents having maladaptive behaviours. Thus, a genome may not always express itself in the phenotype. Incomplete penetrance occurs when the genotype that predisposes a person to a disorder doesn‘t get manifested.

According to the multifactorial polygenic threshold model, several genes of varying influence are involved in the transmission of a disorder or characteristic. The specific combination of inherited genes decides whether the vulnerability or risk is high, low or moderate. The symptoms of the disorder are thought to develop when the combined effect of genetic and environmental factors exceeds a certain threshold. This model is more popular than the single-gene explanations of genetic transmission.

2.5 Evolution of Adaptive Mechanisms

Human beings enter the world with biologically based mechanisms that predispose them to behave, to feel, and to think in certain ways. This allows them to learn, remember, speak a language, perceive certain aspects of their environment at birth, respond with universal emotions, and bond with other human beings.

Evolution is a change over time in frequency with which particular genes together with the characteristics they produce, occur within an inbreeding population. Genetic variations arise due to mutations and thereby result in changes in specific characteristics

Natural Selection: The principle of natural selection was postulated by Charles Darwin. According to the theory, any characteristic that increases the likelihood of survival of the organism and has the ability to reproduce within a particular environment will more likely be preserved in the population and therefore become more common in the species over time. Environmental demands result in development of new characteristics that contribute to survival of the individual and race.

Evolutionary Adaptations: Physical or behavioural changes that allow organisms to meet with recurring environmental challenges to their survival, and thereby increasing their reproductive ability

Brain Evolution: An early human ancestor (4 million years ago) also known as the *Australopithecus,* had a brain capacity of only 450 to 650 cubic centimeters, *Homo erectus* (1.6 million years ago) had 900 cc, the *Neandertal* (14500 cc), and *Homosapiens* (tripled in size). The series reflect that there has been tremendous growth of higher mental processes such as attention, memory, language and thought with time, situation and environment.

Therefore, it can be seen that from an evolutionary perspective, environment and culture provides an important inputs to evolutionary mechanism. The creation of new environments through our own behaviour is another important part of the evolutionary equation. Modern evolutionary theorist acknowledge the role of past evolutionary pressures that led to natural selection process and also to recent causes such as cultural learning and immediate environment in determining or influencing current behaviour.

Self Assessment Questions 3

Choose the correct altenative:

1) The multifactorial polygenic threshold model says that for the transmission of a disorder or characteristic there is an involvement of-

   a) several genes of varying influence.

   b) several genes of similar influence .

   c) single gene of varied influence.

2) Which of them shows the correct series of human development?

   a) *Australopithecus-Neandertal–Homosapiens-Homo erectus*.

   b) *Australopithecus-Homo erectus-Neandertal-Homosapiens*.

   c) *Homo erectus-Neandertal-*. *Australopithecus-Homosapiens*.

3) Genetic disorders have a ..... of transmission.

   a) recessive-recessive

   b) recessive-dominant

   c) dominant-recessive pattern

2.6 LET US SUM UP

It can be summed up from the above discussion that basically there are three aspects of biological foundations of behaviour. The first is the structures and functions of the nervous system, the second is the genetic factors that determine not only the characteristics which humans have in common, but also show the mental, emotional and behavioural aspects of our individual identities. The third are evolutionary factors that underlie human capabilities and behavioural tendencies. Understanding the nature and the extent of biological and

environmental factors that affect one another is important as they influence the development of behaviour.

2.7 ANSWERS TO SELF ASSESSMENT QUESTIONS

Self Assessment Questions 1

1) True

2) False

3) False

4) True

Self Assessment Questions 2

1) Axons and dendrites

2) Inhibitory

3) Chemical substances, synaptic vesicles

4) Electrical impulse

Self Assessment Questions 3

1) a) several genes of varying influence

2) b) *Australopithecus-Homo erectus-Neandertal-Homosapiens*.

3) c) dominant-recessive pattern

2.8 UNIT END QUESTIONS

1) Write about the structure of brain.

2) What is synapse?

3) What are the functions of neurons?

4) Explain the process of neuronal communication

5) Describe genetic transmission.

6) What is the role of genes in psychological disorders?

2.9 REFERENCES

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