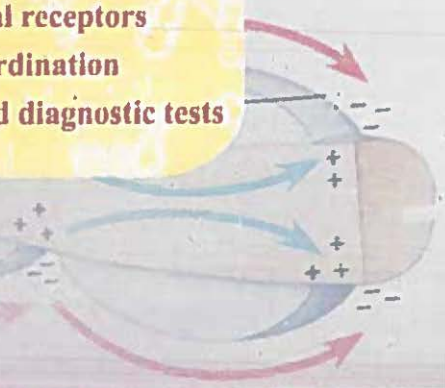
UNIT 17

NERVOUS COORDINATION

KEY CONCEPTS

17.1 Steps involved in nervous coordination
17.2 Neurons
17.3 Nerve impulse
17.4 Synapse
17.5 Basic organization of human nervous system
17.6 Structure and function of special receptors
17.7 Effects of drugs on nervous coordination
17.8 Disorders of nervous system and diagnostic tests



The body of an animal frequently exposed to variety of stimuli in its daily life. For an appropriate response to a particular stimulus, usually more than one body parts are involved, their activities are coordinated either by nervous system or endocrine system or both. These two types of coordination you also have studied in class 10 to some extent, but in this chapter we are mainly focusing the human nervous system.

17.1 STEPS INVOLVED IN NERVOUS COORDINATION

Nervous coordination mainly comprises highly specialized cells, called the neurons. The function of a neuron is to detect and receive stimuli from different sensory organs (receptors) and then, integrate them to determine the mode of response of the living organism, and then commands for an appropriate response are transmitted to the other organ (effectors). Nervous coordination in higher animals is therefore consists of following steps.

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

17.1.1 Reception of stimulus:

Those parts of the body that receive stimuli from internal or external environment are called receptors or transducers. 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.

Classification of receptors:

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 osmotic pressure of blood.

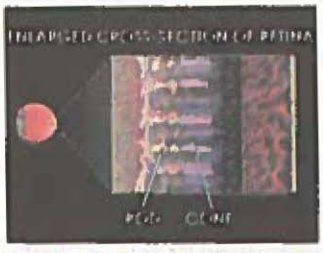


Fig: 17.1 Photoreceptors present in the eye.

- **Mechanoreceptors** detect changes in pressure, position, or acceleration; include receptors for touch (Meissner's corpuscles in skin), stretch or pressure (Pacinian's corpuscle in skin & baroreceptor in the wall of blood vessels), hearing, and equilibrium (ear).

- **Thermoreceptors** detect temperatures stimuli. They are mostly found in the skin.
- **Nociceptors** detect pain.

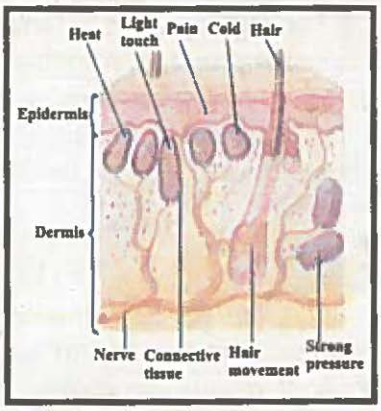


Fig: 17.2 Receptors present in the skin.

17.1.2 Processing/analysis of information:

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

17.1.3 Response to stimulus:

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).

17.2 NEURONS

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. These specialized cells are the information-processing units of the nervous system responsible for receiving and transmitting information from receptors and effectors. A typical neuron consists of a cell body (soma) and fibrous structures called dendrites and axons.

Dendrites are cytoplasmic extensions at the beginning of a neuron that help to increase the surface area of the cell body. Dendrites are usually very thin fibers and have no association of Schwann cells hence they are non myelinated. These fibers receive information from receptors and transmit them to the cell body.

The soma or cell body is where the signals from the dendrites are collected and pass to the axon. The cell body contains single nucleus, many mitochondria, microtubules, neurofibrils and Nissl's granules (collection of group of ribosomes associated with rough ER and Golgi apparatus).

The axon is the elongated fiber that extends from the cell body to the terminal endings and transmits the neural signal to the next neuron. Axons are thick fibers and comparatively have more cytoplasm (axoplasm) than dendrites. Usually axons are covered by Schwann cells (neuroglia), which are strip like cells wrapped around axon fibers.

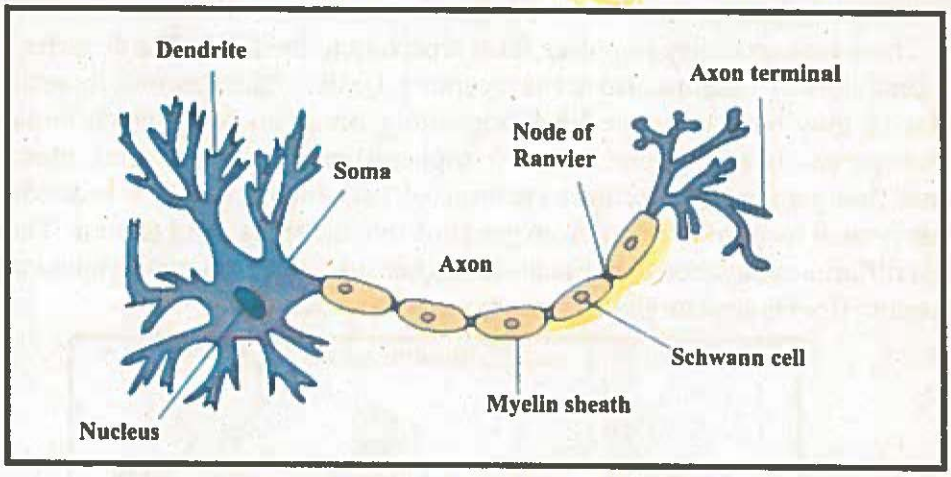


Fig: 17.3 Structure of a typical neuron.

These cells are also covered by a fatty substance called myelin sheath that acts as an insulator. This is why axons are called myelinated fibers. A non myelinated part of axon between two Schwann cells is called node of Ranvier. Velocity of impulse in axon fiber depends upon the diameter, length and myelin sheath.

The larger and thicker the axon, the faster it transmits information. The myelinated axons transmit information much faster than other neurons.

However, all neurons vary somewhat in size, shape, and characteristics depending on the function and role of the neuron.

Some neurons have few dendritic branches, while others are highly branched in order to receive a great deal of information.

Some neurons have short axons, while others can be quite long. 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. Based upon function neurons are three types.

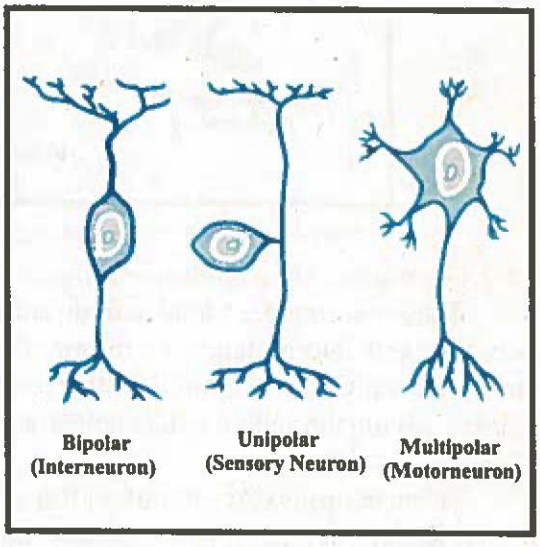


Fig: 17.4 Basic neuron types

17.2.1 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 mono polar i.e they have only one fiber originating from cell body which immediately gives rise 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.

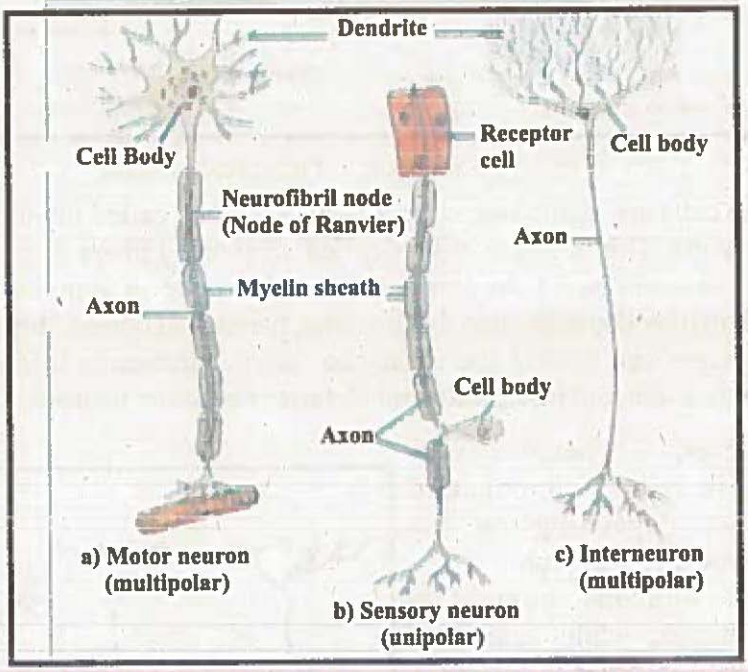


Fig: 17.5 Three types of neurons based upon functions.

17.2.2 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.

17.2.3 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.

17.2.4 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 sensory neuron. An associative neuron in the spinal cord is stimulated, which in turn stimulates the motor neuron,.

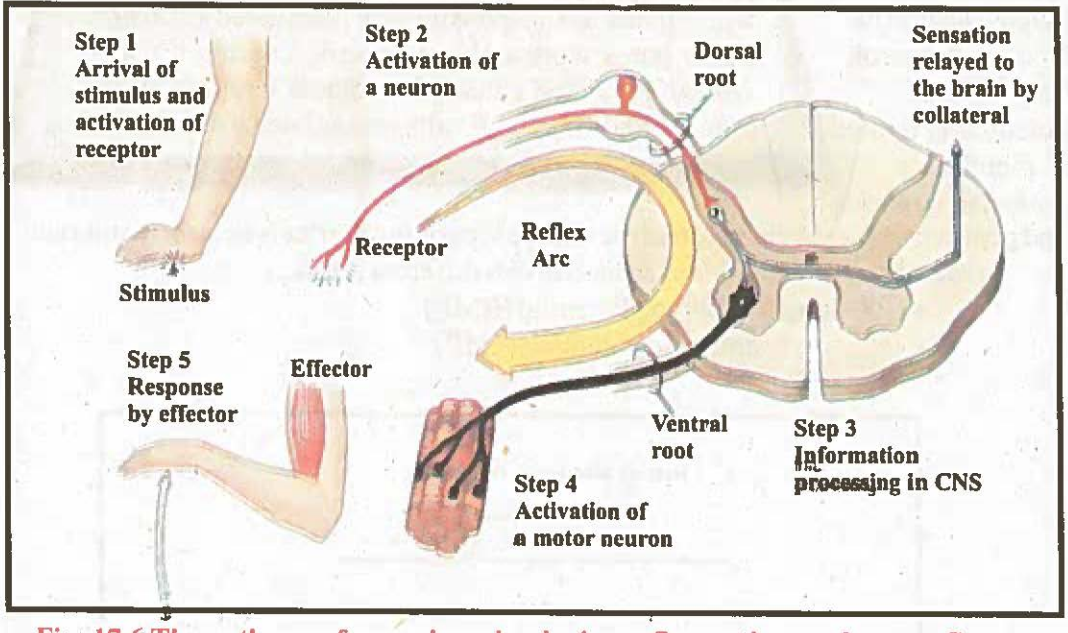


Fig: 17.6 The pathway of nerve impulse during reflex action makes a reflex arc.

The axon of the motor neuron carries impulse to the bicep muscles (effectors), causing them to contract and withdraw the body part from damaging stimulus. The sensory neuron also make a synapse on associative neuron not involved in the reflex that carry signals to the brain, inform it to the danger.

17.3 NERVE IMPULSE

Nerve impulse is information 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 change that travels along the length of neuron, from one end to the other. In nerve impulse conduction, electrochemical means that it uses electricity made with chemical ions and molecules (Na^+, K^+, and charge bearing organic molecules).

A neuron possesses electrical potential which 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, negative and positive ion act as charges and the charge separating barrier is neuron membrane.

For Your Information

The transmission of impulse along the neuron requires the movement of ions across the membrane. This is carried out by tiny holes called channels. These channels basically are of two different types i.e. pumps and gates. Pumps perform active transport while gates are responsible for facilitated diffusion. Some gates work only in specific condition called voltage regulated gates while others function all the time are known as non-voltage regulated gates.

Membrane potential is exhibited in two different forms:

- Resting Membrane Potential (RMP)
- Active Membrane Potential (AMP)

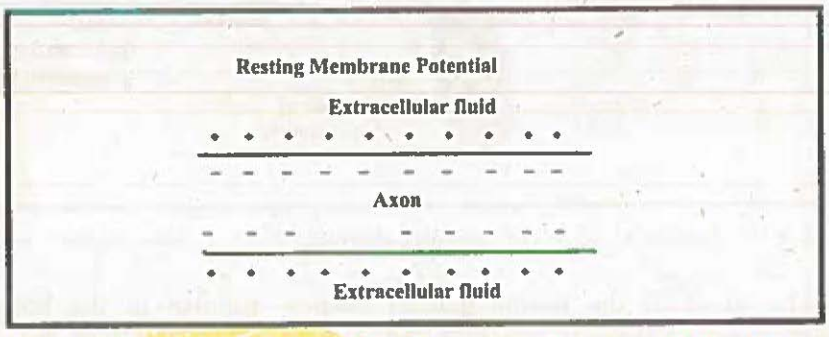


Fig: 17.7 Negative and positive ion act as charges and the charge separating barrier is neuron membrane.

17.3.1 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 millivolts (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:

17.3.2 Distribution and active movement of Na^+ and K^+ ions:

The concentration of potassium (K^+) is 30 times greater in the fluid inside the cell than outside and the concentration of sodium ions (Na^+) is nearly 10 times greater in the fluid outside the cell than inside.These ions are continuously moved against their concentration gradient through active transport pumps by the expenditure of energy. For every two K^+ that are actively transported inward, three Na^+ are pumped out. So inside becomes more negative than outside of the neuron membrane.

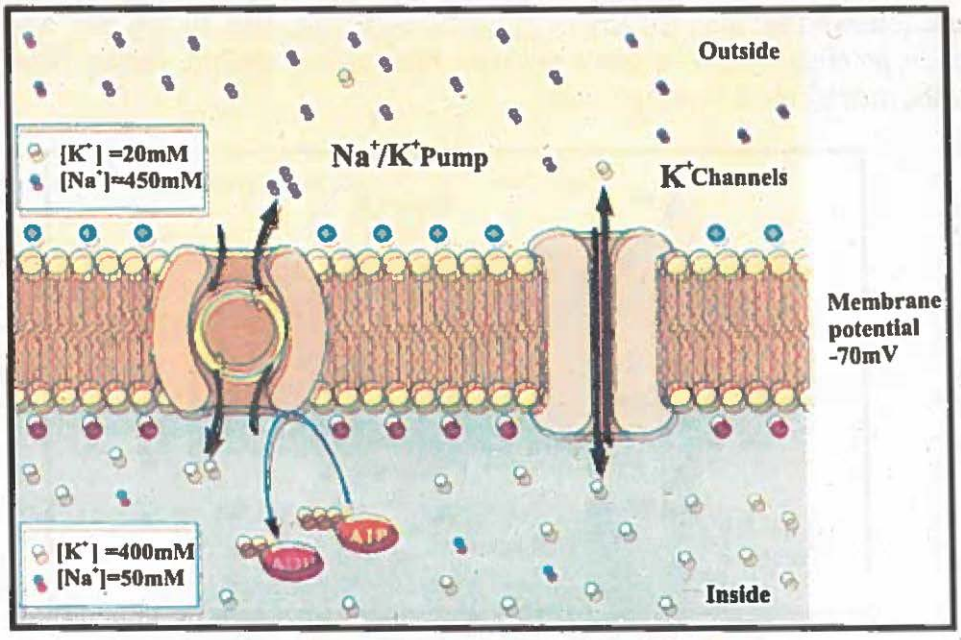


Fig: 17.8 Resting membrane potential.

17.3.3 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, RNA and DNA. Presence of these ions in the neuron cytoplasm makes inside of neuron more negative than outside.

17.3.4 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.

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 a sufficiently strong stimulus (threshold), then action potential will occur.

17.3.5 Development of active membrane potential:

Active membrane potential (also called as 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 pervious 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.

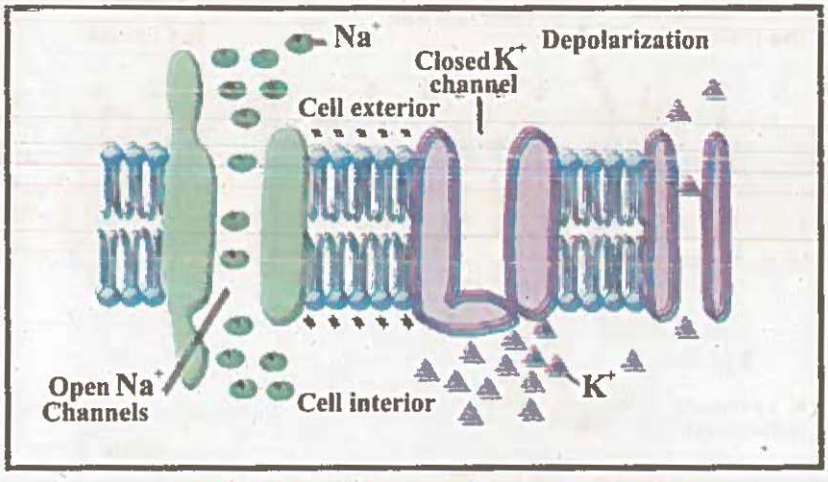


Fig: 17.9 Active membrane potential

17.3.6 Threshold stimulus:

If a stimulus is capable to bring an electrochemical change on neuron or to excite a given tissue, it 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.

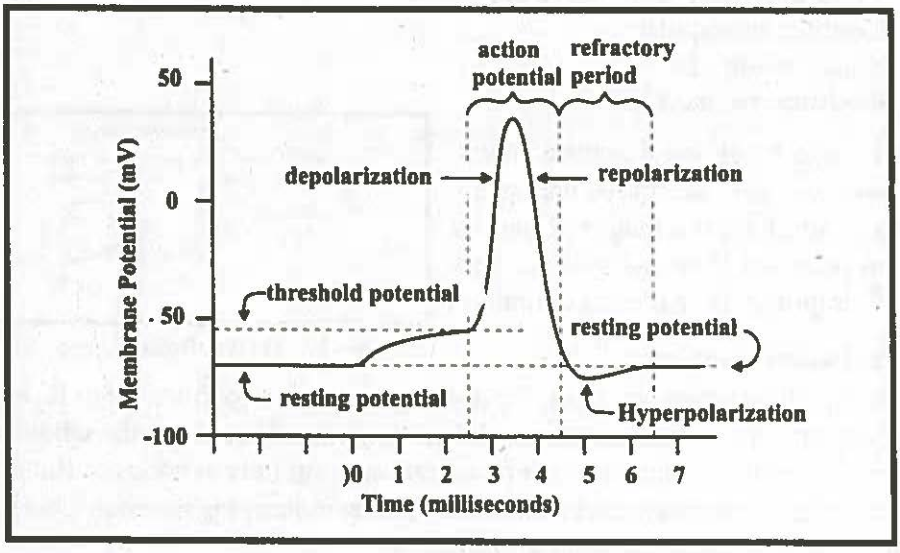


Fig: 17.10 Action Potential in a Neuron.

17.3.7 Influx of Na^+ ions:

When a neuron fiber is stimulated by a stimulus of adequate strength (threshold stimulus), the stimulated area of the fiber becomes several times more permeable to Na^+ than to the K^+ due to the opening of voltage regulated Na^+ gates. As a result Na gates permit the influx of Na^+ ions by diffusion. Since there are more 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 milli second till the Na^+ gates are not closed.

After the peak of action potential, called the spike potential, the permeability of the membrane to Na^+ decreases, while it becomes more permeable to K^+ which rapidly diffuses out from cytoplasm to extracellular fluid due to the opening of K^+ gates. Now Na^+ gates are closed. Soon this part of neuron membrane regains its original polarity and becomes electropositive on outside and electronegative on inside. This is called repolarization.

17.3.8 Refractory period:

After an action potential, nerve fiber 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 fiber is called refractory period.

17.3.9 Types of Nerve Impulse:

There are two types of nerve impulses:

i. Continuous impulse
ii. Saltatory impulse

I. Continuous impulse:

In non myelinated neuron fibers, the K^+ and Na^+ ions can move across the membrane all along the length of neuron so action potential flows as a wave. This type of impulse is called continuous impulse.

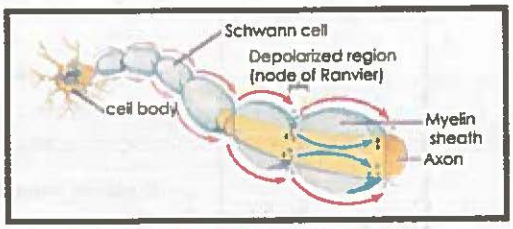


Fig: 17. 11 Myelinated neuron

II. Saltatory impulse:

In myelinated neuron fiber, the myelin sheath is impermeable to K^+ and Na^+ ions, so prevents the ionic exchange and depolarization fiber along the whole length of neuron. The ionic exchange and depolarization occur only at nodes of Ranvier. So the action potential is conducted from node to node in jumping manner. This kind of jumping impulse is called saltatory impulse.

Speed of nerve impulse: Speed of nerve impulse is different in different neuron fibers and depends upon the morphology of nerve fibers. Average speed of nerve impulse is 100 to 120 meter per second.

- The speed of nerve impulse is faster (about 20 times) in myelinated neuron fiber due to salutatory conduction. Another reason that myelinated fibers conduct faster impulse is that myelin sheath acts as an insulating sheath and prevents loss of energy, so myelinated neuron fibers require less energy.
- Speed of nerve impulse also depends upon diameter of neuron fibers. Thick neuron fibers conduct faster impulse than thin fibers because resistance to electrical current flow is inversely proportional to the cross sectional area of the conductor (such as wire or a neuron fiber), so with the increase in thickness of neuron fibers there is decrease in resistance of fiber to nerve impulse.

17.4 SYNAPSE

In most cases, action potentials are not transmitted from one neuron to another or from neuron to other cells. However, information is transmitted, and this transmission occurs at synapses. This 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, but there is no cytoplasmic connection between the two neurons instead a microscopic gap is present.
There are two types of synapses:

- Electrical synapses
- Chemical synapses

17.4.1 Electrical synapses:

In electrical impulses, which are specialized for rapid signal transmission, the cells are separated by a gap, the synaptic cleft, of only 0.2 nm, so that an action potential arriving at the pre synaptic side of cleft, can sufficiently depolarize the post synaptic membrane to directly trigger its action potential.

17.4.2 Chemical synapses: 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.

17.4.3 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 Ca^{2+} to diffuse into the synaptic knob. The resulting rise in 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.

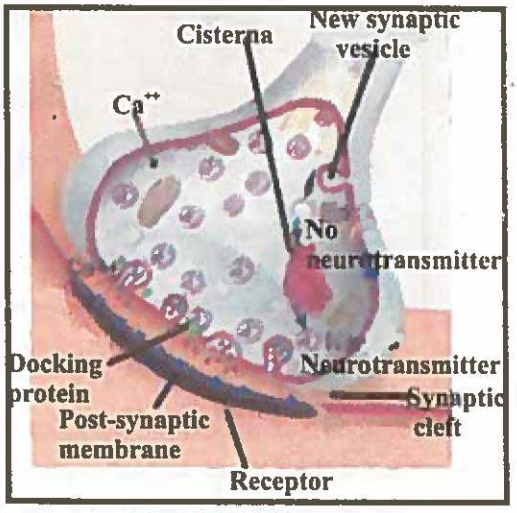


Fig: 17. 12 Synapse

Binding of neurotransmitters to the post synaptic neuron receptors opens some channels and allows 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 K^+ or Cl^-. When these channels open, the post synaptic membrane hyperpolarizes. Hyperpolarization produced in this manner is called **inhibitory postsynaptic potential (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 metabolize as fuel. Other neurotransmitters are removed from synaptic cleft by enzymes that catalyze the hydrolysis of the neurotransmitters, like acetylcholine is hydrolyzed by **acetylcholinestrase** and adrenalin by **monoamine oxidase.**

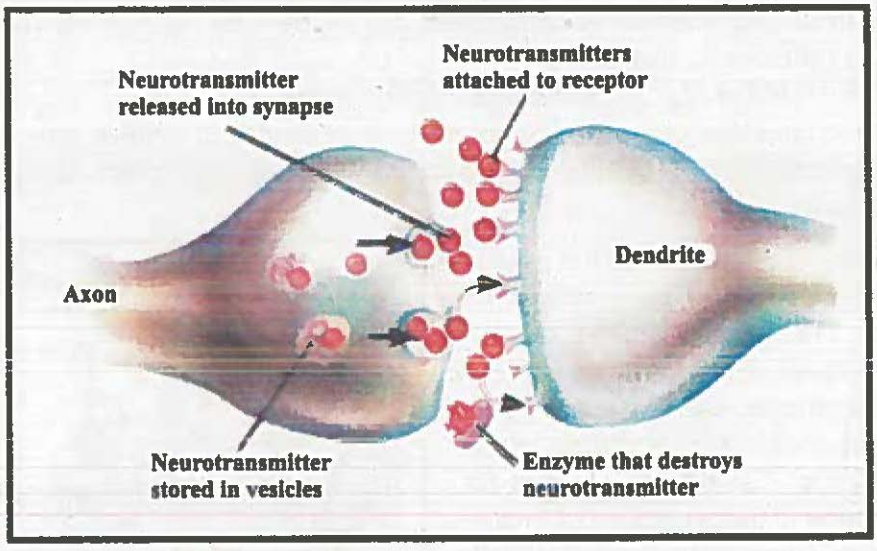


Fig: 17. 13 Neurotransmitters at synapse.

17.4.4 Neurotransmitters:

These are chemical messengers of nervous system. There are more than 100 known neurotransmitters. However, nearly all of these fall into one of a few groups based on chemical structure. Major classes of neurotransmitters are acetylcholine, biogenic amine, amino acid, neuropeptides, and gases. Some neurotransmitters that produce excitation on postsynaptic neuron receptors are called **excitatory neurotransmitters e.g acetylcholine** while other inhibits the postsynaptic action potential are called **inhibitory neurotransmitters e.g Serotonin.**

17.5 ORGANIZATION OF HUMAN NERVOUS SYSTEM

Human nervous system is a typical centralized nervous system. However, centralized nervous system is the characteristic of most animals, from flat worm to chordates, but human nervous system is the most advanced among them.

17.5.1 Divisions of human nervous system:

Human nervous system is primarily divided into central nervous system (CNS) and peripheral nervous system (PNS). CNS acts as a coordinating center while PNS provides communication among receptors, CNS, and effectors. Further division of nervous system are given in the following table.

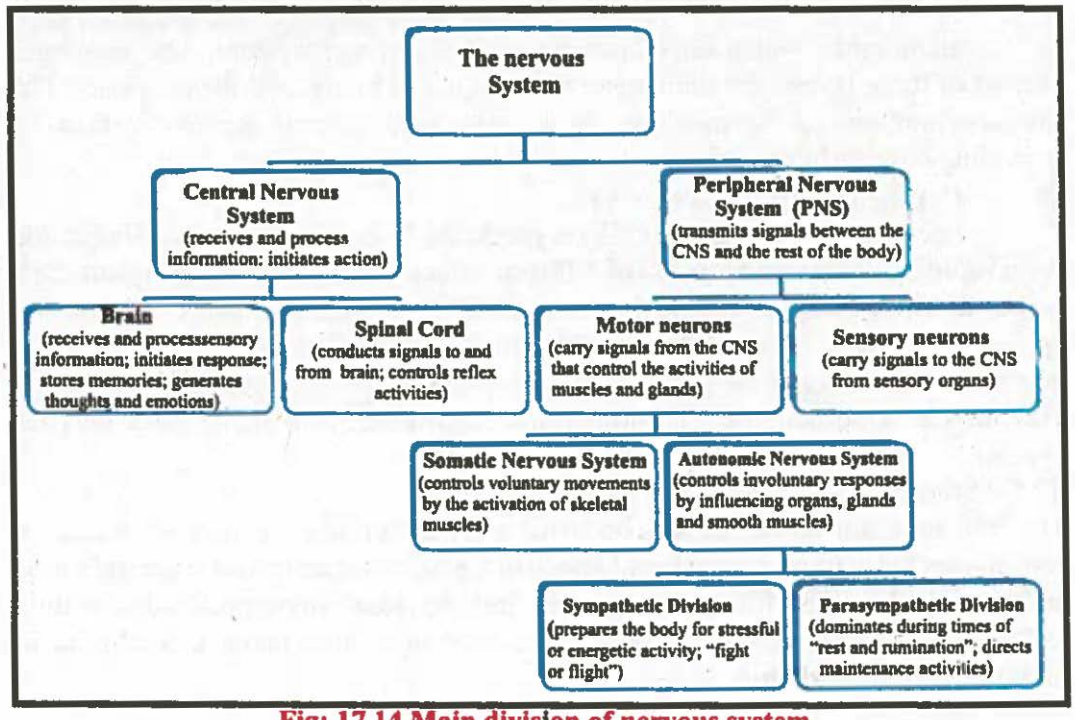


Fig: 17.14 Main division of nervous system

17.5.2 Central Nervous System:

Central nervous system consists of brain and spinal cord, both act as coordinating centers, but brain is involved more in coordination than spinal cord. Spinal cord also acts as a link between PNS and brain.

17.5.3 Protection of brain and spinal cord:

As brain and spinal cord are highly sensitive parts of human body so their protection from mechanical stresses is very important. They are protected in three different ways.

i. Skeleton:

The parts of skeleton that protect the brain and spinal cord are cranium and vertebral column. Cranium is the part of skull that covers the brain. Vertebral column consists of 33 vertebrae that encloses the spinal cord. These parts protect the brain and spinal cord from accidents or other physical traumas.

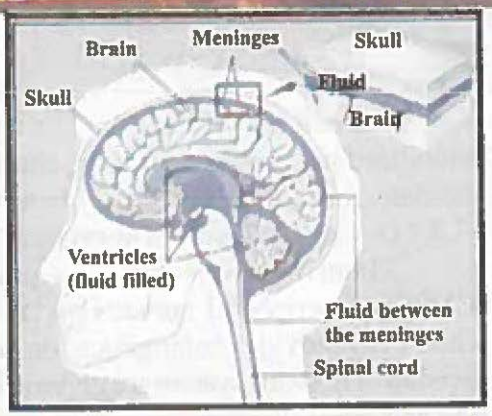


Fig: 17.15 Side way view of human brain.

ii. Meninges:

The meninges is the system of membranes which envelopes the central nervous system. The meninges consist of three layers: the dura mater, the arachnoid mater, and the pia mater. The primary function of the meninges is to protect the central nervous system by providing cushion like matrix.

iii. Cerebrospinal Fluid or CSF:

The cerebrospinal fluid (CSF) is produced from blood vessels of brain and spinal cord by a combined process of diffusion, pinocytosis and active transport. CSF is found in between pia mater and arachnoid mater, around the surface of brain and spinal cord, in the ventricles of brain and in the central hollow canal of spinal cord. It acts as a cushion that protects the brain and spinal cord from mechanical shocks. It also plays an important role in the homeostasis and metabolism of the central nervous system.

17.5.4 Structure and function of brain:

The human brain is the most wonderful and mysterious creation of nature. It coordinates the actions, so that they happen in the right sequence and at the right time and place. It also stores information, so that the behaviour can be modified according to the past experience. Human brain is divided into three parts: i. forebrain, ii. midbrain and iii. hindbrain.

i. Fore Brain

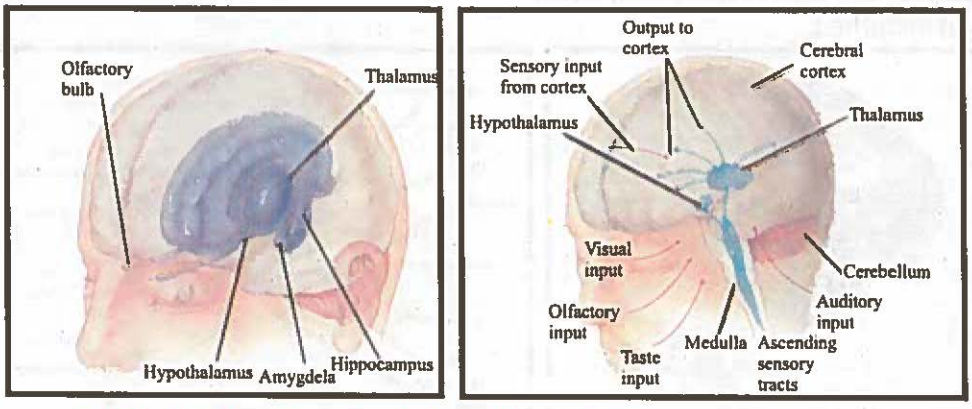
Forebrain is massively developed and contains the most sophisticated integrating centers. It has two subdivision; **telencephalon** and **diencephalon.** The telencephalon consists of a pair of olfactory bulbs and cerebrum.

The olfactory bulbs are concerned with the sense of smell. The cerebrum has many folds or convolutions that may be related to intelligence. The cerebrum is the largest portion of the brain.

It is divided into two cerebral hemispheres, connected together by a bridge of nerve fibres - the corpus callosum, which carries memory available on one side of the brain to the other side.

Cerebrum is the control center of many sensory areas like sight, speech, smell, taste and hearing. It is also concerned with conscious sensations, voluntary movements, learning,memory, thinking, decision-making, reasoning and judgment.

The **Diencephalon region** harbours limbic system, collectively representing parts of **thalamus, hypothalamus, amygdala** and **hippocampus**. Thalamus serves as a relay station between the body and the cerebrum. It receives impulses coming from different sensory areas of the body and carries them to the cerebrum. The function of hypothalamus range from hormones production to the regulation of body temperature, hunger, thirst, sexual response, the flight or fight response and biorhythms. Amygdala produces sensation of pleasure, punishment or sexual arousal when stimulated. Hippocampus plays an important role in the formation of long terms memory and is thus required for learning.



(a) The limbic system extends through several brain regions. (b) The reticular formation.

Fig: 17.16

ii. **The midbrain functions** in the coordination and relay of visual and auditory information. It is reduced in human and contain reticular formation which is a network of neurons running through **medulla** in the **hindbrain,** through the midbrain and up into the thalamus and hypothalamus of the forebrain. It receives input from most of the senses and sends outputs to higher brain centers, filtering the sensory information.

iii. The hindbrain consists of **pons, cerebellum** and **medulla oblongata.** Pons is small and lies above the medulla oblongata. Pons acts as a bridge for the conduction of impulses between cerebellum, medulla oblongata and cerebrum. It is also concerned with rate of breathing, sleep and wakefulness. Cerebellum is the second largest portion of the brain. It consists of a central lobe and two lateral lobes. Cerebellum coordinates muscle activity and guides smooth and accurate motion. If it is destroyed, the movements become jerky, shaky and disturbed.

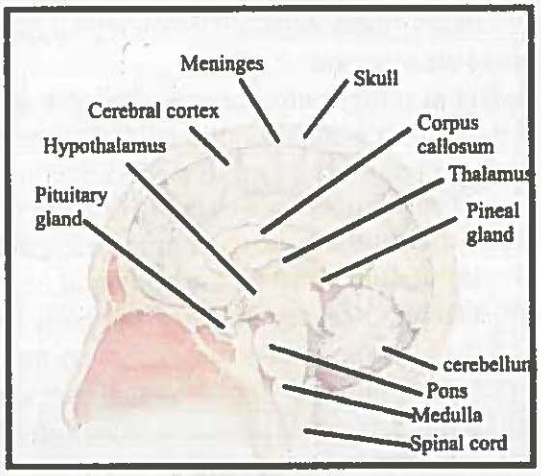


Fig: 17.17 Cross Section of human brain.

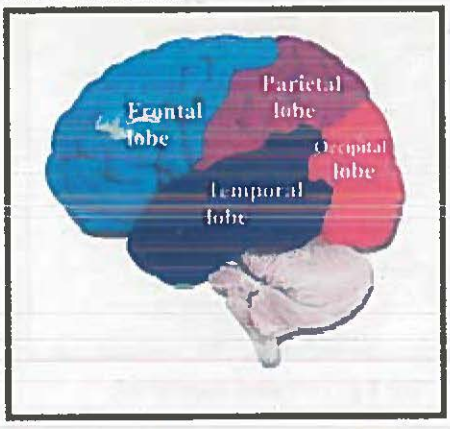


Fig: 17.18 Different lobes of brain.

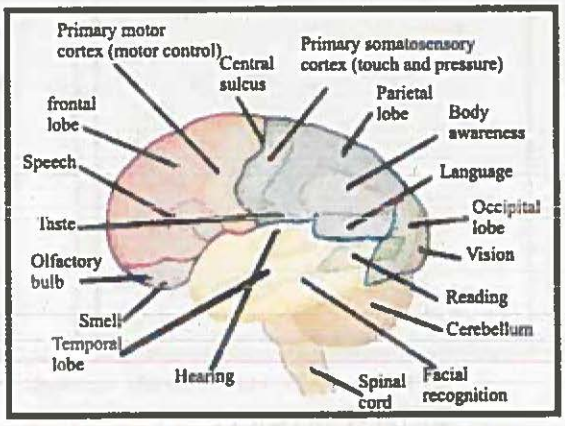


Fig: 17.19 Location of various sensations perceived by different parts of brain.

Medulla oblongata is the posterior most portion of the brain. It is broad in front and narrows behind, where it is continuous with the spinal cord. Medulla oblongata is the highway of communication between the body and the brain. Special reflexes such as heart beat, respiratory movements, salivary secretions, swallowing, vomiting, coughing and sneezing are located in the medulla oblongata.

Spinal Cord

Spinal cord is a central cable of nervous system. It is about 18 inches long and about half an inch in width. It is an elongated, hollow and cylindrical structure, lying in the neural canal of vertebral column.

It is continuous in front with the brain and tapers posteriorly, lying in the canal of urostyle. It is made up of a very large number of neurons. In cross section, the spinal cord shows an inner gray matter and the outer white matter. The gray matter surrounds a central canal, containing cerebrospinal fluid.

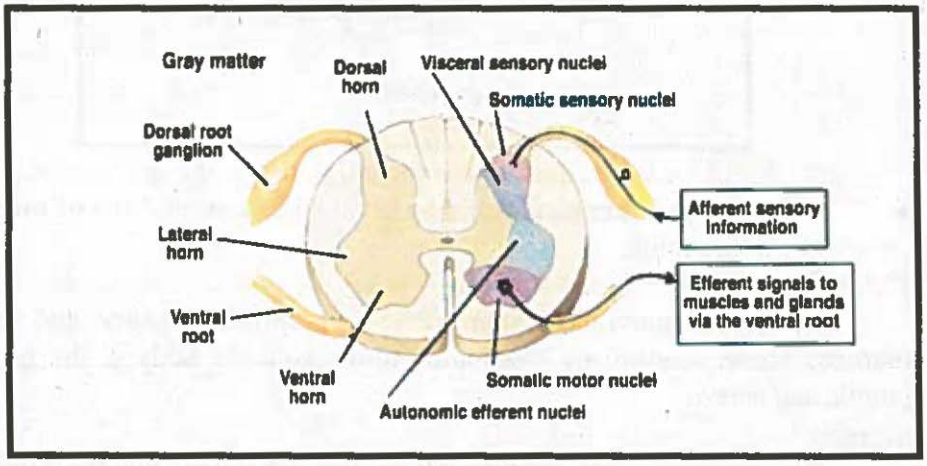


Fig: 17. 20 Spinal cord

The central canal of the spinal cord is continuous in front with the cavities of the brain, but ends blindly behind. The gray matter consists of cell bodies and white matter is made up of nerve fibres.

The spinal cord is covered with a thin pigmented membrane, the pia mater and the neural canal is lined with a thick, tough membrane, the dura mater, the space between the two membranes is filled with a lymphatic fluid which protects the cord from shocks.

Functions of Spinal Cord

Spinal cord is concerned with:

- Many reflex actions involving body structures below the neck region.
- Conducting sensory impulses from the skin and muscles to the brain.
- Carrying motor impulses from the brain to the muscles of the neck and limbs.

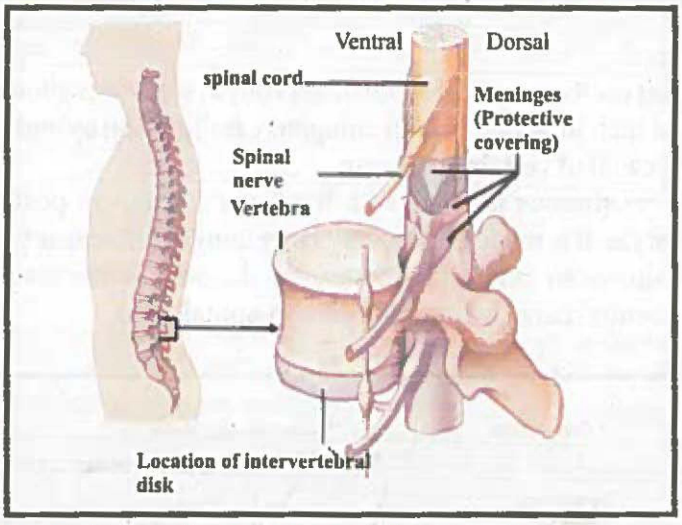


Fig: 17. 21 Location of intervertebral disk in the spinal cord.

- Receiving commands from the brain so it controls parts of the body in the trunk.

17.5.4 Peripheral Nervous System:

Peripheral nervous system (PNS) comprises sensory and motor neurons. These neurons are distributed throughout the body in the form of ganglia and nerves.

Ganglia

The collections of neuron cell bodies are called ganglia (singular ganglion). They provide relay points and intermediary connections between different neurological structures in the body, such as the peripheral and central nervous systems. Ganglia often interconnect with other ganglia to form a complex system of ganglia known as a plexus.

Nerves (Tracts):

The bundles of neuron fibers (dendrite or axons) covered by connective tissues are called nerves. All the communication between receptor to the CNS and from CNS to the effectors is carried out by the nerves. Nerves can be classified on the basis of function and origin. With respect to the functions nerves are of three types:

- **Sensory nerves:** These nerves carry impulses from receptors to the CNS.
- **Motor nerves:** These nerves carry impulses from CNS to the effectors.
- **Mixed nerves:** These nerves are the groups of sensory and motor nerves.

With respect to the origin nerves are of two types:

Spinal nerves: **These nerves** originate from and lead to the spinal cord. There are thirty-one pairs of spinal nerves, which are grouped as follows: Cervical, 8; Thoracic, 12; Lumbar, 5; Sacral, 5; Coccygeal, 1.

Cranial or Cerebral nerves: Those nerves that originate from or lead to the brain are called cranial or cerebral nerves. There are twelve pairs of cranial nerves which pass through the foramen (an opening) of the skull and mainly supply the peripheral tissues in the head except vagus nerve which extends event up to the abdomen.

Functionally, three pairs of cranial nerves are sensory in nature (I, II, VIII), five pairs are motor in nature (III, V, VI, XI, XII), and four pairs are mixed in nature (IV, VII, IX, X).

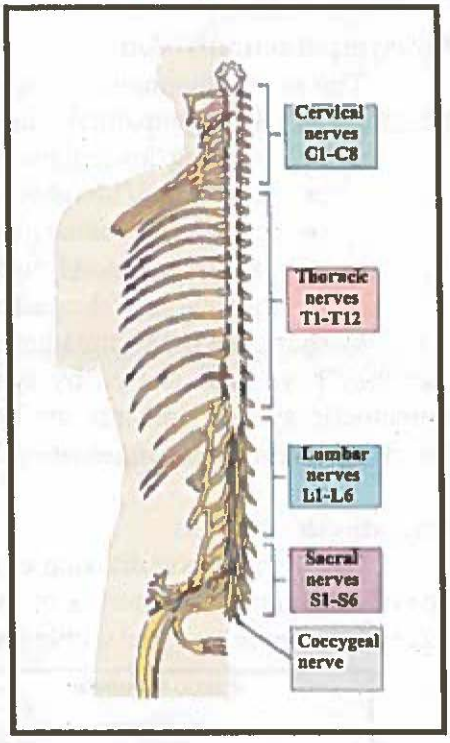


Fig: 17. 22 Spinal nerves.

17.5.5 Somatic Nervous System:

The somatic system is the part of the peripheral nervous system responsible for carrying sensory and motor information between CNS and voluntary parts of the body. The somatic nervous system controls skeletal muscle as well as external sensory organs such as the skin. This system is said to be voluntary because the responses can be controlled consciously. Reflex reactions of skeletal muscle however are an exception. These are involuntary reactions to external stimuli.

17.5.6 Autonomic Nervous System (ANS):

The autonomic nervous system consists of sensory neurons and motor neurons that run between the central nervous system (especially the hypothalamus and medulla oblongata) and various internal organs such as heart, lungs, viscera, glands (both exocrine and endocrine). The contraction of both smooth muscle and cardiac muscle is controlled by motor neurons of the ANS. The actions of the autonomic nervous system are largely involuntary (in contrast to those of the sensory-somatic system). The autonomic nervous system can further be divided into the parasympathetic and sympathetic divisions.

For Your Information

Pain receptors are the most numerous types of receptors of skin. Every square centimeter of your skin contains around 200 pain receptors but only 15 receptors for pressure, 6 for cold and 1 for warmth.

17.7 EFFECTS OF DRUGS ON NERVOUS COORDINATION

There are many drugs which are being used to treat nervous disorders, but abuse/misuse of these drugs can produce ill effects on the nervous coordination. One should be aware of uses and abuses of some common drugs used in our society.

17.7.1 Heroine:

Heroin is an illegal, highly addictive drug. Heroin is processed from morphine, a naturally occurring substance extracted from the seed pod of certain varieties of poppy plants.

Medical use:

Under the chemical name diamorphine, diacetylmorphine, the heroine is prescribed as a strong analgesic, where it is given via subcutaneous, intramuscular, or intravenous route. Its use includes treatment for acute pain, such as in severe physical trauma, myocardial infraction, post-surgical pain, and chronic pain, including end-stage cancer and other terminal illnesses.

Abuses/Misuses

Heroin is usually injected, sniffed/snorted, or smoked. With heroin, short term effects include warm flushing of the skin, dry mouth, depressed respiration, and suppression of pain, nausea, vomiting, severe itching, and spontaneous abortion. Long term effects of heroin use include addiction, infectious diseases, for example, HIV/AIDS and hepatitis B and C, collapsed veins, bacterial infections, abscesses, infraction of heart lining and valves, and arthritis.

Fig: 17.26 Poppy plant

17.7.2 Cannabis

Cannabis *(Cannabis sativa)*, also known as marijuana refers to preparations of the Cannabis plant which is being used as a psychoactive drug.

Hashish (commonly called as Chars) is another form of cannabis which is a concentrated resin produced from the flowers of the female cannabis plant. It can often be more potent than marijuana and can be smoked or chewed.

Fig: 17.27 *Cannabis sativa*

Medical use

Cannabis has very beneficial effects as medicine. Among these are: the amelioration of nausea and vomiting, stimulation of hunger in chemotherapy and AIDS patients, lowered intraocular eye pressure (shown to be effective for treating glaucoma), as well as general analgesic effects.

Abuses / Misuses:

The most common adverse effect due to the abuse of cannabis is anxiety (restlessness, feelings of loss of control, panic, fear of impending death), depression, suicidal thoughts and psychosis (a severe mental disorder in which contact with reality is lost or highly distorted).

17.7.3 Nicotine

Nicotine is an alkaloid, mainly found in tobacco leaves but also found in many other plants of family Solanaceae.

Medical use:

The primary therapeutic use of nicotine is in treating the patients habitual of smoking. It stimulates the release of many chemical messengers including acetylcholine, norepinephrine, epinephrine, serotonin, vasopressin, dopamine, and beta-endorphin. so it acts as a nerve stimulant. At higher doses, nicotine enhances the effect of serotonin and beta-endorphin activity, producing a calming, pain-killing effect. Nicotine is unique in comparison to most drugs, and acts both as nerve stimulant and sedative/pain killer.

Abuses / Misuses:

Unfortunately, many people do not know that nicotine is also sold commercially in the form of a pesticide. It is fact that nicotine is an extremely toxic poison Sixty milligrams of nicotine (about the amount in three or four cigarettes if all of the nicotine were absorbed) will kill an adult, but consuming only one cigarette's worth of nicotine is enough to make a child severely ill. **Nicotine poisoning** causes vomiting and nausea, headaches, difficult breathing, and stomach pains. In smoker mothers, nicotine damages the placenta, increasing the likelihood of miscarriages, pre mature births and damages to the foetus.

17.7.4 Alcohols:

The alcohol is among the most harmful of drugs particularly in view of the frequency of its use. It is absorbed quickly into the blood from digestive tract after drinking.

Medical uses:

It stimulates the body when taken in a small quantity as medicine to improve health conditions. Since it is an excellent solvent so many drugs are delivered into the body by dissolving in it. Alcohol is also used as a component of many medicines like cough syrups. Due to its antiseptic nature, it is also used to wash wounds during bandages and while administering injections.

Abuses / Misuses:

When people take alcohol in large quantities for non-medical purposes, it will be called as abuse of the drug. In small quantities it can suppress the cellular activity in brain. In large doses, it can kill them. Alcohol reduces levels of serotine and dopamine and act as a depressant.

Driving, after only drinking a small amount of alcohol, is dangerous because alcohol affects your reaction time and judgment of speed. This can result in an accident which may hurt you or other people. People who have drunk too much lose control of speech and movement. Extreme drunkenness can result in people becoming unconscious and even dying from choking on their own vomit or of alcohol poisoning. Alcohol addiction also causes memory loss, damage (cirrhosis or hardening) of the liver, **hallucinations** (where people imagine they are in a magical world and see enemies everywhere, this disease called paranoia), **depression** and anxiety which can result in suicide. Alcohol in gut also destroys certain vitamins and interferes with absorption of others leading to severe vitamin deficiencies.

17.7.5 Common inhalants like Nail Polish Removers & Glue:

Inhalants are chemical vapours or gases that produce psychoactive (mind-alerting) effects when abused or misused by concentrating and intentionally inhaling these fumes. These include volatile organic solvents, fuel gases, nitrites, and anesthetic gases, which are commonly found in glue, paint thinner, gasoline, and nail polish remover.

Effects of abuses:

Inhalants provide an instant "rush" and, like alcohol, cause euphoria followed by central nervous system depression. Deep breathing may result in loss of self-control, violent behavior, nausea, vomiting, unconsciousness, giddiness, loss of appetite, and, at higher doses, hallucinations, loss of motor skills, slurred speech, and heart palpitations.

17.8 NERVOUS DISORDERS AND DIAGNOSTIC TESTS

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:

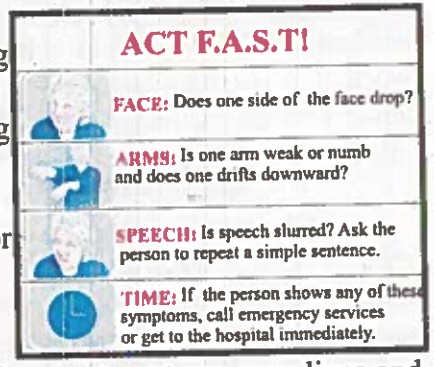
- Vascular (Stroke)
- Infectious (Meningitis)
- Structural (Brain Tumor)
- Functional (Headache)
- Degenerative (Alzheimer's disease)

17.8.1 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 to part of the brain is disrupted, causing brain cells to die. There are two kinds of 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.

17.8.2 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.

Fig: 17.28 Patient with head and neck arched backwards in meningitis attack.

Treatment:

Treatment for meningitis depends on the organism causing the infection. Antibiotics and corticosteroids are used as general treatment.

17.8.3 Brain Tumors:

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 in 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.

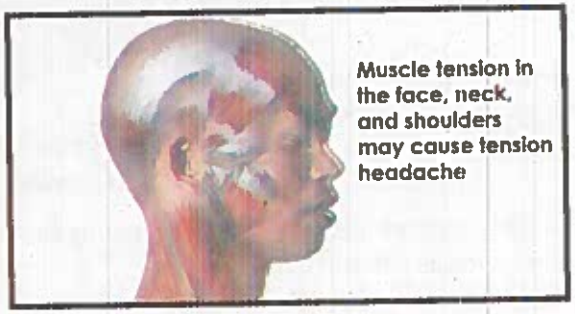


Fig: 17.29 Headaches

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 disturbances in reasoning, planning, language, and perception.

Signs & Symptoms:

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 intellectual functions develop. The person may begin to have trouble with figures when 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.

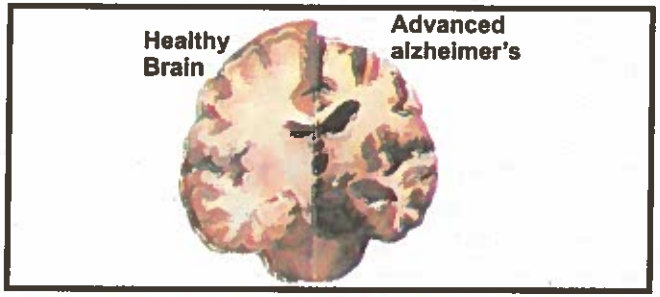


Fig: 17.30 Massive cell loss changes the whole brain in advanced Alzheimer's disease.

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.

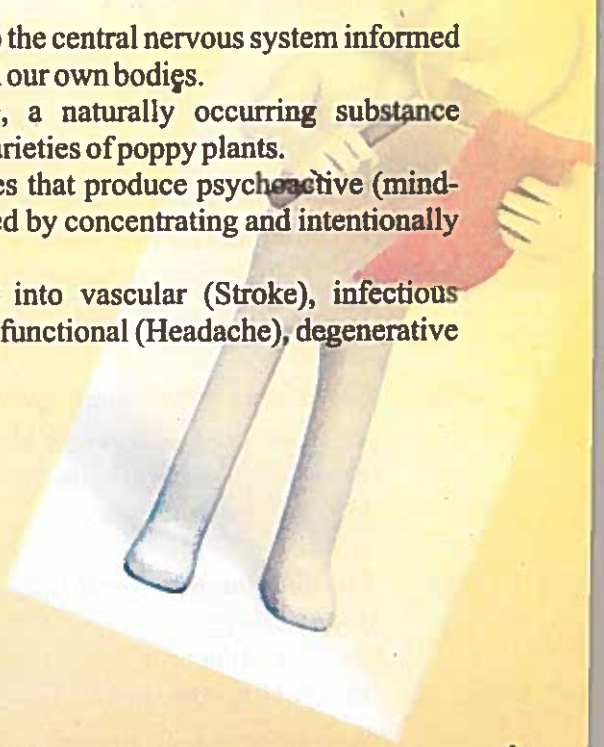
KEY POINTS

- Nervous coordination in higher animals 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. Fp conduction it uses electricity made with chemical ions and molecules (Na^+, K^+, and charge bearing organic molecules).
- Nerve impulses are of two types: continuous impulse and saltatory impulse.
- Synapsess 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.
- Some neurotransmitters that produce excitation on postsynaptic neuron receptors are called **excitatory neurotransmitters e.g acetylcholine** while other inhibits the postsynaptic action potential are called **inhibitory neurotransmitters e.g Gluamate.**
- Human nervous system is primarily divided into central nervous system (CNS) and peripheral nervous system (PNS).
- Human brain coordinates the actions, so that they happen in the right sequence and at the right time and place.
- Spinal cord is a central cable of nervous system.
- The somatic system is the part of the peripheral nervous system responsible for carrying sensory and motor information between CNS and voluntary parts of the body.
- The autonomic nervous system consists of sensory neurons and motor neurons that run between the central nervous system (especially the hypothalamus and medulla oblongata) and various internal organs such as heart, lungs, viscera, glands (both exocrine and endocrine).

KEY POINTS

ensory receptors receive stimuli and keep the central nervous system informed of any change in the surroundings and in our own bodies.

- Heroin is processed from morphine, a naturally occurring substance extracted from the seed pod of certain varieties of poppy plants.
- Inhalants are chemical vapours or gases that produce psychoactive (mind-alerting) effects when abused or misused by concentrating and intentionally inhaling these fumes.
- Neurological disorders are classified into vascular (Stroke), infectious (Meningitis), structural (Brain Tumor), functional (Headache), degenerative (Alzheimer's disease).



EXERCISE ?

1- Multiple choice questions.

(i) ***Which of the following is common to all neurons?***

(a) A cell body which contains a nucleus (b) A thick myelin sheath
(c) Presence of nodes of Ranvier (d) Presence of Schwann cells

(ii) ***What will occur if a drug at the neuromuscular junction blocks the receptor sites on the post-synaptic membrane?***

(a) Inhibition of Acetylcholine release (b) Muscle contraction
(c) Muscle paralysis (d) Release of calcium ions

(iii) ***The groups of ribosomes present in the cell body of the neuron, which are associated with rough endoplasmic reticulum are called:***

(a) Meissner's corpuscles (b) Pacinian corpuscles
(c) Nissl's granules (d) Lysosome granules

(iv) ***The mammalian forebrain is differentiated into the thalamus, limbic system and the:***

(a) Cerebellum (b) Cerebrum
(c) Hippocampus (d) Hypothalamus

(v) ***Information back from the control center to the effectors as done by _____ nerve path way.***

(a) afferent (b) efferent
(c) both (d) none

(vi) ***The number of human spinal nerves is:***

(a) 24 (b) 50
(c) 62 (d) 64

(vii) ***The electrical potential of cell membrane of neuron when it is not transmitting any signal is called _____.***

(a) resting membrane potential (b) action potential
(c) propagation of impulse (d) synapse

EXERCISE ?

2- Short questions.

(i) Give the structure of a typical neuron.
(ii) What do you know about the distribution and pumping of Na^+ and K^+ ions across the neuron membrane during resting membrane potential?
(iii) How the K^+ ions are moved across the neuron membrane during resting membrane potential?
(iv) Differentiate between resting membrane potential and active membrane potential.
(v) Give a graphical representation of nerve impulse.
(vi) How does an impulse move from one neuron to another neuron across the synapse?
(vii) Name the part of human brain concern with storage of memories.
(viii) Differentiate between sympathetic & parasympathetic nervous system.
(ix) Differentiate between gray mater & white mater.
(x) Differentiate between medulla & pons.

3- Extensive questions

(i) Compare the structure and function of three types of neuron.
(ii) Describe the mechanism of conduction of nerve impulse.
(iii) Explain the structure and function of human fore brain
(iv) Critically discuss the use and abuse of any one narcotic drug.
(v) Give in detail the cause symptoms and treatment of any one nervous disorder

4- Skills (Initiating and Planning)

- Predict from every day experience what various kind of receptos can be found in human body.

5- Interpreting and Communicating

- Draw a labeled diagram of human brain
- Identify different components in the diagram of CNS and PNS.
- Conceptualize the activity of brain as a electrical activity, which can be recorded using magnet and tomography.
- Compare MRI scan of a sleeping human with that of fully awaked individual.

EXERCISE

6- Science, Technology, and Society Connections

- Justify the way nervous system coordinate complex and intricate movements of hand to play a piano, or write alphabets.
- Ascertain the effect of nerve gas as an inhibiter of acetylcholinesterase.
- Justify that development of modern computer is in fact a product of the understanding of the way nervous coordination occurs in complex organisms like human.

7- Online Learning

- *www.free-ed.net/free-ed/HealthCare/Physiology*
- www.nlm.nih.gov/medlineplus/degenerativenervediseases
- www.ninds.nih.gov
- *www.*kidshealth.org