

**CHAPTER**  
**17****NERVOUS COORDINATION****Key Concepts**

- 17.1 Nervous system of man
- 17.2 Neurons
- 17.3 Nerve impulse
- 17.4 Synapse
- 17.5 Basic organization of human nervous system
- 17.6 Effects of Drugs on nervous coordination.
- 17.7 Disorders of nervous system and diagnostic tests.

**EXERCISE****SECTION I: Multiple Choice Questions**

**Select the correct answer from the following choices.**

1. The function of the nerve gas is to inhibit the function of:  
(a) acetylcholine (b) atropine  
(c) cholinesterase (d) noadrenaline
2. The cell transmits impulses from the:  
(a) effector organ to the spinal cord (b) receptor cells to the effector organ  
(c) receptor cells to the spinal cord (d) spinal cord to the effector organ
3. Depolarization of an axon is produced by the movement of:  
(a)  $\text{Na}^+$  into the axon and  $\text{K}^+$  out of the axon  
(b)  $\text{Na}^+$  into the axon to bond with  $\text{K}^+$   
(c)  $\text{K}^+$  into the axon and  $\text{Na}^+$  out of the axon  
(d)  $\text{Na}^+$  and  $\text{K}^+$  within the axon toward the axon terminal
4. What will happen if the receptor sites on the post-synaptic membrane are blocked by a drug at the neuromuscular junction?  
(a) inhibition of acetylcholine (b) inhibition of cholinesterase

5. Which of these are the first and last elements in a spinal reflex?  
 (a) axon and dendrite (b) sense organ and muscle effector  
 (c) ventral horn and dorsal horn (d) motor neuron and sensory neuron
6. Impulses travel very rapidly along nerves to the leg of a man. Which fact accounts for the speed at which they travel?  
 (a) a nerve impulse is an all or none phenomenon  
 (b) the nerves contain myelinated fibres  
 (c) there is a high concentration of Na<sup>+</sup> ions inside the axons  
 (d) there is a potential difference across the axon membranes
7. Where are neurotransmitter receptors located?  
 (a) on the nuclear membrane (b) at nodes of Ranvier  
 (c) on the postsynaptic membrane (d) in the myelin sheath

Answer

1	(a)	2	(d)	3	(a)	4	(d)	5	(a)
6	(d)	7	(c)						

**SECTION II: Short Questions**

**Give short answers of the following questions.**

**Q.1. Why is nervous coordination important?**

Answer

All organisms respond to stimuli. These stimuli may be internal or external, at molecular, sub-cellular, cellular or organism level-to which the organisms respond. The activities of different body parts in response to these stimuli must be coordinated. The coordination makes possible the integration of functions essential to organismic behaviour. Coordination is a must for any organism to survive.

**Definition**

All the aspects such as organization, regulation, integration and control in the constitution and work of the complex multicellular animals come under the fold of the term coordination.

**Q2. What is a basic organization of a nervous system?**

Answer

In nervous system the basic organization comparison of i) structural and function unit called neuron, along this following are the steps required to achieve coordination.

- Reception of stimulus
- Processing / analysis of information
- Response to stimulus

**Q3. Draw and label the three functional types of neurones and write their**

**Answer****Sensory Neuron**

These neurons carry impulses from receptors to the CNS. The dendrite endings of some sensory neurons also act as receptors. Unlike other neurons, these are monopolar i.e. they have only one fiber originating from cell body which immediately gives rise to two branches, one branch (peripheral) running between receptor site and dorsal root ganglion (collection of neuron cell) in which cell body is located, and the other branch (central) running from ganglion into the spinal cord or brain. There is no clear difference between dendrite and axon because, except for its terminal portions, the entire fiber is structurally and functionally of axon type.

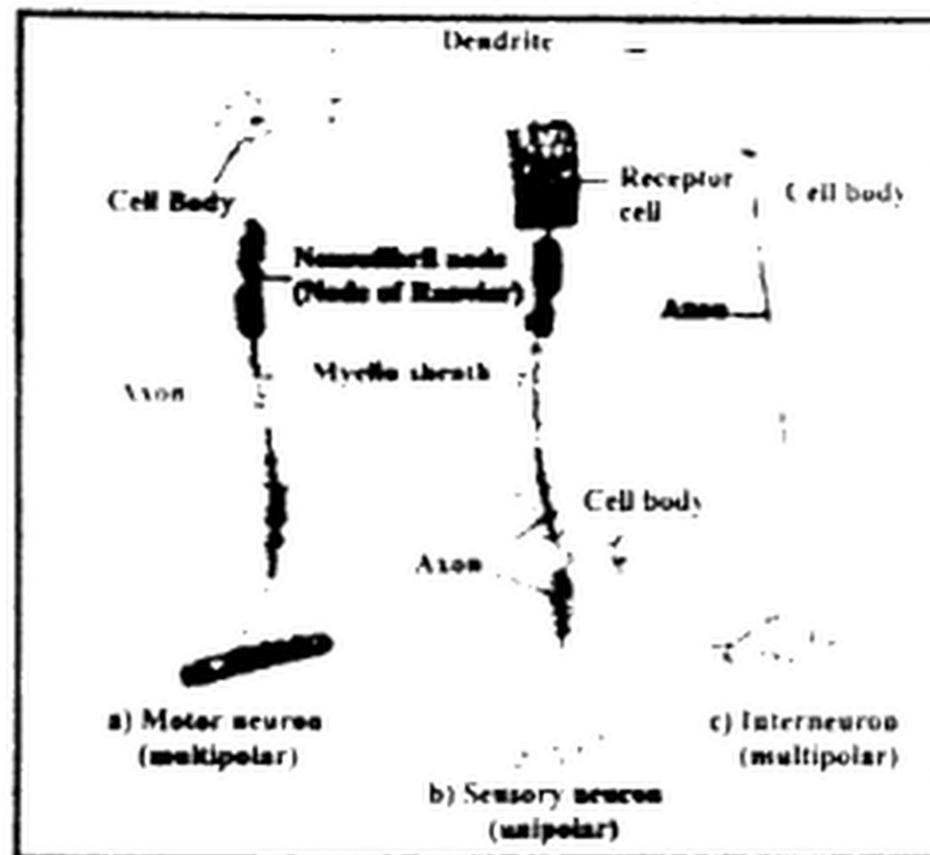


Fig. Three types of neurons based upon functions.

**Associative/Intermediate Neuron**

These neurons are found in brain and spinal cord (CNS). They are involved in processing and interpretation of information coming from receptors. Associative neurons are multipolar and unlike other neurons have highly branching network of dendrites, giving the cell a tree like appearance.

**Motor Neuron**

These neurons carry impulses from CNS to the effectors. Motor neurons are also multipolar but have long axons that run from the CNS to the effectors. Flow of information in nervous coordination can be explained with the help of a reflex arc.

**Q4. How does the structure of a motor neuron suits its function?****Answer**

Motor neuron get command from central nervous system or spinal cord for appropriate response according to stimulus this message is taken towards the effectors for response by means of motor neuron. Motor neurons are myelinated for speedy movement of

### Q5. Name the five fundamental parts of reflex arc.

Answer

#### Reflex Arc

The pathway of nerve impulse during reflex action is called reflex arc. Reflex actions are spontaneous involuntary activities performed unconsciously. For example, if you touch a hot or sharp pointed object by your hand, you will experience that your hand moves back at once before you think about it. Reflex activities have no involvement of brain; therefore the pathway of nerve impulse is slightly modified and quick than the general pathway.

A reflex arc consists of all the basic components of nervous coordination like receptor, sensory neuron, associative neuron, motor neuron and effectors. In the above example of reflex action, when your hand touches the sharp pointed object, pain sensitive endings of sensory neurons present in the skin are stimulated.

Peripheral branch of sensory neuron transmit impulse to the dorsal root ganglion from where impulse is carried to the spinal cord by central branch of stimulates the motor neuron, also in the spinal cord.

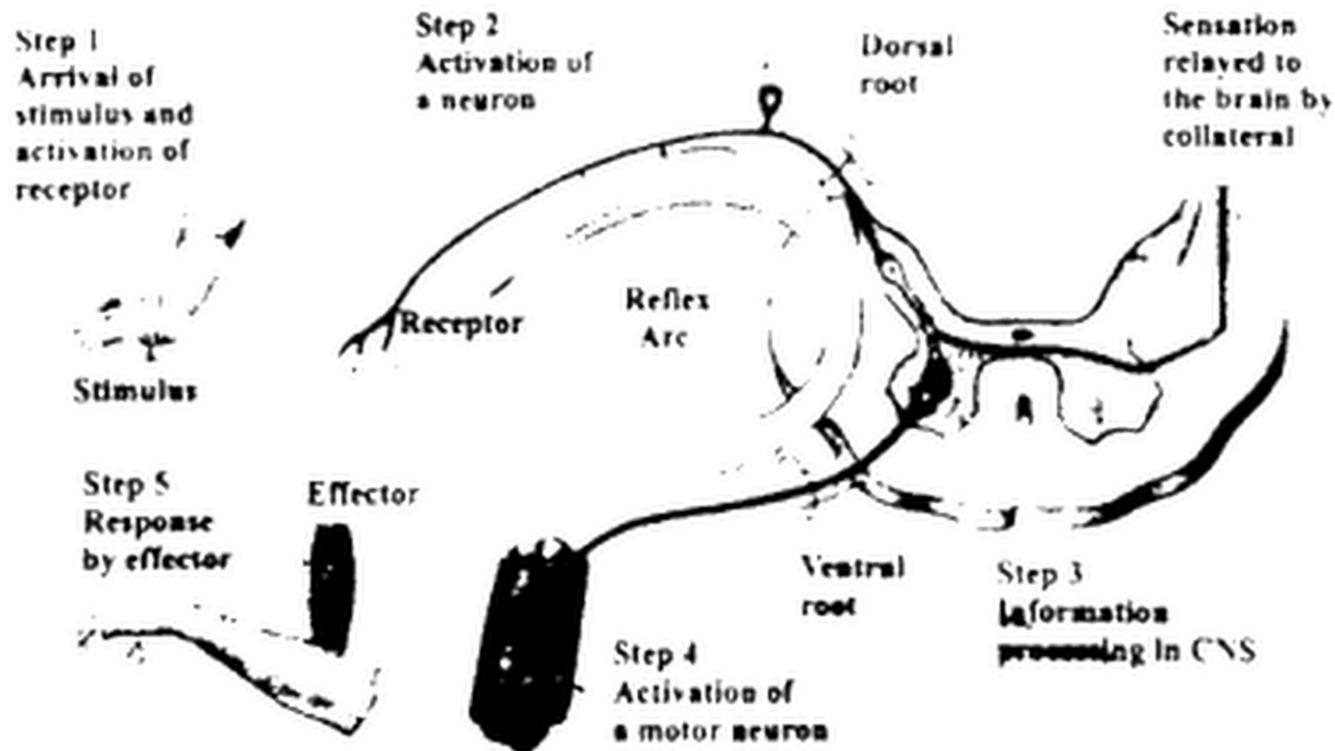


Fig. The pathway of nerve impulse during reflex action makes a reflex arc.

### Q6. How impulse conduction differs in myelinated and unmyelinated nerve fibers?

Answer

Myelin sheath is a fatty covering produced by Schwann cells. These Schwann cells and fibers of neurons are covered by this sheath that acts as an insulator.

While non-myelinated fibers of nerve are not covered by sheath.

In myelinated neurons between two Schwann cells exposed area (non-myelinated) is called node of Ranvier.

**Q7. What is the function of a neurotransmitter?****Answer**

Neurotransmitters are chemical substances which are released from the terminal ends of neurons used to pass on the message in the form of impulse from one to next neuron.

**Q8. What characteristics do the brain and spinal cord have in common?****Answer**

Together brain and spinal cord form the central nervous system.

- i) Both are involved with our senses seeing, hearing, touching, tasting, and smelling.
- ii) Both are protected by cerebrospinal fluid.
- iii) Both are having grey (bundles of cells bodies and white matter (bundles of myelinated fibers).
- iv) Both combinely constitute peripheral nervous system.

**Q9. Trace the pathway of an olfactory impulse from a receptor to the cerebrum.****Answer**

The smell or olfactory receptors are chemoreceptors, stimulated by chemicals dissolved in liquid. The olfactory organs which contain the olfactory receptors are present in the upper part of nasal cavity. The olfactory receptor cells are neurons. These cells are surrounded by columnar epithelial cells having cilia at the distal ends. Chemicals that stimulate the olfactory receptors enter the nasal cavity as gases. They must dissolve at least partially in the watery fluids that surround the cilia before they can be detected. The nerve impulses travel along the axons of the receptor cells which lead to olfactory bulb which is situated on the inferior (bottom) side of the force brain. The olfactory bulb transmits smell information from the nose to the brain, and is thus necessary for a proper sense of smell.

**Q10. What do EEG, CT Scan and MRI Stand for?****Answer**

- i) EEG stands for electro encephalography
- ii) C.T scan stands for computerized tomography scan.
- iii) MRI stands for magnetic resonance in aging.

**Q11. Distinguish between:**

**Myelinated and unmyelinated nerve fibers, cranial nerves and spinal nerves, drug addiction and drug tolerance, an axon and derdrites, a neuron and neuroglial cell, somatic and autonomic nervous system.**

**Answer****1) Myelinated Nerve Fibers**

The nerve fibers which are covered by fatty substances produced by Schwann cells. These covered nerve fibers are called myelinated nerve fibers.

**2) Non-myelinated Nerve Fibers**

nerve fibers.

### 3) Cranial Nerves

These nerves which originate from brain are called cranial nerves. These are 12 pairs of cranial nerves.

### 4) Spinal Nerves

Those nerves which originate from spinal cord are called spinal nerves. There are 31 pairs of spinal nerves. Both cranial and spinal nerves constitute peripheral nervous system.

### 5) Drug Addiction:

is a dependence on an illegal drug or a medication when you are addicted, you may not be able to control your drug use and you may continue using the drug despite the harm it causes. Drug addiction can cause an intense craving for the drug. You want to quit, but most people find they cannot do it on their own.

### 6) Drug tolerance

Drug tolerance is a person's diminished response to a drug, which occurs when the drug is used repeatedly and the body adapts to the continued presence of the drug. For instance, when nicotine or caffeine is used for along time, larger and larger doses must be taken to produce the same effect. Usually, tolerance develops because metabolism of the drug speeds up (often because the liver enzymes involved in metabolizing drugs become more active and because the number of sites (cell receptors) that the drug attaches to or the strength of the bond (affinity) between the receptor and drug decreases.

### 7) Axon

Neuron fiber which send/directs nerve impulse away from cell body.

### 8) Dendrites

Cytoplasmic projection / extension which are branched and directs nerve impulses towards cell body.

### 9) Neuron

A structural and functional unit of nervous system, which is used in transmission of nerve impulse from receptors to central nervous system and from C.N.S to effectors for accomplishing a function in an accurate way and in a coordinated manner.

### 10) Neuroglial cell

Beside neuron, nervous system also consist of neuroglial or glial cells, which support, protect and nourish the neurons.

### 11) Somatic nervous system

Motor neurons form somatic nervous system, which controls voluntary movements, which are under the conscious control of the body involving skeletal muscles.

### 12) Autonomic nervous system

Motor neurons also form autonomic nervous system, which controls involuntary responses by influencing organs, glands and smooth muscles. The autonomic nervous

nervous system. Both of these systems function automatically, innervate all internal organs, utilize two neurons and one ganglion for each impulse.

- i) **Sympathetic Nervous System:** A few cranial nerves including the vagus nerve together with fibres from the bottom portion of spinal cord, from the middle portion of the spinal cord and almost terminate in ganglia that lie near the cord. This system is important during emergency situations and is associated with "fight or flight". This system accelerates the heart beat and dilates and inhibits the digestive tract.
- ii) **Parasympathetic Nervous System:** A few cranial nerves including the vagus nerve together with fibres from the bottom portion of spinal cord, form the parasympathetic nervous system. It promotes all the internal response which are associated with the relaxed state i.e., contracts of the pupils, promotes digestion of food, retards heart beat.

### Q12. What are the advantages of saltatory conduction?

#### Answer

In myelinated axon at the nodes of ranvier local circuits are set up and current flows across the axon membrane to generate the next action potential. This means, in fact, that the action potential jumps from one node to node and passes along myelinated axon faster than the series of smaller local currents in a non-myelinated axon. This type of conduction is called saltatory conduction (saltare, to jump) and can lead to conduction speeds of up to  $120 \text{ ms}^{-1}$ .

### Q13. What happens to neurotransmitter after they are released?

#### Answer

The majority of synapses are chemical synapses where synaptic cleft has gap of more than 20 nm. Through these synapses, information of impulse from one neuron is transmitted to another by means of chemical messengers, the neurotransmitters.

#### Transmission of nerve impulse across synapse

The axon terminals of pre synaptic neurons have expanded tips called synaptic knobs. The cytoplasm of synaptic knob contains numerous tiny spherical sacs called synaptic vesicles.

Each of these vesicles has as many as 10,000 molecules of a neurotransmitter substance. The arrival of action potential at the pre synaptic terminal depolarizes the plasma membrane, opening voltage gated channels that allow  $\text{Ca}^{2+}$  to diffuse into the synaptic knob. The resulting rise in  $\text{Ca}^{2+}$  concentration in the cytoplasm of synaptic knob causes some of the synaptic vesicles to fuse with the pre synaptic membrane, releasing the neurotransmitters. The neurotransmitters then diffuse across the synaptic cleft, and bind to the receptors on post synaptic membrane.

Binding of neurotransmitters to the post synaptic neuron receptors opens some channels and allows  $\text{Na}^+$  ions to diffuse across the post synaptic membrane as a result post synaptic membrane depolarizes and an action potential is generated. Since this depolarization brings the membrane potential towards threshold level, it is called Excitatory postsynaptic Potential (EPSP). At other synapses, different neurotransmitters bind to channels that are selectively permeable for only  $\text{K}^+$  or  $\text{Cl}^-$ .

(IPSP).

Various mechanisms rapidly clear neurotransmitters from the synaptic cleft, terminating their effect on postsynaptic cells. Certain neurotransmitters may be actively transported back into the presynaptic neuron, to be repackaged into synaptic vesicles, or they may be transported into the neuroglia, to be metabolized as fuel. Other neurotransmitters are removed from synaptic cleft by enzymes that catalyze the hydrolysis of the neurotransmitters, like acetylcholine is hydrolyzed by acetylcholinesterase and adrenaline by monoamine oxidase.

**Q14. Compare the velocities of nerve impulse in the axon membrane and the synaptic cleft.**

**Answer**

**Velocities of Nerve Impulse**

Velocities of nerve impulse in the axon membrane and in the synaptic cleft are variable. In human non myelinated fibres, nerve impulses travel at 1 to 3 metres per second. Myelinated fibres conduct at speeds of up to 120 meters per second. The velocity of nerve impulse is faster in myelinated neuron fibre due to salutatory conduction. Another reason that myelinated fibres conduct faster impulse is that myelin sheath acts as an insulating sheath and prevents loss of energy, so myelinated neuron fibres require less energy. Velocity of nerve impulse also depends upon diameter of neuron fibres. Thick neuron fibres conduct faster impulse than thin fibres because resistance to electrical current flow is inversely proportional to the cross sectional area of the conductor (such as wire or a neuron fibre), so with the increase in thickness of neuron fibres there is decrease in resistance of fibre to nerve impulse.

The short journey across the synapse takes about a millisecond, longer than a electrical signal takes to travel the same distance. This time is therefore called synaptic delay.

**Q15. Contrast the functions of CNS with those of PNS.**

**Answer**

PNS comprises of sensory neurons and motor neurons which may form ganglia and nerves. Ganglia are the connections of cell bodies of neuron.

Nerves are the bundles of axons or dendrites bounded by connective tissues. These may be sensory, mixed or motor nerves depending upon the direction impulse they conduct. In human there are 12 pairs of cranial and 31 pairs of spinal nerves.

The main function of PNS is to interlink the body parts with C.N.S.

PNS is divided into:

**i) Somatic nervous system**

It includes sensory and motor pathways. These control voluntary movements which are under conscious control of body involving skeletal muscles.

**ii) Autonomic nervous system**

The autonomic nervous system (ANS) is essentially a motor system. This means that it carries impulses from brain and spinal cord to organs it serves.

**Central Nervous System:** It mainly consists of brain and spinal cord

relay neurons.

### Q16. Compare the functions of somatic and autonomic nervous system.

**Answer**

#### 1) Somatic System

It includes sensory pathway and motor pathways. These control voluntary movements which are under the conscious control of body invading skeletal muscles.

#### 2) Autonomic Nervous System

The autonomic nervous system (ANS) is essentially a motor system. This means that it carries impulses from brain and spinal cord to organs it serves. The general function autonomic nervous system is to promote homeostasis.

#### Division:

Autonomic nervous system is also divided into two system:

- i) Sympathetic system
- ii) Parasympathetic system

#### i) Sympathetic System

This system is generally active during emergency or threatening conditions. It is often referred to as the fight or flight system. This system accelerates that heart beat and dilates branches and inhibits digestive tract.

#### ii) Parasympathetic System

A few cranial nerves including the vago nerve together with fiber from the bottom portion of spinal cord form the parasympathetic nervous system. This system is active when the body is calm and at rest and control such responses as contraction of pupils, promoting digestion of food, retards heart beat.

### Q17. How narcotic drugs interact with the normal nervous activity?

**Answer**

A narcotic is a group of substances when administered diminish the perception of pain. Narcotics bind to certain pain killing sites in brain. With constant use, they build up in the brain and block the production of endorphins, the brain's natural painkilling chemicals. Their side effects are drowsiness, depression, euphoria (an exaggerated feeling of well being), changes in mood, mental clouding, respiratory depression, nausea, vomiting, inhibition of defecation and urination. It also causes inhibition of endocrine and autonomic nervous system.

The narcotics are the drugs that act as agent which interact with normal nervous activity.

### Q18. Find out some of the common withdrawal symptoms of alcohol.

**Answer**

Alcohol withdrawal refers to a group of symptoms that may occur from suddenly stopping the use of alcohol. The symptoms are feeling of nervousness shakiness, anxiety, irritability, rapid emotional changes, depression fatigue headache, pulsating

**Q19. List the types of brain waves recorded on electroencephalogram.**

**Answer**

### **Electroencephalography**

Neurons within the cerebral cortex continuously generate electrical activity. This activity can be recorded by electrodes attached to precise locations on the scalp, producing electroencephalogram and this technique is called electroencephalography (EEG). An EEG pattern is commonly called brain waves. The EEG regular patterns are classified as alpha, beta or delta waves. Theta waves can occur in adults who have certain brain disorders. Delta waves occur in deep sleep, in the infancy and in patients with severe brain disorders. Distinct types of EEG patterns can be detected in patients with specific brain disorders such as epilepsy.

**Q20. How nerve gas acts as an inhibitor of acetylcholinesterase?**

**Answer**

Acetylcholine and the enzyme, acetylcholinesterase, enable muscles to contract and relax. Normally acetylcholine, a neurotransmitter, when released into the synapse of a muscle elicits the contraction of a muscle and is subsequently broken down by the enzyme, acetylcholinesterase, and relaxation of the muscle can occur. However, sarin, a nerve gas, irreversibly binds to acetylcholinesterase blocking it from breaking down the acetylcholine, thereby causing muscles to remain contracted. There exists a structural similarity between the active sites of the acetylcholine and the sarin molecule that enables the sarin molecule to fit into the acetylcholinesterase molecule. If the muscle is the diaphragm, it would remain contracted and the person would not be able to breath. Nerve gases are extremely toxic; a small droplet can kill a person. They exist in both liquid and gaseous form.

**Q21. How MRI is better diagnostic test than CT Scan?**

**Answer**

Image and resolution produced by MRI is quite detailed and can detect tiny changes of structures within body. While CT scan is used to define normal and abnormal structures in body and assist in procedures by helping to accurately guide the placement of instruments or treatment.

## **SECTION III: Extensive Questions**

**Q.1. Explain the steps involved in nervous coordination.**

**Answer**

### **Steps Involved in Nervous Coordination**

The system of the body that provides coordination through electric signals among different body parts for the response to a particular stimulus is called nervous system. Human nervous system is the most evolved among all the animals.

Nervous coordination mainly comprises highly specialized cells, called the neurons. The function of a neuron (neurone) is to detect and receive stimuli from different

to the other organ (effectors). Nervous coordination in higher animals therefore consists of three basic steps i.e., reception of stimulus, processing/analysis of information and response to stimulus.

Those parts of the body that receive stimuli from internal or external environment are called receptors or transducer. A receptor may be a complete organ or a cell or just neuron endings. The information collected by the receptor is transmitted to the central nervous system (CNS) through sensory neurons.

Receptors are classified into different types on the basis of stimuli. Photoreceptors detect light stimuli. For example, rods and cone cells in the retina of eye. Chemoreceptors detect ions or molecules (chemical). For example, receptors found in nasal epithelium for detection of smell (olfaction) and those, found in tongue for taste (gustation). Chemoreceptors are also found in hypothalamus, called osmoreceptors that detect changes in pressure, position, or acceleration: include receptors for touch (Meissners corpuscles in skin), stretch or pressure (Pacini's corpuscle in skin and baroreceptor in the wall of blood vessels), hearing and equilibrium (ear). Thermoreceptors detect hot or cold temperatures stimuli. Nociceptors respond to damage to body tissues leading to pain perception.

Sensory inputs from various receptors are received by CNS (brain and spinal cord) that act as coordinating centre of the body. This collected information is further processed/analyzed for an appropriate response by special type of neurons called interneuron.

Those parts of the body which produce an appropriate response are called effectors (muscles and glands). An effector organ, on receiving signal from CNS by motor neuron, provides an appropriate response either by producing movements (muscles) or secretions (glands).

- Q.2.a) What is a neuron? Write a note on structure of neuron.**  
**b) What are Schwann cells and their function?**  
**c) What are the types of neurone?**

**Answer**

### **Neuron**

A neuron is a structural and functional unit of nervous system.

### **Structure of Neuron**

Neurons vary considerably in size and shape, they all have three basic components

- a) Cell body b) Dendrites c) Axon

### **Cell body**

The cell body is called neuron cell body. It contains a mass of granular cytoplasm, and centrally placed with a prominent nucleolus. Organelles are present. The cytoplasm is characterised by the presence of Nissl's bodies and neurofibrils. Nissl's bodies are group of protein synthesis.

### **Dendrites**

(sin-apse) with the dendrites. The function of the dendrite is to receive stimuli and conduct impulses to the cell body.

**Axon**

An axon is comparatively a long and thick nerve fibre which has a constant diameter and can vary in size from a few mm to more than a metre length. It may be branched or un-branched. The cytoplasm of the axon is called axoplasm and its cell membrane is called axolemma (Greek, lemma, sheath). Axons terminate by branching to form small extensions with enlarged ends called presynaptic terminals. Functionally, axons conduct action potentials from the neuron cell body to the presynaptic terminals.

**b) Myelin Sheath and Schwann Cells**

Beside neuron, nervous system also consists of neuroglia or glial cells, which support, protect and nourish the neurons. Schwann cells are neuroglial cells in peripheral nervous system. Usually axons are covered by Schwann cells which are strip like cells wrap around axon fibres. These cells are also covered by a fatty substance called myelin sheath that acts as an insulator. This is why axons are called myelinated fibres. A non myelinated part of axon between two Schwann cells is called node of Ranvier. Conduction of action potentials from one node of Ranvier to another in myelinated neurons is called saltatory conduction

**c) Types of Neurons**

However, all neurons vary somewhat in size, shape, and characteristics depending on the function and role of the neuron. Based upon function there are three types of neurons.

**Sensory neurons** (afferent neurons) are unipolar and conduct impulses towards the central nervous system from the sensory receptors. The cell body is at the end of a short stalk on one side of the main conducting fibre just outside the CNS. The branches at one end are connected to the receptor.

**Motor neurons** (efferent neurons) are multipolar neurons and conduct impulses away from the central nervous system. The dendrites make contact with other neurons in the spinal cord. The terminal branches at the far end of

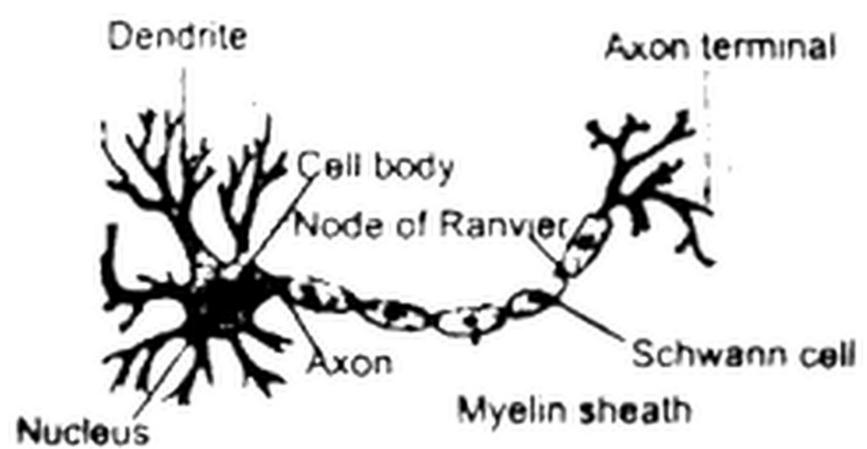
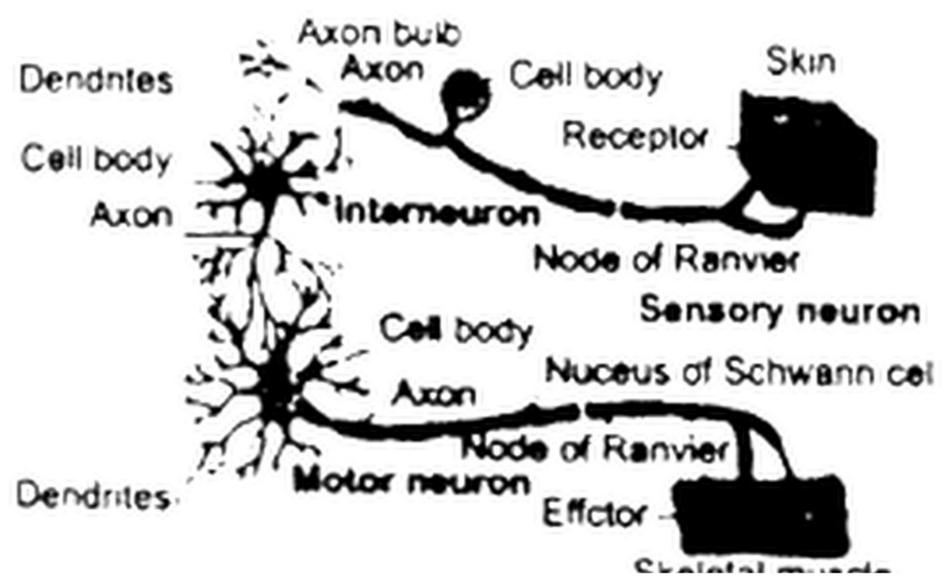


Fig. Structure of neuron



**Interneuron** (association neurone, intermediate neurone, relay neuron) occur entirely within the CNS and are multipolar neuron. They convey messages between various parts of the CNS. The axon is comparatively thin and non-myelinated.

**Q3. What is reflex action and reflex arc? Explain how reflexes are important in maintaining body homeostasis.**

**Answer**

### Reflex Arc

Reflex action or reflexes are immediate and automatic or involuntary responses to external and internal environmental changes. The path of the nerve impulse during reflex action is called reflex arc.

### Example

A typical reflex arc includes five fundamental parts: receptors, sensory neurons, interneuron, motor neuron and effectors. For example if one unexpectedly touches a hot object, the hand is rapidly removed from the source of heat. Receptors in the skin of the hand are activated by the heat of the object. The receptors stimulate a sensory neuron (afferent neuron) leading to the spinal cord via a spinal nerve. The cell body of the sensory neuron is outside the cord. The sensory neuron enters a dorsal nerve root of the spinal cord. The impulse then crosses a synapse to an interneuron which lies completely within the cord. The impulse travels along the interneuron and then passes across a synapse to the dendrites and the cell body of motor neuron (efferent neuron) which lies ventrally within the spinal cord. The motor neuron to the muscles, which cause them to contract (Fig. 17.3)

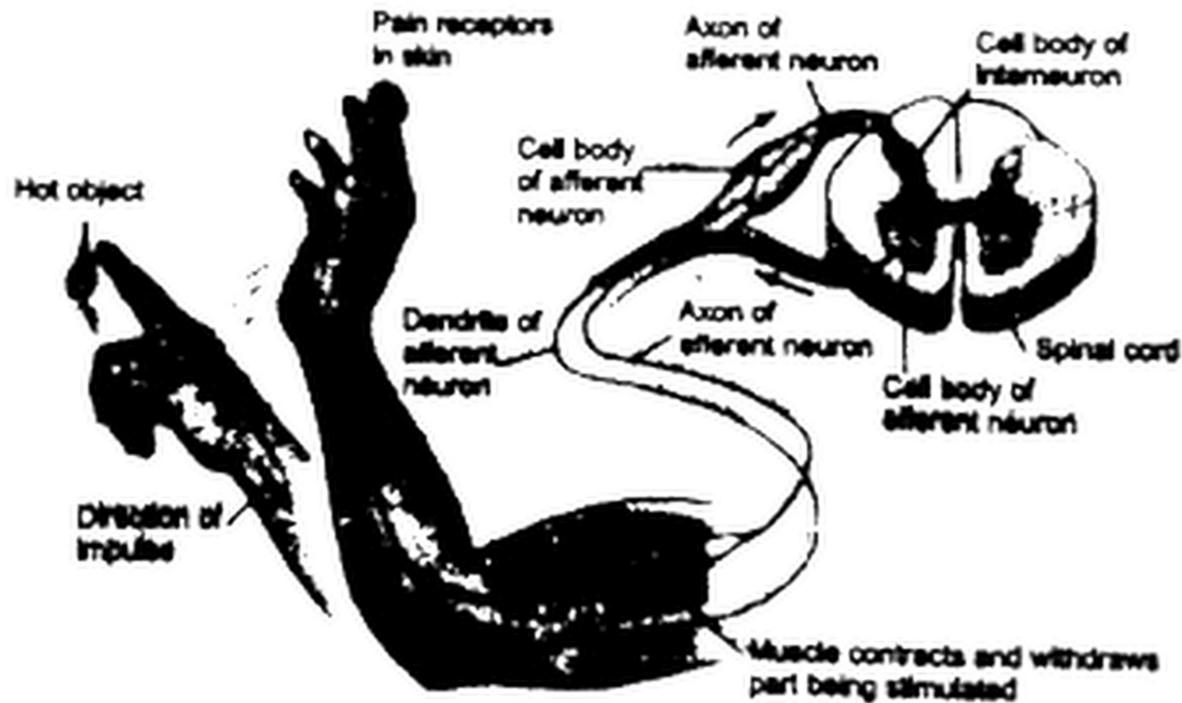


Fig. A reflex arc

**Q4. What is a nerve impulse? Describe the generation and transmission of nerve impulse, with the help of graph.**

**Answer**

## Nerve Impulse

Nerve impulse is information or signal about a stimulus that is transmitted from receptors to the CNS and from CNS to the effectors. In technical terms a nerve impulse can be defined as a wave of electrochemical changes that travel along the length of neuron, from one end to the other.

### Generation and Transmission of Nerve Impulse

Here, word electrochemical refers to the electrical potential (a capacity to do electrical work) that exists on neuron membrane. It is a sort of stored (potential energy which is manifested during separation of charges across the barrier. In case of neuron the electrical potential is termed as membrane potential which is exhibited in two different forms i.e., Resting Membrane Potential (RMP) and Active Membrane Potential (AMP).

### Resting Membrane Potential

It is characterized by more positive outer surface of neuron membrane than inner surface. This state is also referred as polarized state and the neuron is supposed to be at rest. This means that there is an unequal distribution of ions on the two sides of the nerve cell membrane. This potential generally measures about 70 mV (with the inside of the membrane negative with respect to the outside). So, the resting membrane potential is expressed as  $-70$  mV, and the minus means that the inside is negative relative to (or compared to) the outside. It is called a resting potential because it occurs when a membrane is not being stimulated or conducting impulses. Resting membrane potential is established by the following factors:

### Distribution and Active Movement of $\text{Na}^+$ and $\text{K}^+$ Ions

The concentration of potassium ( $\text{K}^+$ ) is 30 times greater in the fluid inside the cell than outside, and the concentration of sodium ions ( $\text{Na}^+$ ) is nearly 10 times greater in the fluid outside the cell than inside (see table No. 17.1). These ions are continuously moved against their concentration gradient through active transport pumps by the expenditure of energy. For every two  $\text{K}^+$  that are actively transported inward, three  $\text{Na}^+$  are pumped out. So inside becomes more negative than outside of the neuron membrane.

**Table 17.1 Ion Concentration Inside and Outside Typical Neural Membrane**

	Concentration (mmol/L)	
	Inside	Outside
$\text{Na}^+$ ions	15	145
$\text{K}^+$ ions	150	5
Negative organic ions	156	30

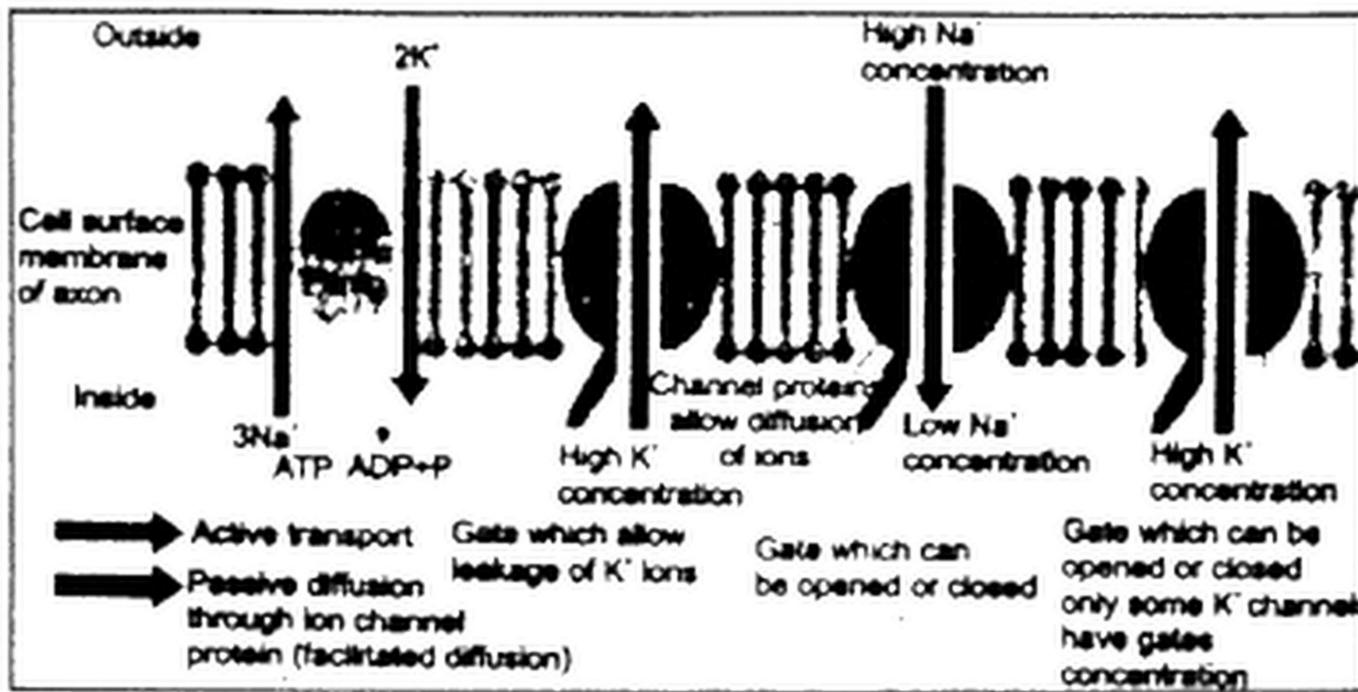


Fig. 17.4 Ion movement across neuron membrane

### Negative Organic Ions

There are many types of organic compounds in the neuron cytoplasm that also have negative charges. These ions include some amino acids, many proteins and RNA. Presence of these ions in the neuron cytoplasm makes inside of neuron more negative than outside.

### Leakage of $K^+$ Ions

Cell membrane of neuron also has many channel proteins called gates.  $K^+$  ions are continuously moved out of the neuron through some non-voltage regulated gates. This also makes more positive outside of neuron than inside (Fig. 17.4)

Overall there are more positive charges on the outside than on the inside. This is known as resting membrane potential. This potential will be maintained until the membrane is disturbed or stimulated by sufficiently strong stimulus (threshold), then action potential will be produced.

### Development of Active Membrane Potential

Active membrane potential (also called action potential) is characterized by more positive inside of neuron than outside (depolarized state). This happens when positive charges tend to move inside of neuron on receiving a particular stimulus. This electrochemical change appears on a short region of neuron for a brief period of time followed by the recovery of polarized state. In this way a wave of action potential begin to move towards other end of neuron. Action potential is established by the following factors.

### Threshold Stimulus

If a stimulus is capable to bring an electrochemical change on neuron or to excite a given tissue, is called threshold stimulus or adequate stimulus. If stimulus is not capable to excite or fails to arise any response, it is called sub threshold or inadequate stimulus.

### Inflow of Action

stimulus), the stimulated area of the fibre becomes several times more permeable to  $\text{Na}^+$  than to the  $\text{K}^+$  due to the opening of voltage regulated  $\text{Na}^+$  gates. As a result  $\text{Na}^+$  gates permit the influx of  $\text{Na}^+$  ions entering than leaving, the electrical potential of the membrane changes from  $-70$  mV towards zero and then reach to the  $50$  mV.

This reversal of polarity across two sides of membrane is called depolarization. This electropositive inside and electronegative outside lasts for about one millisecond till the  $\text{Na}^+$  gates are not closed.

### Repolarization of Neuron Fibre

A fraction of second after the sodium gates open, depolarization of the axon membrane causes potassium gates to open. Potassium therefore diffuses out of the cell. Since the potassium is positively charged, this makes the inside of the cell less positive, or more negative and starts the process of repolarization or return to the original resting potential.

### Hyper-polarization (More $\text{K}^+$ ions are on the outside than $\text{Na}^+$ ions on the inside)

At the peak of the action potential, the sodium gates start to close again. Sodium permeability therefore declines. The sodium-potassium pump continues to work during this time, so it gradually begins to restore the original resting potential. This repolarization is shown by the falling phase of the action potential spike and results in the membrane potential returning to its original level. In fact, there is a slight overshoot into a more negative potential than the original resting potential. This is called **hyperpolarization**. It is due to the slight delay in closing all the potassium gates compared with the sodium gates. As potassium ions continue to return to the inside of the axon their positive charge restores the normal resting potential.

### Refractory Period

After an action potential, nerve fibre undergoes a period of recovery in which it regains its original ionic distribution and polarity and prepares itself for the next stimulation. This period of recovery of nerve fibre is called refractory period. The part of refractory period in which the nerve fibre is not able to give response to a stimulus

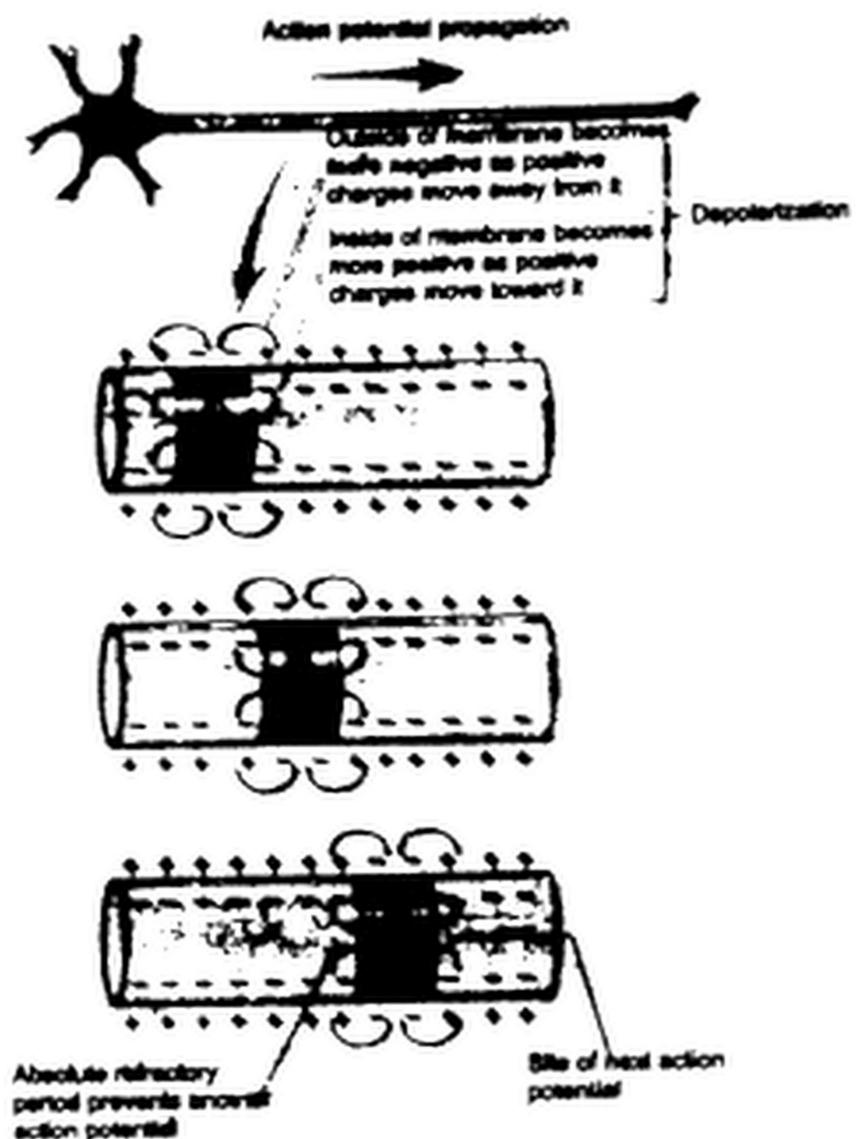


Fig. Conduction of nerve impulse

Although a repolarised neuron fibre has same polarity as that of a polarized neuron fibre but has different ionic distribution. It has more  $K^+$  outside and more  $Na^+$  inside. So the repolarised nerve fibre undergoes a refractory period of few milliseconds during which the original ionic distribution is restored by a sodium-potassium exchange pump which actively transports  $Na^+$  ions out and  $K^+$  ion in. This returns the membrane to its resting potential i.e.,  $-70mV$ . Refractory period lasts for about 4 millionseconds so a neuron can conduct 250 impulses per seconds.

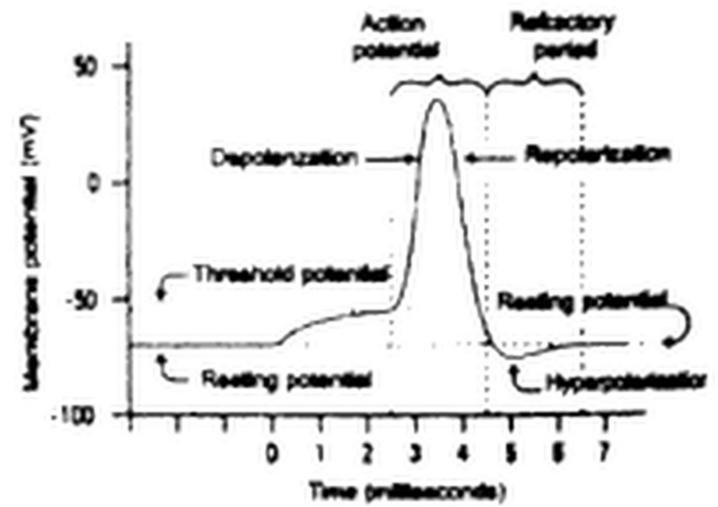


Fig. 17.6 Action potential in a nervous

**Q5. Describe in detail transmission of action potential between neuron and synapse.**

Answer

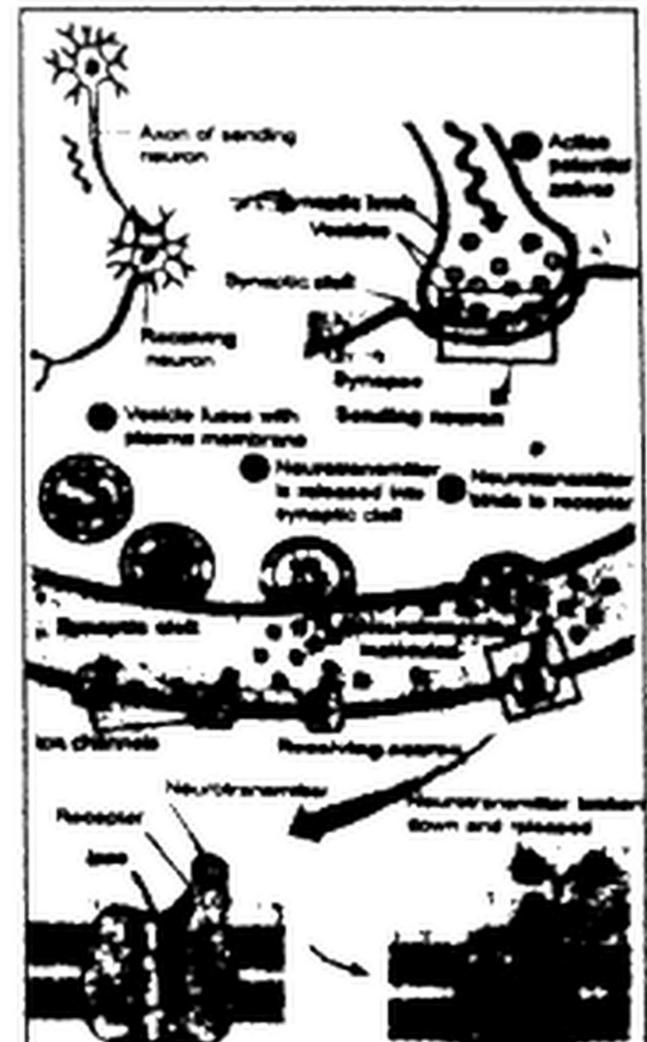
**Synapse**

The neurons are not in direct contact at a synapse. There is a gap, called a synaptic cleft between them. A single neuron may form synapses with many incoming fibres of different neurons. A neuron which carries an impulse toward a synapse is called presynaptic neuron (transmitting neuron). A neuron which receives the impulse after it crosses the synapse is a **post synaptic neuron**.

**Mechanism of Synapitic Transmission**

The movement of impulse across the synapse is called a synaptic transmission. It takes place in the formation of a message which is transmitted across the synapse in the form of chemical messenger called neurotransmitter.

The typical one-way transmission from one axon to a dendrite or cell body is due to the fact that the axons usually have several rounded synaptic knobs at their distal ends, which dendrites lack. These knobs contain numerous membranous sacs, called synaptic vesicles and when a nerve impulse reaches a knob, some of the vesicles respond by releasing a neurotransmitter. Fig: 17.8 show the following numbered sequence: (1) An action potential (red arrow) arrives at the synaptic knob. Calcium channels open in the presynaptic membrane. As the calcium ion concentration inside the bulb is lower than the outside, calcium ions rush in. As the calcium concentration increases,



membrane of the transmitting cell. (3) The fused vesicles release their neurotransmitter molecules (green) into the synaptic cleft. (4) The released neurotransmitter molecules diffuse across the cleft and bind to receptor molecules on the postsynaptic cell surface membrane. (5) Binding of neurotransmitters to the post synaptic neuron receptors opens some channels and, allows Na<sup>+</sup> ions to diffuse across the post synaptic membrane as a result post synaptic membrane depolarizes and, an action potential is generated. Since this depolarization brings the membrane potential towards threshold level, it is called excitatory postsynaptic potential (EPSP).

- (6) Once the neurotransmitters have acted on the postsynaptic membrane, they are immediately broken down by enzymes. like acetylcholine is hydrolyzed by acetylcholinesterase and adrenalin by monoamine oxidase.

**Q6. Give the function of each of the following structures in human brain. (a) Cerebrum (b) Thalamus (c) Hypothalamus (d) Midbrain (e) Medulla.**

**Answer**

### **The Brain**

The brain is divided into three parts, forebrain, midbrain and hindbrain.

Forebrain consists of cerebrum, thalamus and limbic system.

Cerebrum is the largest part of the human brain. Cerebrum is divided into two cerebral hemispheres which are interconnected with each other by a band of axons, called corpus callosum.

Each hemisphere contains four surface lobes: frontal, parietal, temporal and occipital lobe. Each lobe further contains different functional areas e.g., auditory (hearing) visual area etc.. Each functional area consist of three sub-areas i.e., sensory area, association area and motor area. Sensory area receives impulses from different body parts. Association area interprets or analyzes the incoming information. The motor area control responses of the body. Cerebrum also functions in the analysis and interpretation of memory reasoning judgement, thoughts and dreams.

Thalamus is below the cerebrum. It receives all sensory impulses (except sense of smell) and channels them to limbic system and to appropriate regions of the cortex interpretation.

The limbic system is a complex set of structures that lies on both sides of the thalamus, just under the cerebrum. It includes the hypothalamus, the hippocampus, the amygdala, and several other nearby areas. Between limbic system and to ventricle (cavities) are present which are commonly known as lateral ventricles or 1<sup>st</sup> and 2<sup>nd</sup> ventricles. Another cavity called 3<sup>rd</sup> ventricle is present between limbic system and thalamus. On the ventral side of the thalamus is the hypothalamus. It maintains homeostasis and contains centres for regulating hunger, sleep, thirst, body temperature, water balance and blood pressure menstrual cycle and sleep wake cycle. The hypothalamus also controls the pituitary gland and thereby serves as link between the nervous and endocrine system.



Fig. Architecture of human brain

The amygdalae (singular: amygdale) are two almond-shaped masses of neurons on either side of the thalamus at the lower end of the hippocampus. They control feeling and emotions of love, hate, anger, fear, rage and sexual arousal.

The hippocampus consists of two horns that curve back from the amygdale. It appears to be very important in converting things that are in your mind at the moment (in short-term memory) into things that you will remember for the long run (long-term memory).

Midbrain is reduced in humans. It acts as a relay station for tracts passing between the cerebrum and the spinal cord or cerebellum. Midbrain contains reticular formation, which is a relay centre connecting hindbrain with forebrain.

Hindbrain consists of cerebellum, medulla oblongata and pons. Cerebellum controls equilibrium i.e., body position and coordination of the actions of individual muscles to produce complex activities such as walking, running, riding bicycles, doing delicate work with hand. The cerebellum is also involved in learning memory storage for behaviour. Pons acts as a bridge between the cerebellum, medulla and cerebrum. It also controls rate and pattern of heartbeat and breathing. Medulla controls the automatic functions of the body, such as heartbeat, blood pressure, respiration, swallowing etc..

Brain is hollow structure as it has cavities called ventricles. There are four ventricles in the brain.

### Q7. Describe the peripheral nervous system in Man?

#### Answer

The peripheral nervous system consists of the nerves that branch out from the central nervous system and connect it to other body parts. The peripheral nervous system includes cranial nerves which - arise from the brain and the spinal nerves, which arise from the spinal cord.

There are twelve pairs of cranial nerves. Some of these are sensory nerves, some are

originate from the spinal cord. They are all mixed nerves, and they provide two-way communication between the spinal cord and parts of the arms, legs, neck and trunk. Each spinal nerve emerges from the spinal cord by two short branches or roots, which lie within the vertebral column. The dorsal root contains the fibres of sensory neuron, which conduct impulses to the spinal cord. The ventral root contains the fibres of motor neurons, which conduct impulses away from the cord. The two roots join just before a spinal nerve leaves the vertebral column.

Each spinal nerve serves the particular region of the body in which it is located.

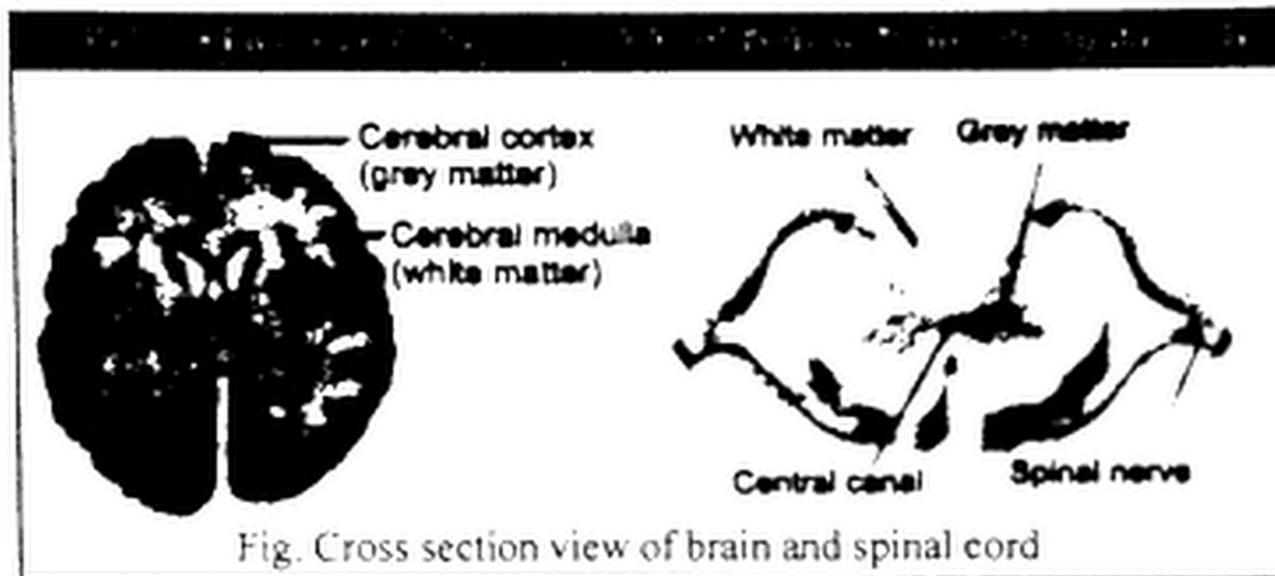


Fig. Cross section view of brain and spinal cord

### Somatic and Autonomic Nervous System

The peripheral nervous system can also be subdivided into the somatic and autonomic nervous systems. Generally, the somatic nervous system consists of the cranial and spinal nerve fibres that connect the CNS to the skin and skeletal muscles; it is involved in conscious activities. The autonomic system includes those fibres that connect the CNS to the visceral organs, such as the heart, stomach, intestines and various glands. It is concerned with unconscious activities. The autonomic system is divided into sympathetic and parasympathetic system. Both of these systems function automatically and usually subconsciously in an involuntary manner.

### Sympathetic Division

The sympathetic division controls various autonomic functions during the state of emergency. It prepares the body for fight or flight response. It consists of only spinal nerves that arise from first thoracic segment (T1) to second lumbar segment (L2) of the spinal cord. They pass into sympathetic ganglia which are organized into two chains that run parallel to and on either side of the spinal cord.

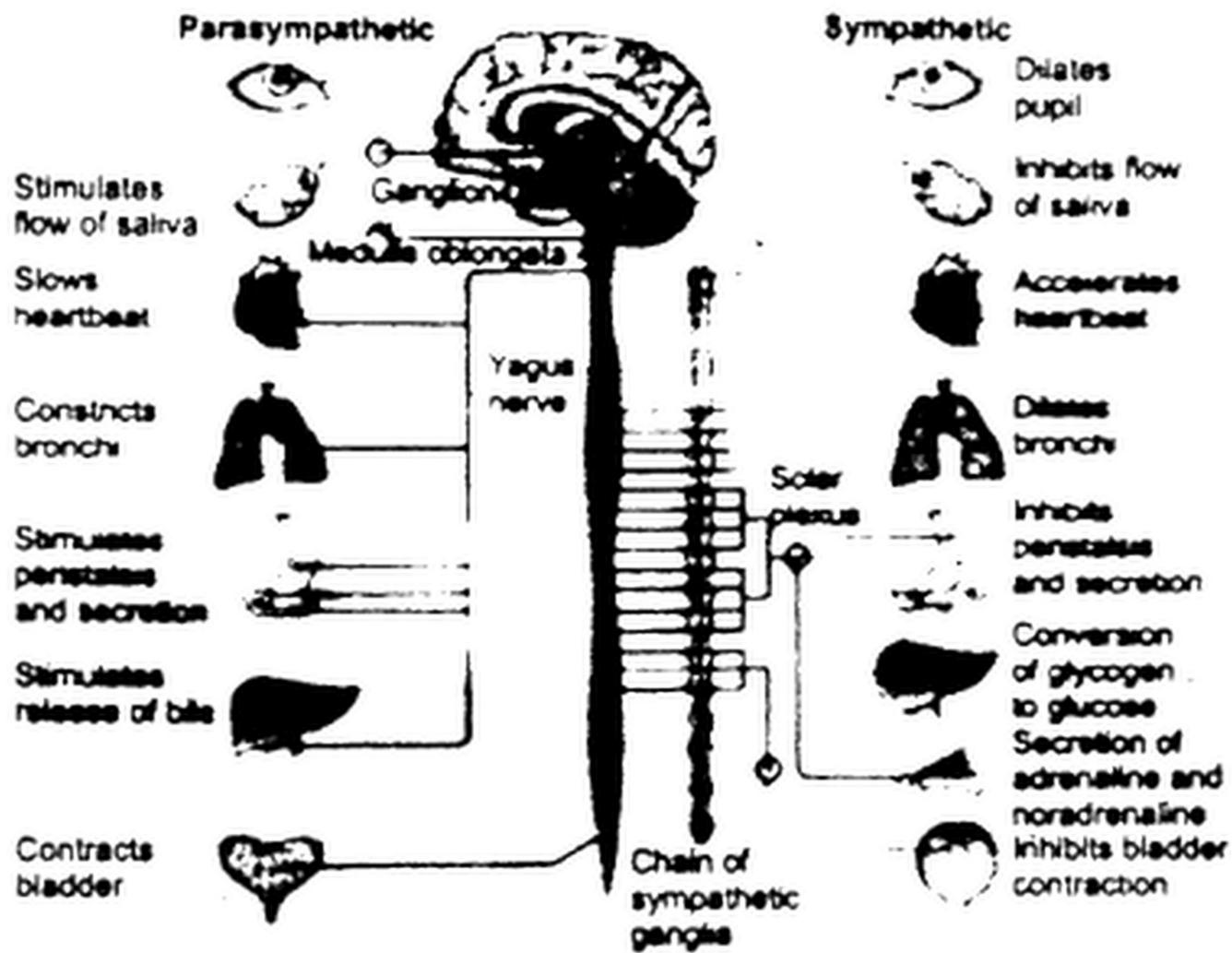


Fig. Autonomic nervous system: structure and function

### Parasympathetic Division

A few cranial nerves, including the vagus nerve, together with nerves that arise from the sacral portion of the spinal cord, form the parasympathetic division. It controls various autonomic functions during the state of rest. In short, the parasympathetic system returns the body functions to normal after they have been altered by sympathetic stimulation. In times of danger, the sympathetic system prepares the body for violent activity. The parasympathetic system reverses these changes when the danger is over.

**Q8. Discuss the sensory receptors of smell, taste, touch and pain in man.**

**Answer**

The body must detect what is occurring inside and outside the body and is performed by sensory receptors. Sensory receptors are for smell, taste, touch and pain.

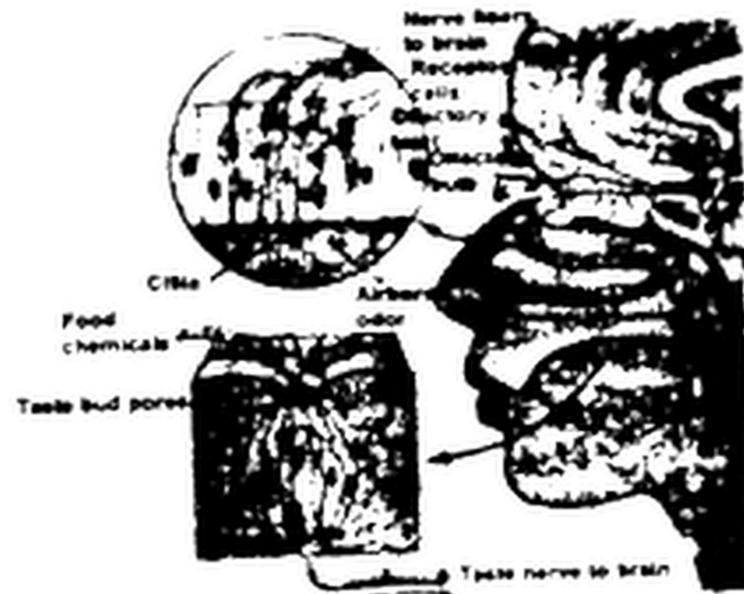
#### i) Olfactory/Smell Receptors

The smell receptors are chemoreceptors, stimulated by chemical dissolved in liquids. The olfactory organs which contain the olfactory receptors, are present in upper part of nasal cavity. The olfactory receptor cells are neurons. These cells are surrounded by columnar epithelial cells having cilia at the distal ends. Chemicals that stimulate the olfactory receptors enter the nasal cavity as gases. They must dissolve at least partially in the watery fluids that surround the cilia before they can be detected. The nerve

smell information from the nose to the brain, and is thus necessary for a proper sense of smell.

### Taste receptors

Taste buds occur primarily on the surface of the tongue and are associated with tiny elevations called papillae. Each taste bud includes a group of modified epithelial cells, the taste cells, the taste cells, which function as receptors. The taste cell has an opening the taste pore on its free surface. Tiny projections, called taste hairs, protrude from outer ends of taste cells and just protrude through the taste pore. There are four primary taste sensations i.e., sweet, sour, salty and bitter, which are situated at various regions on the tongue. All the four regions overlap at certain places.



### Sensory Receptors in Human Skin

The dermis of the skin contains receptors for touch, pressure, temperature and pain. Meissner's corpuscles and Merkel disks are touch receptors. These consist of small, oval masses of flattened connective tissue cells. Two or more sensory nerve fibres branch into each corpuscle. They end as tiny knobs. Meissner's corpuscles are especially numerous in the lips, fingertips, palm, and soles. Paccinians corpuscles are also encapsulated nerve ending present in the fatty layer deep into the skin. They are concerned with sensation of pressure. Receptors for touch and pressure are also called mechanoreceptors.

Pain receptors are technically called nociceptors. Pain receptors are located at the top of the skin in the epidermis area to detect pain. These receptors are naked dendrites that respond to chemicals released by damaged tissues or excess stimuli of heat or pressure. These receptors are widely distributed throughout the skin and inter tissues, except in the tissue of the brain.



Fig. Distribution of taste receptors on tongue

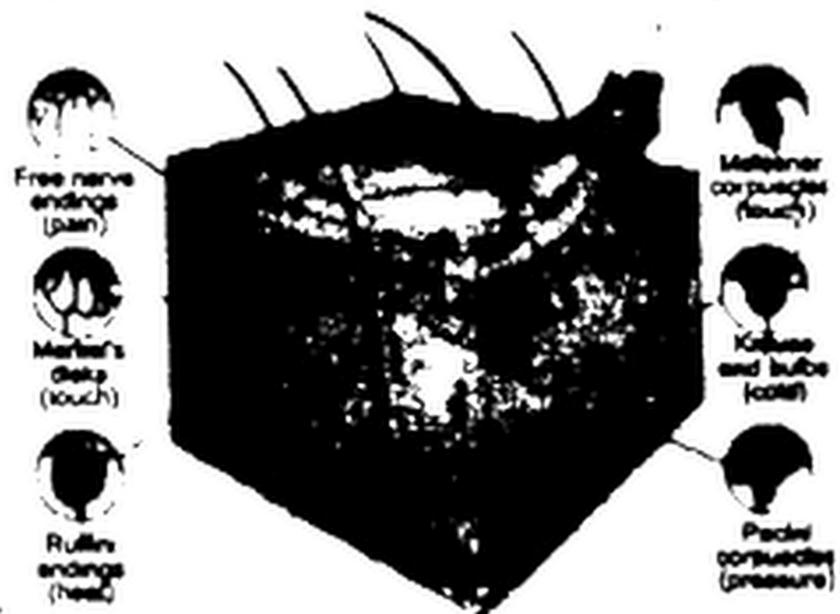


Fig. Receptors in human skin

These receptors are naked dendrites that respond to chemicals released by damaged tissues or excess stimuli of heat or pressure. These receptors are widely distributed throughout the skin and inter tissues, except in the tissue of the brain.

such as Ruffini ending for the sensation of hot and Krause end bulbs for the sensation of cold. Both are encapsulated nerve endings (Fig. 17.16).

### Q9. Explain the effects of nervous coordination in man.

Answer

#### **Effects of Drugs on Nervous Coordination**

A narcotic is a group of substances when administered diminish the perception of pain. Narcotics bind to certain painkilling sites in the brain. With constant use, they build up in the brain and block the production of endorphins, the brain's natural painkilling chemicals. Their side effects are: drowsiness, euphoria (an exaggerated feeling of well being), changes in mood, mental clouding, respiratory depression, nausea, vomiting, inhibition of defaecation and urination, inhibition of the endocrine and autonomous nervous system. Thus narcotics are the drugs that act as agents which interact with the normal nervous activity. Common narcotic drugs are heroin, Cannabis, nicotine, alcohol.

#### **Narcotic Drugs**

##### **Heroin**

It binds to the receptors meant for the endorphins. Heroin gives a feeling of euphoria along with relief of pain. Side effects can include nausea, vomiting, dysphoria (abnormal depression and discontent), and respiratory and circulatory depression leading to death. The addiction of heroin is difficult to treat.

##### **Cannabis**

It is the dried flowering tops, leaves and stem of Indian hemp plant *Cannabis sativa*. It includes marijuana and hashish. Usually the users report a mild euphoria, along with alterations in vision and judgement. Motor incoordination occurs as well as the inability to concentrate and speak coherently. Intoxication is recognised by the presence of hallucinations, anxiety, and depression, rapid flow of ideas, disoriented behaviour, and paranoid reactions. (paranoid is a type of mental disorder characterized by constant delusion).

##### **Nicotine**

It is an alkaloid derived from tobacco. When smoking a cigarette, nicotine is quickly distributed to all body organs, including the CNS and PNS. In the CNS, nicotine causes neurons to release dopamine, a neurotransmitter. The excess of dopamine has a reinforcing effect that leads to the dependence on the drug and a person becomes addict. In peripheral nervous system, nicotine stimulates postsynaptic receptors (like acetylcholine) and leads to increased skeletal muscular activity. It also increases heartbeat rate and blood pressure.

##### **Alcohol**

It is primarily metabolized in the liver, where it disrupts the normal working of glycolysis and the Krebs cycle. The pH of the blood decreases and becomes acidic. Fat accumulation, the first stage of liver deterioration, begins immediately. The immune

cancer are increased. Protein digestion and amino acid metabolism is also upset. Muscle atrophy and weakness results. Fat deposits occur in the heart wall and hypertension develops. There is an increased risk of cardiac arrhythmias (irregular heartbeat) and stroke.

### **Withdrawal Symptoms of Alcohol**

Alcohol withdrawal refers to a group of symptoms that may occur from suddenly stopping the use of alcohol. The symptoms are feeling of nervousness, shakiness, anxiety, irritability, rapid emotional changes, depression, fatigue, headache, pulsating sweating, a state of confusion and hallucinations (visual) etc..

### **Inhalants**

These are volatile organic chemicals, commonly referred to as "glue sniffing". Inhalant abuse now includes a broad range of volatile solvents and gas products (e.g., model airplane glue, paint thinner, gasoline, and nail polish remover), aerosols e.g., hair spray, anaesthetics e.g., ether etc.. Inhalants provide an instant "rush" and, like alcohol, cause euphoria followed by central nervous system depression. Deep breathing of the toxic vapours may result in a loss of self-control, violent behaviour, nausea, unconsciousness, giddiness, loss of inhibition, loss of appetite, and at higher doses, hallucinations.

### **Drug Addiction and Drug Tolerance**

Drug addiction a state of heavy dependence on a drug; sometimes defined as physical dependence but usually also including emotional dependence

#### **Drug Addiction**

Drug addiction is a dependence on an illegal drug or a medication. When you're addicted, you may not be able to control your drug use and you may continue using the drug despite the harm it causes. Drug addiction can cause an intense craving for the drug. You may want to quit, but most people find they can't do it on their own.

#### **Drug Tolerance**

Drug tolerance is a person's diminished response to a drug, which occurs when the drug is used repeatedly and the body adapts to the continued presence of the drug. For instance, when nicotine or caffeine is used for a long time, larger and larger doses must be taken to produce the same effect. Usually, tolerance develops because metabolism of the drug speeds up (often because the liver enzymes involved in metabolizing drugs become more active) and because the number of sites (cell receptors) that the drug attaches to or the strength of the bond (affinity) between the receptor and drug decreases.

### **Effects Drug Addiction and Tolerance on the Central Nervous System**

There are three main types of drug affecting the central nervous system.

**Depressants** are drugs that slow down the functions of the central nervous system. Depressant drugs do not necessarily make a person feel depressed. They include: Alcohol, heroin etc.. In small quantities, depressants can cause the user to feel more

slow down a person's ability to respond to unexpected situations.

**Stimulants** act on the central nervous system to speed up the messages to and from the brain.

They can make the user feel more awake, alert or confident. Stimulants increase heart rate, body temperature and blood pressure. Other effects include reduced appetite, dilated pupils talkativeness, agitation and sleep disturbance. Mild stimulants include, ephedrine used in medicines for bronchitis, caffeine in coffee, tea and cola drinks and nicotine in tobacco etc.. Large quantities of stimulants can "over-stimulate" the user, causing anxiety, panic, seizures, headaches, stomach cramps, aggression and paranoia. Prolonged use of strong stimulants can mask some of the effects of depressant drugs, such as alcohol, making it difficult for a person to judge their effects.

Hallucinogens affect perception. People who have taken them may believe they see or hear things that aren't really there, or what they see may be distorted in some way. Hallucinogens include: *Datura*, *Cannabis* etc..

### **Q10. Discuss the disorders of nervous system in Man.**

**Answer**

#### **Disorders of Nervous System**

The disorders of the nervous system may be classified as vascular, infectious, structural, functional and degenerative. While classifying the site of involvement is also considered. We will discuss here causes, symptoms and treatment of few diseases of the major categories.

#### **Vascular Disorders of the CNS**

Any disorder of nervous system which occurs due to abnormality in blood circulation is called vascular disorder of the nervous system e.g., strokes, brain haemorrhage.

#### **Stroke**

It occurs due to rupture of small perforating cerebral arteries. The cause and risk factors for stroke include hypertension, cigarette smoking, diabetes mellitus, high alcohol intake, thrombosis, blood disorders, blood embolism and cocaine abuse. The symptoms include sudden loss of function in one region of brain. Weakness and heaviness occur in arm, leg or face. Paralysis occurs on the side of the body opposite the cerebral infarct (a portion of the tissue that is dying because of blood supply to it has been cut off). Aphasia (inability to express through in words) may be present. Medical treatment is aimed at preventing further attacks and stroke: Anticoagulants and platelet aggregation inhibitor (such as aspirin) is given. Blood pressure management and nursing care is essential.

#### **Hematoma**

A hematoma or haematoma is a localized collection of blood outside the blood vessels usually in liquid form within the tissue. A hematoma of the skin is larger than 10 mm. Internal bleeding is generally considered to be a spreading of blood within the

## **Infectious Disorders of the CNS**

Infections of the central nervous system can be caused by almost any infectious agent, including viruses, bacteria, fungi, protozoa, and platyhelminthes.

### **Meningitis**

It is an inflammation of the meninges. The cause is that it may be virally induced but more often bacterial. Symptoms usually include stiffness in the neck, headache and fever. In severe cases, meningitis may also cause paralysis, coma or death. For viral meningitis, there is no specific treatment and the condition is usually benign and self-limiting. Recovery usually occurs within days. Spread is by air-borne route, but close contact is necessary.

### **Encephalitis**

Encephalitis is irritation and inflammation of the brain. Aetiology: Encephalitis is most often caused by a viral infection. Many types of viruses may cause it. The most common causes of acute viral encephalitis are rabies virus, Herpes simplex, poliovirus, measles virus, etc.. Symptoms include headache, fever, confusion drowsiness, and fatigue. More advanced and serious symptoms include seizures or convulsions, tremors, hallucinations, and memory problems. Younger children or infants may present irritability, poor appetite and fever. Treatment: The goals of treatment are to provide supportive care (rest, nutrition, fluids) to help the body fight the infection, and to relieve symptoms.

Medications may include: Antiviral medications, Anti-seizure medications, Steroids, Sedatives, Acetaminophen-for fever and headache.

## **Structural Disorders of the CNS**

Several disorders that disturb the structure of brain are referred as structural disorders, such as tumours.

### **Tumour**

It is an abnormal mass of neuroglial cells produced as a result of uncontrolled cell division. It is caused by mutation which may occur at any age in brain and spinal cord. Symptoms vary widely, depending on the location of the tumour but may include headaches, neuralgia (pain along the distribution of a peripheral nerve), paralysis, seizures, coma and death. Treatment is surgical.

## **Functional Disorders of the CNS**

### **Headache**

A headache or cephalalgia is pain anywhere in the region of the head or neck. It can be a symptom of a number of different conditions of the head and neck. The brain tissue itself is not sensitive to pain because it lacks pain receptors. Rather, the pain is caused by disturbance of the pain-sensitive structures around the brain. There are two major categories of headaches i.e., primary headaches (due to the headache condition itself and not due to another cause) and secondary headaches (due to an underlying structural problem in the head or neck such as bleeding in the brain, tumour, meningitis).

painless delivery) which is given during labour). Several analgesic drugs are available for treatment of any kind of headache.

### **Epilepsy**

Epilepsy is a common disorder of the central nervous system characterized by periodic loss of consciousness with or without convulsions.

**Aetiology:** Epilepsy has no identifiable cause in about half of those who have the condition. In the other half, the condition may be traced to various factors such as genetic influence, head trauma, medical disorders, dementia, diseases, prenatal injury, developmental disorders etc. **Symptoms:** Seizures are the only visible symptom of epilepsy. **Treatment:** There is no cure for epilepsy. However, with the right type and strength of medication, the majority of people with epilepsy do not have seizures.

### **Neuralgia**

Neuralgia is a sharp, shocking pain in a nerve pathway. Neuralgia is more common in elderly people, but it may occur at any age. **Aetiology:** Causes of neuralgia include: chemical irritation, chronic renal insufficiency, Diabetes, infections, and syphilis, medications porphyria, pressure on nerves by nearby bones, ligaments, blood vessels, or tumour trauma (including surgery). **Symptoms:** Increased sensitivity of the skin along the path of the damaged nerve, so that any touch or pressure is felt as pain, numbness along the path of the nerve, weakness or complete paralysis of muscles supplied by the same nerve.

**Treatment:** Treatment varies depending on many things, including the cause, location, and severity of the pain. Strict control of blood sugar may speed recovery in people with diabetes. Medications to control pain may include: antidepressant, antiseizure, narcotic analgesics etc..

## **Q11. Describe the causes, symptoms and treatment of stroke, headache, meningitis, brain tumour and Alzheimer disease.**

### **Answer**

Diseases of nervous system are also called neurological disorders. They can be categorized according to the primary location affected, the primary type of dysfunction involved, or the primary type of cause. The broadest division is between central nervous system (CNS) disorders and peripheral nervous system (PNS) disorders. Neurological disorders are classified into following categories:

- Vascular (Stroke)
- Infectious (Meningitis)
- Structural (Brain Tumour)
- Functional (Headache)
- Degenerative (Alzheimer's disease)

### **Stroke**

Brain cell function requires a constant delivery of oxygen and glucose from the bloodstream. A stroke, or cerebrovascular accident (CVA), occurs when blood supply

stroke. The more common kind, called Ischemic stroke, is caused by a blood clot that blocks or plugs a blood vessel in the brain. The other kind, called hemorrhagic stroke, is caused by a blood vessel that breaks and bleeds into the brain. "Mini-strokes" or transient ischemic attacks (TIAs), occur when the blood supply to the brain is briefly interrupted.

### Symptoms of Stroke

- numbness or weakness of the face, arm or leg (especially on one side of the body)
- confusion, trouble speaking or understanding speech
- trouble seeing in one or both eyes
- trouble walking, dizziness, loss of balance or coordination
- severe headache with no known cause

### Treatment

A stroke is a medical emergency. Immediate treatment can save lives and reduce disability, so it is very important for people who are having stroke symptoms to get to a hospital as quickly as possible (within 3 hours after symptoms begin). Treatment depends on the severity and cause of the stroke. In the hospital a CT scan or MRI scan must be done to see whether the stroke is from a clot or from bleeding. Clot-busting drugs (thrombolytic therapy) and blood thinners such as heparin are prescribed for the treatment.



### Meningitis

Meningitis is characterized by inflammation of the protective membranous covering of the brain and spinal cord, the meninges. The inflammation may be the result of infection with viruses, bacteria, or other microorganisms, and less commonly by certain drugs. Meningitis can be life-threatening because the location of inflammation is very close to the brain and spinal cord; therefore the condition is classified as a medical emergency.

### Symptoms

Symptoms usually come on quickly, and may include: fever and chills, mental status changes, nausea and vomiting, sensitivity to light (photophobia), severe headache, stiff neck, agitation, decreased consciousness, poor feeding or irritability in children, rapid breathing, and unusual posture, with the head and neck arched backwards.

### Treatment

Treatment for meningitis depends on the cause.



Fig. Patient with head and neck

and corticosteroids are used as general treatment.

## Brain Tumours

A brain tumor is a mass or growth of abnormal cells due to uncontrolled cell division in the brain. A brain tumor may be benign (noncancerous) or malignant (cancerous). A tumor can originate in brain (primary brain tumors), or it can be originated other parts of the body and spread to the brain (secondary, or metastatic brain tumors).

## Symptoms

The signs and symptoms of a brain tumor vary greatly and depend on the brain tumor's size, location and rate of growth. General signs and symptoms caused by brain tumors may include: new onset or change in pattern of headaches that gradually become more frequent and more severe, unexplained nausea or vomiting, vision problems, such as blurred vision; double vision or loss of peripheral vision, gradual loss of sensation or movement in an arm or a leg, difficulty with balance, speech difficulties, confusion in everyday matters, personality or behavior changes, and hearing problems.

## Treatments and Drugs

Treatment for a brain tumor depends on the type, size and location of the tumor, as well as overall health and preferences. Surgery, radiotherapy and chemotherapy is the general treatment for tumors.

## Headache

A headache or cephalalgia is pain anywhere in the region of the head or neck.

It can be a symptom of a number of different conditions of the head and neck. It is one of the most common locations of pain in the body and has many causes. The brain tissue itself is not sensitive to pain because it lacks pain receptors. Rather, the pain is caused by disturbance of the pain-sensitive structures around the brain. Several areas of the head and neck have these pain-sensitive structures, which are the cranium (the periosteum of the skull, muscles, nerves, arteries and veins, subcutaneous tissues, eyes, ears, sinuses and mucous membranes etc..



Fig: 17.29 Headaches

## Alzheimer's Disease

Alzheimer's disease (AD) is a slowly progressive disease of the brain that is characterized by impairment of memory and eventually by disturbance in reasoning, planning, language, and perception.

Most prominent symptom of Alzheimer's disease is dementia which is characterized by the loss of memory, particularly for recent events (short-term memory). In addition to this mild personality changes, such as less spontaneity, apathy (absence of emotion or enthusiasm), and a tendency to withdraw from social interactions, may occur early in the illness. As the disease progresses, problems in abstract thinking and in other

working on bills, with understanding what is being read, or with organizing the day's work.

Further disturbances in behavior and appearance may also be seen at this point, such as agitation, irritability, quarrelsomeness (having different point of view than others), and a diminishing ability to dress appropriately.

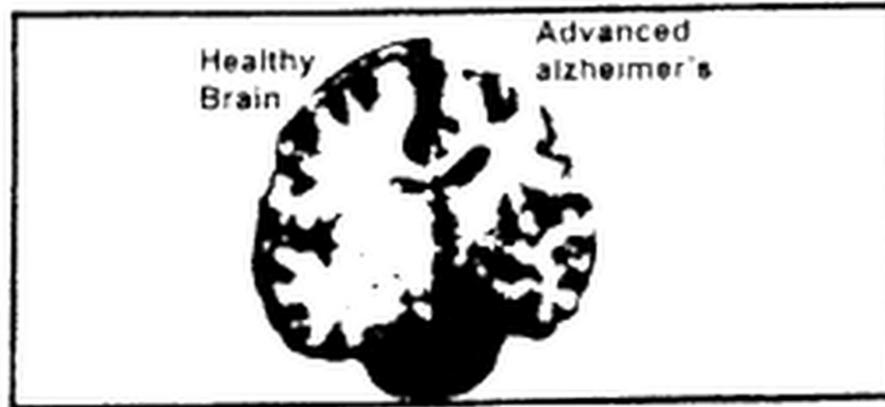


Fig. Massive cell loss changes the whole brain in advanced Alzheimer's disease.

### Causes and Risk Factors

The likelihood of having Alzheimer's disease increases substantially after the age of 70 and may affect around 50% of persons over the age of 85. Nonetheless, Alzheimer's disease is not a normal part of aging and is not something that inevitably happens in later life. For example, many people live to over 100 years of age and never develop Alzheimer's disease.

Many scientists believe that Alzheimer's disease results from an increase in the production or accumulation of a specific protein (beta-amyloid protein) in the brain that leads to nerve cell death. The onset of Alzheimer's disease is usually gradual, and it is slowly progressive.

**Q12. Explain the principles of the following diagnostic tests of nervous disorders EEG, CT scan and MRI.**

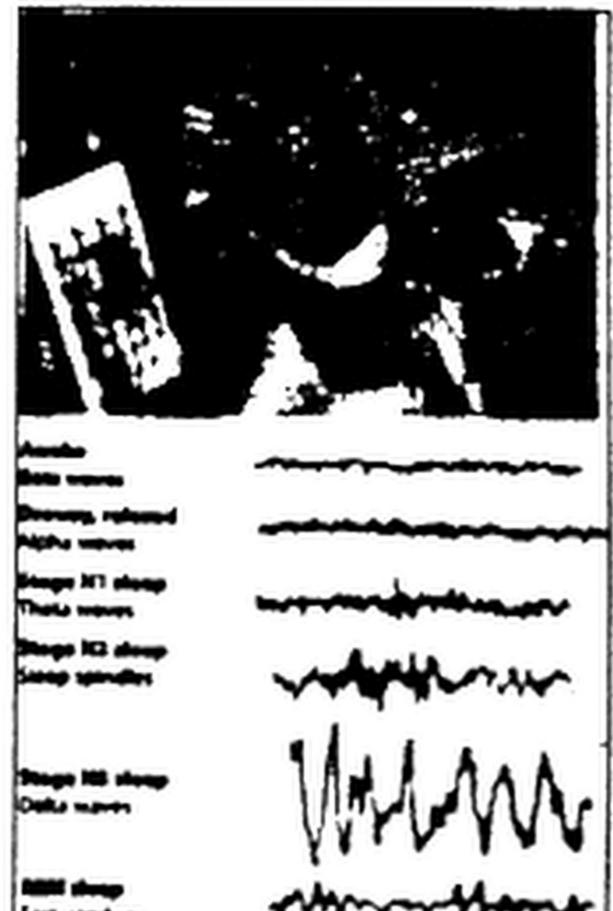
**Answer**

### Diagnostic Test for Nervous Disorders

These days number of diagnostic tests have been developed for nervous disorders. Some of them which are commonly used are given below.

#### Electroencephalography

Neurons within the cerebral cortex continuously generate electrical activity. This activity can be recorded by electrodes attached to precise locations on the scalp, producing electroencephalogram and this technique is called electroencephalography (EEG). An EEG pattern is commonly called brain waves. The EEG regular patterns are classified as



waves occur in deep sleep, in infancy and in patient with severe brain disorder. Distinct types of EEG patterns can be detected in patients with specific brain disorders such as epilepsy.

### Computed Tomography Scan

Computerized (or computed) tomography (CT), and often formerly referred to as computerized axial tomography (CAT) scan, is an X-ray produce that combines many X-ray images with the aid of a computer to generate cross-sectional views, and, if needed, three-dimensional images of the internal organs and structures of the body.

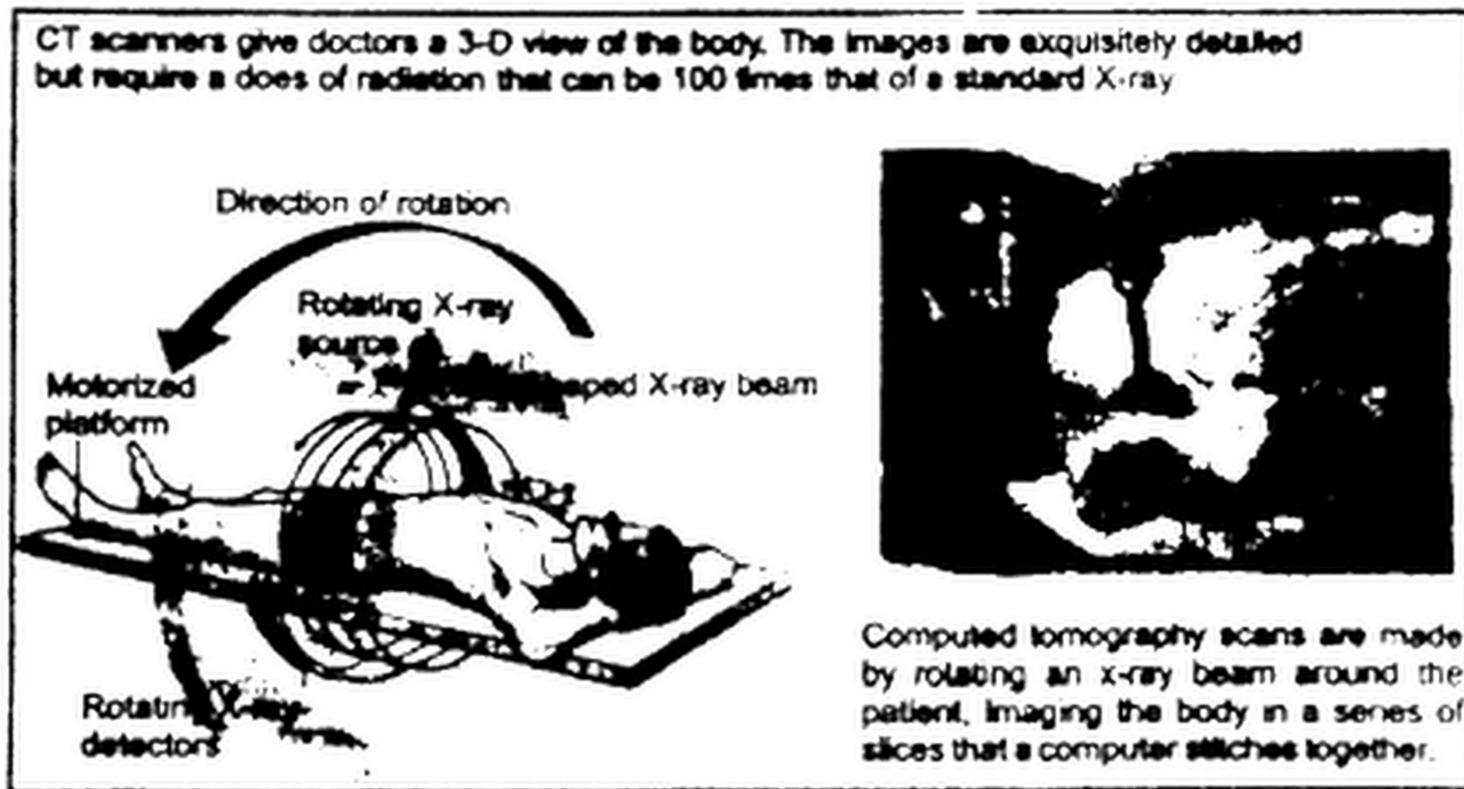


Fig. CT scans

Computerized tomography is more commonly known by its abbreviated names, **CT scan** or **CAT scan**. A CT scan is used to define normal and abnormal structure in the body and/or assist in procedures by helping to accurately guide the placement of instruments or treatments.

A large donut-shaped X-ray machine or scanner called tomograph takes X-ray images at many different angles around the body (see the Fig. 17.18). These images are processed by a computer to produce cross-sectional pictures of the body. In each of these pictures the body is seen as an X-ray "slice" of the body, which is recorded on a film. This recorded image is called a tomogram.



Fig. 17.19 MRI scanner

magnetism, radio waves, and a computer to produce images of body structures. The MRI scanner is a tube surrounded by a giant circular magnet. The patient is placed on a moveable bed that is inserted into the magnet. The magnet creates a strong magnetic field that aligns the protons of hydrogen atoms, which are then exposed to a beam of radio waves. This spins the various protons of the body, and they produce a faint signal that is detected by the receiver portion of the MRI scanner. The receiver information is processed by a computer, and an image is produced. The image and resolution produced by MRI is quite detailed and can detect tiny changes of structures within the body. For some procedures, contrast agents, such as gadolinium, are used to increase the accuracy of the images.

## ADDITIONAL QUESTIONS

### Q13. What are generative disorders of the CNS?

Answer

#### **Degenerative Disorders of the CNS**

Many diseases cause degeneration in different part of the nervous system without an identifiable external cause. Genetic factors are known to be involved. Example of such diseases is Alzheimers disease.

#### **Alzheimers Disease**

Alzheimer's disease (AD) is a slowly progressive disease of the brain that is characterized by impairment of memory and eventually by disturbances in reasoning, planning, language, and perception. Although onset of this disease occurs in aged peoples but it is not particularly associated with aging. There is genetic predisposition or cause in many peoples, so tends to run in families. Most prominent symptom of Alzheimers disease is dementia which is characterized by the loss of memory, particularly for recent events (short-term memory). There is no effective treatment for this disease.

#### **Parkinsons Disease**

Parkinson's disease is a disorder of the brain that leads to shaking (tremors) and difficulty with walking, movement and coordination. Parkinson's disease most often develops after age 50. Sometimes Parkinson's disease occurs in younger adults. It affects both men and women. Aetiology: Nerve cells use a brain chemical called dopamine to help control muscle movement. Parkinson's disease occurs when the nerve cells in the brain that make dopamine are slowly destroyed. Without dopamine, the nerve cells in that part of the brain cannot properly send messages. This leads to the loss of muscle function. The damage gets worse with time. Symptoms: Symptoms may be mild at first. Symptoms may affect one or both sides of the body. Symptoms include: Slow blinking, constipation, difficulty swallowing, drooling (spittle running from the mouth), problems with balance and walking, no expression in the face, muscle aches and pains, shaking, called tremors, slowed quieter speech and monotone voice, stooped position etc.

control symptoms. Medications control symptoms, mostly by increasing the levels of dopamine in the brain. Lifestyle changes may be helpful for Parkinson's disease. Surgery may be an option for some patients with Parkinson's disease.

### Multiple Sclerosis

Multiple sclerosis (MS) is a nervous system disease that affects the brain and spinal cord. It damages the myelin sheath, the material that surrounds and protects the nerve cells. This damage slows down or blocks messages between the brain the body. Symptoms: The symptoms of MS include: Visual disturbances, muscle weakness, trouble with coordination and balance, sensations such as numbness, prickling, or "pins" and needles" and thinking and memory problems. Aetiology: It may be an autoimmune disease, which happens when the body attacks itself. It often begins between the ages of 20 and 40. Usually, the disease is mild, but some people lose the ability to write, speak or walk Treatment: There is no cure for MS, but medicines may slow it down and help control symptoms. Physical and occupational therapy may also help.

### Huntingtons Disease

Huntington's disease is a progressive brain disorder caused by a single defective gene on chromosome 4. This defect is dominant. Aetiology: The defective gene codes the blueprint for a protein called huntingtin. Defective huntingtin protein leads to brain changes that cause abnormal involuntary movements, a severe decline in thinking and reasoning skills, and irritability. Symptoms: Symptoms of Huntington's disease usually develop between ages 30 and 50, but they can appear as early as age 2 or as late as 80. The hallmark symptom of Huntington's disease is uncontrolled movement of the arms, legs, head, face and upper body.

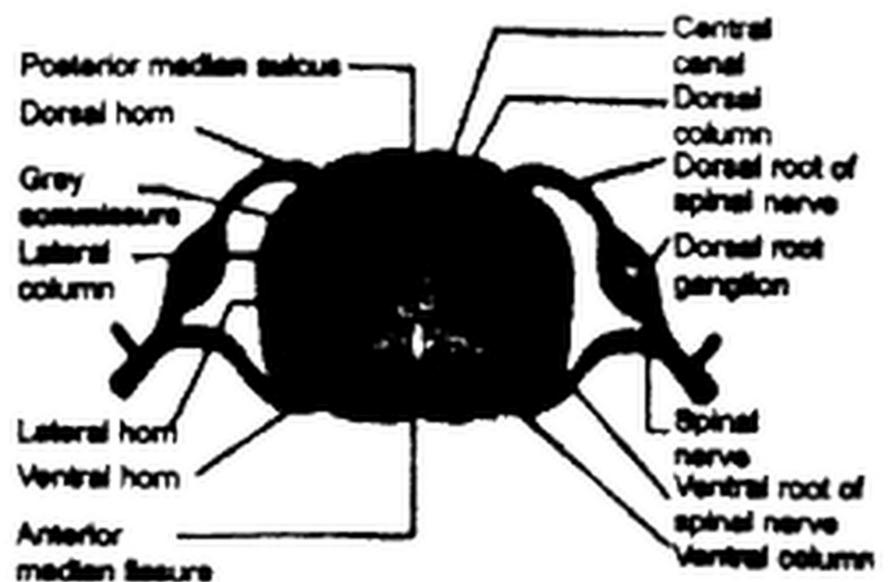
Treatment: There is currently no cure for Huntington's disease. Treatments focus on managing symptoms.

## Q14.What is a role of spinal cord in coordination between body and brain?

Answer

### Spinal Cord

The spinal cord is the most important structure between the body and the brain. The spinal cord extends from the foramen magnum (a hole in the bottom of skull) where it is continuous with the medulla to the level of the first or second lumbar vertebrae. It is a vital link between the brain and the body, and from the body to the brain. A transverse section of the



inside, and a tiny central canal filled with CSF at its center. Surrounding the canal is a single layer of cells, the ependymal layer. Surrounding the ependymal layer is the grey matter a region containing cell bodies shaped like the letter H or a butterfly. The two wings of the butterfly are connected across the midline by the dorsal grey commissure and below the white commissure. As in the other part of the nervous system, the grey matter consists of neuron cell bodies and non-myelinated parts of the fibres. The white matter is made up of bundles of myelinated fibres. White matter shows deep grooves from both side i.e., from dorsal side to the central canal and from ventral side to the central canal. These grooves are called posterior median sulcus and anterior median sulcus respectively. The grey matter is divided into four main columns: dorsal horn, intermediate column, lateral horn and ventral horn column. Several pairs of spinal nerves originate from ventral horn. Similarly several pairs of spinal nerves join the spinal cord through dorsal horn of grey matter. Dorsal root of spinal nerves, also contain ganglia present just beside the spinal cord.

**Q15. What is a role of local circuits in saltatory conduction of nerve impulse?**

Answer

### **The Role of Local Circuits in Saltatory Conduction of Nerve Impulse**

The "local circuit," explains how the action potential (AP) is transmitted along the neurone. Basically an action potential at a point in the axon, develops a local circuit because, the influx of sodium ions at that point makes that particular point positively charged. However, regions around that point are still negatively charged (because they are still in the "resting potential formation"). The sodium ions at the point of AP are then attracted to these negatively charged regions, hence setting up a "local circuit" at those regions. This circuit then opens the sodium channels at these points, sodium ions flow in and the whole AP cycle continues, hence the AP moves along the axon.

In myelinated axon at the nodes of Ranvier local circuits are set up and current flows across the axon membrane to generate the next action potential. This means, in effect, that the action potential jumps from one node to node and passes along the myelinated axon faster than the series of smaller local currents in a non-myelinated axon. This type of conduction is called saltatory conduction (saltare, to jump) and can lead to conduction speeds of up to  $120 \text{ ms}^{-1}$ .

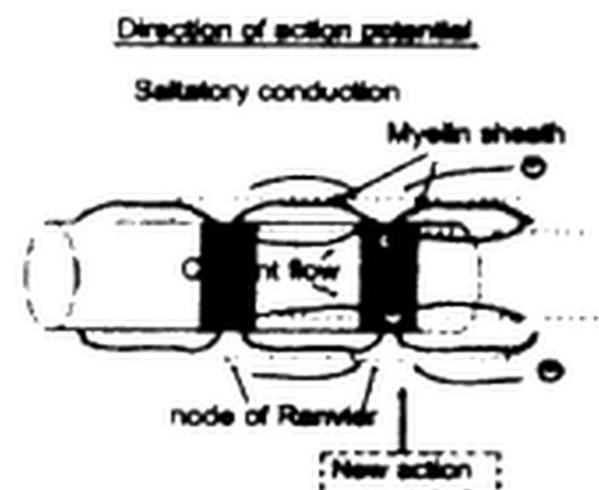


Fig. Role of local circuit in saltatory conduction

**Q16. a) What is the classification of neurotransmitters?  
b) What is the basic organization of human nervous system?**

## Classification of Neurotransmitters

Neurotransmitters are classified as excitatory and inhibitory. Neurotransmitters that cause increased membrane permeability to sodium ions and thus, trigger nerve impulses are said to be excitatory. Acetylcholine is an excitatory neurotransmitter of peripheral nervous system whereas biogenic amines derived from amino acids are important neurotransmitters in central nervous system. They include epinephrine, norepinephrine, serotonin and dopamine, all of which also function as hormones. Epinephrine and norepinephrine increase the heartbeat rate during stress. Serotonin and dopamine affect sleep, mood, attention and learning. Other neurotransmitters cause decreased membrane permeability to sodium ions thus causing the threshold of stimulus to be raised. This action is called inhibitory; because it lessens the chance that nerve impulse will be transferred to an adjoining neuron e.g., amino acids gamma-aminobutyric acid (GABA) and glycine. The endonephrins are peptides that function as both neurotransmitters and hormones, decreasing our perception of pain.

### b) Basic Organization of Human Nervous System

The human nervous system consists of central nervous system (CNS) and peripheral nervous system (PNS). The CNS is a coordinating centre and it lies in the midline of the body whereas the PNS transmits information from receptors to CNS and transmits orders and commands from CNS to effectors. An outline of nervous system is given in figure 17.9.

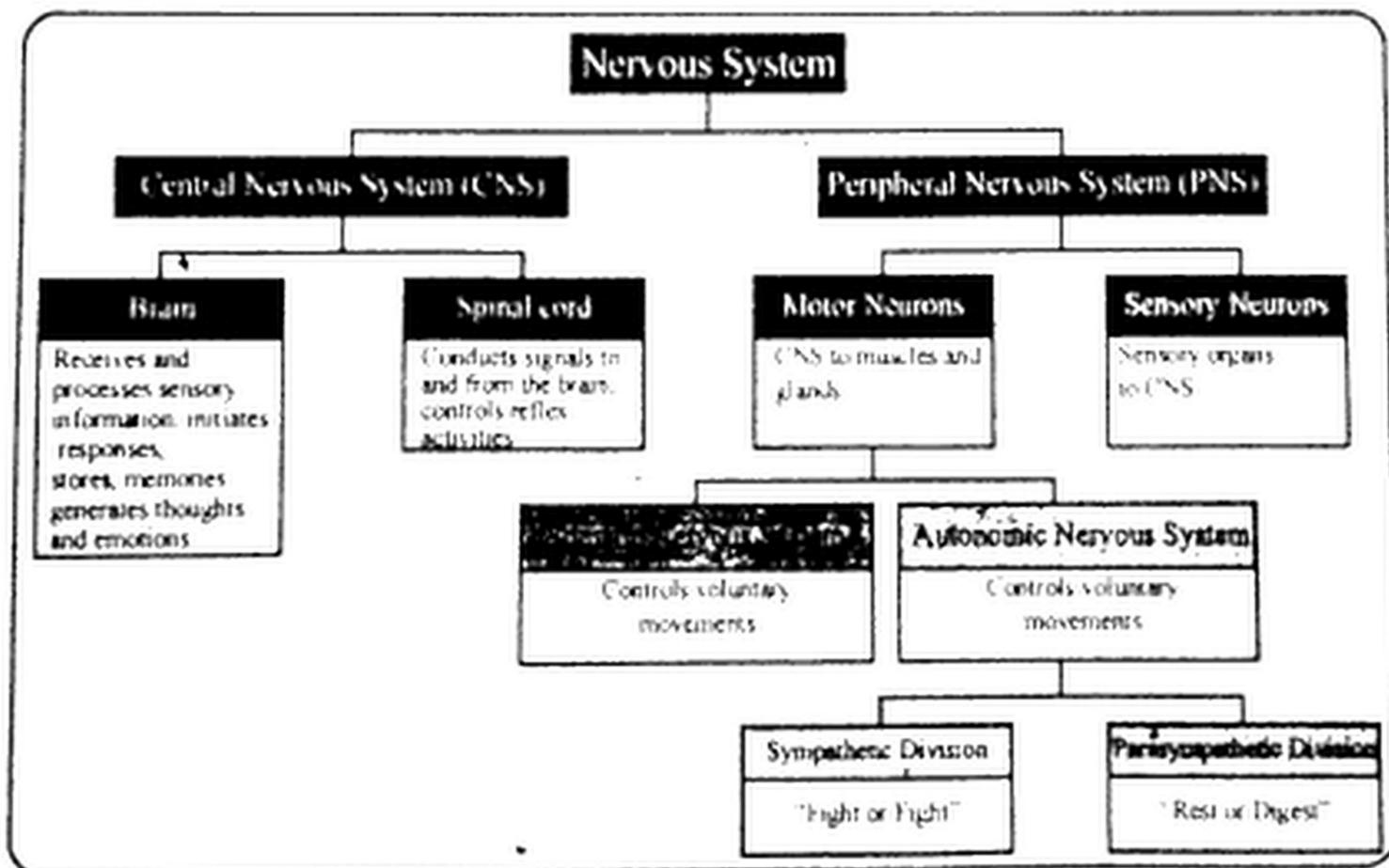


Fig. Division of human nervous system

**Q17.a) Justify the way nervous system helps to coordinate complex and intricate movement and intricate movement of hand to play a piano or write alphabets.**

**b) Justify that the development of a modern computer is in fact**

**knowledge has helped man to treat diseases like epilepsy, paralysis.**

**Answer**

- a) Different sensory information is collected by the sensory receptors and ultimately transmitted to the central nervous system. Here, the signals are integrated: that is they are brought together, creating a sensation (perceptions), adding to the memory or helping to produce thoughts. As a result of this integrative function, conscious or subconscious decisions are made and then acted upon by effector, i.e., muscles that contract when stimulated by impulses. Thus hand and fingers move, so that we may play a piano or write alphabets.
- b) Electronic computers have input circuits that are comparable to the sensory input and output circuits are comparable to the motor output of the nervous system. In simple computers, the output signals are controlled directly by the input signals, operating in a manner similar to that of simple reflexes of the spinal cord. In complex computer, there is a unit called central processing unit (CPU), which determines the sequence of all operations. This unit is analogous to the mechanism in our brain. The basic components of the general-purpose computer are analogous to those of the human nervous system. With the help of modern knowledge of computer, several diagnostic techniques have now been developed such as CT scan, MRI scan, EEG and it has now become possible to diagnose and treat many diseases like epilepsy, paralysis etc..

## KEY POINTS

- Nervous coordination in higher animal consists of reception of stimulus, processing/analysis of information and response to stimulus.  
Receptors are classified into different types on the basis of stimuli.
- Those parts of the body which produce an appropriate response are called effectors (muscles and glands).
- Although more than 50% of nervous system consists of neuroglial (neuroglia) cells, but the neuron is considered as chief structural and functional unit of nervous system.
- Neuron having only one fiber radiating from cell body is called unipolar neuron, while those having two fibers called bipolar and those having many fibers are called multipolar.
- The pathway of nerve impulse during reflex action is called reflex arc.
- Nerve impulse is a wave of electrochemical change that travels along the length of neuron, from one end to the other. For conduction it uses electricity made with chemical ions and molecules ( $\text{Na}^+$ ,  $\text{K}^+$ , and charge bearing organic molecules).
- Nerve impulses are of two types: continuous impulse and saltatory impulse.
- Synapses is the junction between axon terminal of one neuron and the dendrite of another neuron, where information from one neuron is transmitted or relayed (handed over) to another neuron.

