NERVOUS SYSTEM

INTRODUCTION

In all the multicellular animals above the level of sponges, the system meant to perceive stimuli detected by the receptors, to transmit these to various body parts, and to effect responses through effectors, is called *nervous system*. In vertebrates, it is highly specialized and plays at least three vital roles

(i) **Response to stimuli :** By responding to all sorts of stimuli, it acquaints the organism with them so that the organism may react and orient itself favourably in the surrounding environment.

(ii) **Coordination :** Along with endocrine system, the nervous system also serves to coordinate and integrate the activities of various parts of the body so that they act harmoniously as a unit. This makes possible the integrated control of the internal body environment (*homeostasis*). However, the nervous system brings about rapid coordination by means of nerves, whereas the endocrine system does so gradually and slowly by secreting hormones into blood.

(iii) **Learning :** By accumulating memories from past experiences, in higher vertebrates at least, the nervous system serves as a centre for learning. The branch of medical science dealing with the structure (anatomy), functions (physiology) and diseases (pathology) of nervous system is called *neurology*.

7.1 NERVOUS SYSTEM IN VARIOUS ANIMALS

(i) **Coelenterata :** True nerve cell or ganglion cells occur for the first time in coelenterates. They are derived from interstitial cells of epidermis, forming nerve net or nerve plexus below whole epidermis.

(ii) **Platyhelminthes :** Nervous system of planarians marks the beginning of a centralized nervous system encountered in higher animals. That is made up of brain or cerebral ganglia, two lateral longitudinal nerve chords, numerous peripheral nerves and transverse commissures or connectives. This is sometimes called the ladder type of nervous system. In addition to the centralized nervous system planaria also possesses a sub-epidermal nerve net like that of coelenterates. Brain receives stimuli from the sense organs and conveys them to different parts of body. Special receptors, as found in turbellarians, are lacking in tapeworm. However numerous free sensory nerve-endings are present throughout the body specially in the scolex.

In Nematoda (*e.g.* ascaris) these system made up of central nervous system, peripheral nervous system and rectal nervous system. Rectal nervous system more developed in male**.**

(iii) **Annelida :** Nervous system well developed and concentrated. It consists of three parts : central nervous system, peripheral nervous system and sympathetic nervous system, central N.S. made up of Nerve ring and ventral nerve cord. Nerves are of mixed type, consisting of both afferent (sensory) and efferent (motor) fibres.

(iv) **Arthopoda :** The nervous system of prawn or arthopods is of the annelidan type. However it is somewhat larger and has more fusion of ganglia. It consists of (i) The central nervous system including brain connected with a ventral ganglionated nerve cord through a pair of circum-oesophageal commissures, (ii) The peripheral nervous system including nerves and (iii) The sympathetic nervous system.

(v) **Mollusca :** In gastropodes (*e.g.* pila) consists of paired ganglia, commissures and connective uniting them and nerves running from these central organs to all parts of the body. It has various type of ganglia as cerebral, buccal, pleuro-pedal, supraintestinal and visceral etc. In palecypoda nervous system is greatly reduced due to sluggish and sedentary mode of life and there is little evidence of the brain. But in cephalopoda shows a high grade of organization attained only by some insects and arachnids among the other invertebrates.'

(vi) **Echinodermata :** Echinodermates has simple and primitive type nervous system. It has the form of a nerve net, consisting of nerve fibres and a few ganglion cells, all confined to the body wall except the visceral nerve plexus situated in the gut wall. At certain places the nervous tissue is concentrated to form distinct nerve cords. It is made up of (i) Superficial or ectoneural nervous system (ii) Hyponeural or deep nervous system (iii) Aboral or coelomic nervous system and (iv) Visceral nervous system.'

(vii)**Hemichordata :** Nervous system is of primitive type resembling that of coelenterates and echinodermates.

Chordates : Nervous system well developed and formed by ectoderm. It is formed by CNS, peripheral nervous system and autonomous N.S.

7.2 Development of central nervous system in human

The central nervous system of vertebrates includes the *brain* and the *spinal cord*. These are derived from a longitudinal mid-dorsal ectodermal thickening of the embryo, called the *meduallary* or *neural plate*. This neural plate or neural groove is converted by fusion into a closed mid-dorsal longitudinal *neural tube* lying above the notochord. Histologically, the embryonic neural tube exhibits three zones of cells.

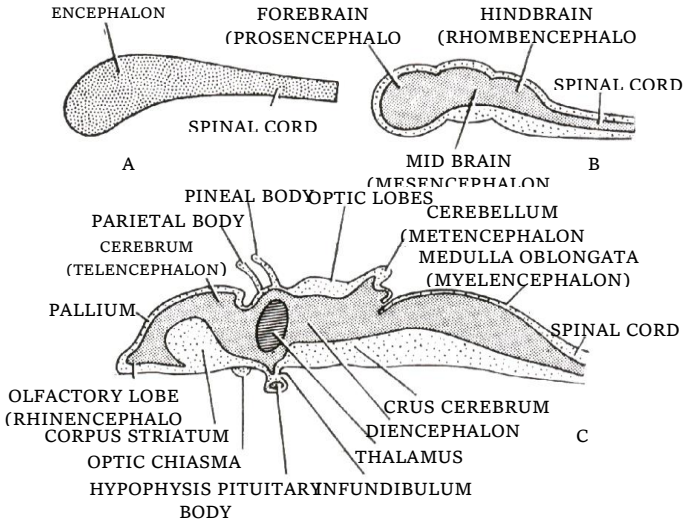


Fig. – Stages in development of brain. A – Anterior end of neural tube in lateral view. B – M.L.S. of embryonic brain to show three primary cerebral vesicles. C – Differentiation of brain from three vesicles.

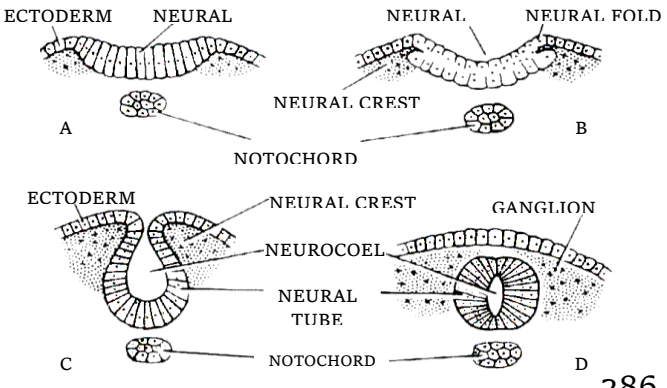


Fig. – Stages in the embryonic development of central nervous system inT.S.

(i) **Germinal layer :** These are actively dividing cells lining the neural canal. They form the connective tissue lining of neural canal, called *ependyma*, and also proliferate into mantle layer cells.

(ii) **Mantle layer :** It consists of embryonic neurons or *nematoblasts*, forming the gray matter.

(iii) **Marginal layer :** It consists of nerve fibres, mostly surrounded by fatty myelin sheaths, and forms the *white matter*. Neurons and fibres are supported by a special connective tissue of ectodermal origin, the *neuroglia*, cells of which become increasingly abundant and diversified in higher vertebrates.

Development of brain : The anterior end of embryonic neural tube is already enlarged forming the embryonic brain, called *encephalon*. By differential growth and two constrictions, it is divided into a linear series of three *primary cerebral vesicles*, termed the *forebrain*, *midbrain* and *hindbrain*. These give rise to the three major divisions of the adult brain – (1) *prosencephalon* (forebrain), (2) *mesencephalon* (midbrain), and (3) *rhombencephalon* (hindbrain). These further become subdivided into 5 subdivisions. The various parts of the adult brain in different vertebrates are formed by modifications. That is, by thickenings and foldings of these 5 subdivisions. The adult brain has a series of cavities, called *ventricles*, which are in continuation with the central canal of the spinal cord and filled with a cerebro-spinal fluid.

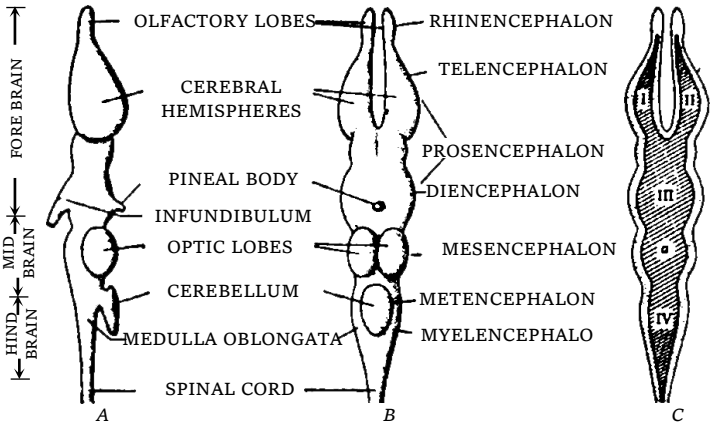


Fig. – Pattern of generalized vertebrate brain. A – Lateral view. B – Dorsal surface. C – H.L.S. showing ventricles

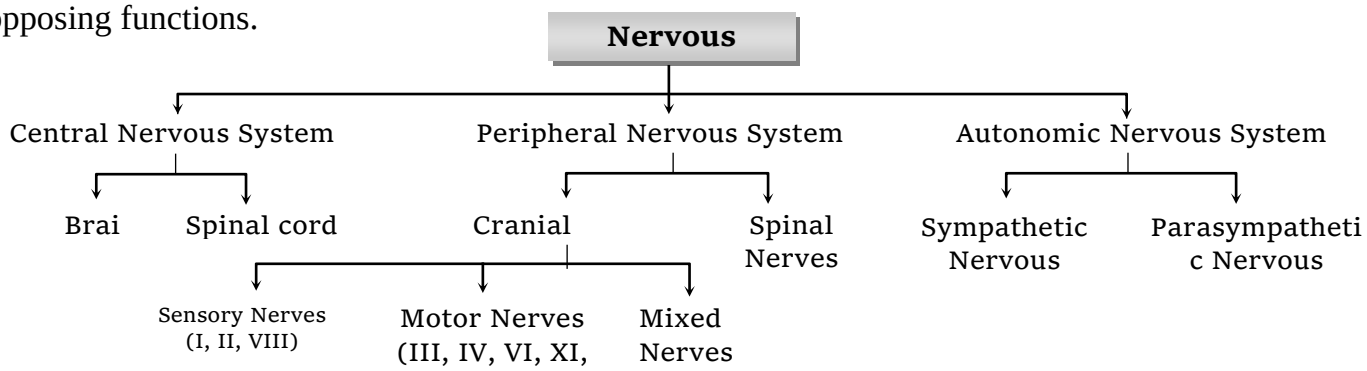
7.3 Parts of nervous system

Nervous system is divided into three parts

(i) **Central nervous system (CNS) :** In all the vertebrates including man, CNS is dorsal, hollow and non-ganglionated while in invertebrates when present, it is ventral, solid and ganglionated. CNS is formed of two parts : **Brain –** Upper and broader part lying in the head; and **Spinal cord –** Lower, long and narrow part running from beginning of neck to trunk.

(ii) **Peripheral nervous system (PNS) :** It is formed of long, thin, whitish threads called nerves which extend between CNS and body parts (muscles, glands and sense organs). It controls the voluntary functions of the body. It has cranial and spinal nerves.

(iii) **Autonomic nervous system (ANS) :** It is formed of nerve fibres extending upto visceral organs and controls the involuntary functions of visceral organs of body like heart beat, peristalsis etc. It is again formed of two systems: sympathetic and para-sympathetic nervous system which have opposing functions.



(i) **Central nervous system :** Central nervous system is made up of brain and spinal cord. CNS is covered by 3 meninges and its wall has two type of matter.

Types of matter : CNS of vertebrates is formed of two types of matter –

(a) **Grey matter :** It is formed of cell-bodies and non-medullated nerve fibres.

(b) **White matter :** It is formed of only medullated nerve fibres which appear white due to presence of medullary sheath.

Meninges : The meninges are connective tissue membranes which surround the brain and spinal cord of CNS. In the fishes, there is only one meninx called meninx primitiva. In amphibians, reptiles and birds, the brain is covered by two meninges or membranes : inner pia-arachnoid and outer dura mater. In mammals, CNS is covered by three meninges or membranes

(a) **Duramater (Dura = tough; mater = mother):** Outermost, thick, fibrous, 2-layered meninge. The outer layer adheres to skull at many places while the inner layer follows the major convolutions (sulci and gyri) of the brain and spinal cord. Meningeal artery traverses via duramater. The two layers of duramater are widely separated at some places to form the large sinuses called venous sinus. This drains deoxygenated (= venous) blood from the brain to the large veins that return it to the heard. The space between duramater and the next meninge in succession is called sub-dural space is filled with cerebrospinal fluid and has arachnoid villi in the region of dural space. Similarly the space between the skull and durameter is called epidural space. Duramater extends in the form of straight sulcus between cerebrum and cerebellum posteriorly. Here it is called tentorium.

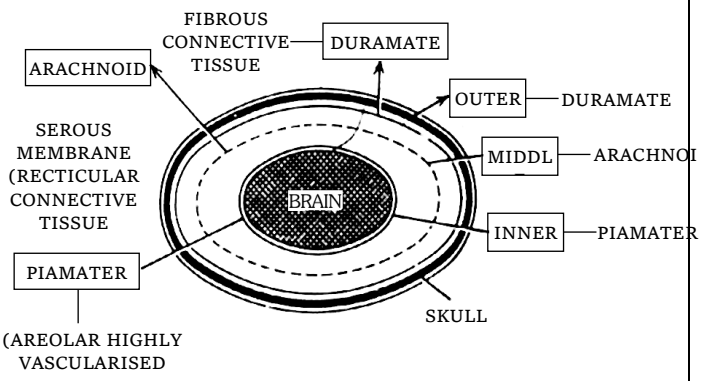


Fig. – Meninges of brain

(b) **Arachnoid (= spider-like web) :** It is closely related to duramater on its outside and with piameter on the inside. The space between the arachnoid and piameter is called sub-arachnoid space and is filled with cerebro-spinal fluid.

(c) **Piameter (Pia = soft = tender) :** This is the innermost meninge and follows the convolutions of the outer surface of brain and spinal cord. It is highly vascular and penetrates deeply in certain places bringing it with its vasculature and placing it in contact with the ventricles of the brain and neurocoel of spinal cord.

Cerebrospinal fluid : All the ventricles of the brain are continuous and lined by a columnar, ciliated epithelium, the ependyma. They contain lymph-like extracellular fluid called the cerebrospinal fluid (C.S.F.). This fluid is secreted by the choroid plexuses by filtration of blood. The choroid plexuses

consist of loose connective tissue of pia mater covered internally by a simple cuboidal epithelim of secretory (glandular) nature. The cerebrospinal fluid slowly flows toward the fourth ventricle by secretion pressure and passes into the spinal cord. Some fluid escapes into the subarachnoid spaces through three pores in the roof of the fourth ventricle in the medulla. From the subarachnoid spaces, the cerebrospinal fluid is transferred to the blood of the venous sinuses. Nervous tissue is without lymphatic vessels.

The cerebro-spinal fluid (CSF) provides

(a) Protection to brain from mechanical socks.

(b) Optimum physiological fluid environment for neural functions *e.g.* conduction of nerve impulses, transport of aminoacids, sugars, O_2 etc.

(c) 'Relief' mechanism for the increase in intracranial pressure that occurs with each arterial pulse of blood to brain.

(d) 'Sink' like facility for metabolites of brain.

(e) The blood CSF barrier for selective transport process between blood and CSF.

Major site of CSF formation is choroid plexus, and mid ventricular wall and sub-arachnoid wall also contribute. CSF is cell free, slightly alkaline, and is isotonic to plasma. Rate of formation of C.S.F is 80 *ml*/*hour* approx, 1/2 *litre* per day. Total amount present in and around CNS is 150 *ml* it means there is atleast 3 times renewal of C.S.F. every day.

Blood brain barrier facilitate maintenance of stable internal environment. Its acts as physiological and pathological barrier as well. Hydrocephalus **:** The enlargement of head, a pathological condition characterized by an abnormal accumulation of cerebrospinal fluid resulting headache, vomiting, pain and stiffness of the neck.

- Increased cerebrospinal fluid may result Meningites.
- Meningites may appear due to infection and inflamation of meninges or injury of meninges.
- Infection may be viral, bacterial or both. The most common cause of meningitis in the infection of streptococcus and neumoniae, neisseria meningitidis and haemophilus influenzae.
- Lumber puncture is done for drainage of excess of cerebrospinal fluid during meningitis.

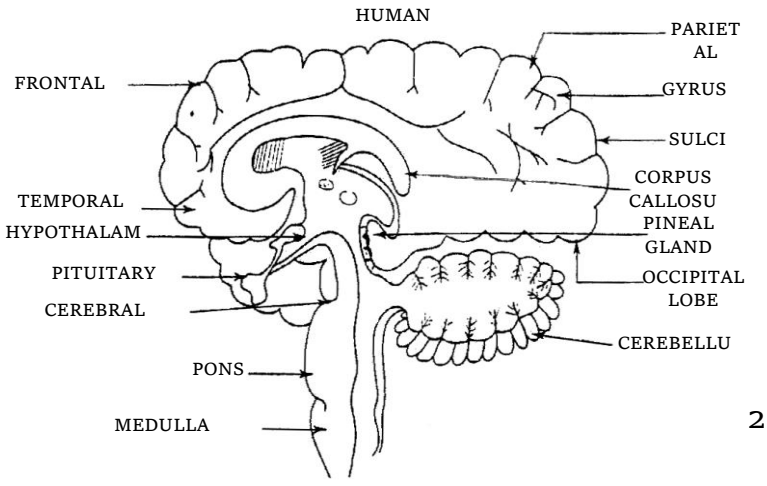


Fig. – Sagittal section of human

- Cerebro-spinal fluid is formed by choroid plexus (ACP and PCP).

There are three choroid plexus in humans

(a) **Lateral choroid plexus :** It is in the roof of I and II ventricle.

(b) **Anterior choroid plexus :** It is in the roof of III ventricle (diacoel).

(c) **Posterior choroid plexus or pelochoroida :** It is in the roof of IV ventricle.

Oxygen and glucose requirements : Brain controls the functions of our body organs and also provides the qualities of mind – learning, reasoning, and memory. For these activities, brain needs a large and constant energy supply. At any given time, the activities of the brain account for 20% of the body's consumption of oxygen and 15% of its consumption of blood glucose. Brain deprived of oxygen for just 5 minutes is permanently damaged. Mental confusion results if brain is deprived of glucose.

(a) **Brain (Encephalon) :** It is soft, whitish, large sized and slightly flattened structure present inside cranial cavity of cranium of the skull. In man, it is about 1200-1400 *gm* in weight and has about 10,000 million neurons. Brain is made up of 3 parts

(1) **Fore brain (Prosencephalon)**

(i) Olfactory lobe – Rhinencephalon

(ii) Cerebrum – Telencephalon

(iii) Diencephalon – Diencephalon

(2) **Mid brain (Mesencephalon)**

(i) Optic lobes – Mesencephalon

(3) **Hind brain (Rhambencephalon)**

(i) Cerebellum – Metencephalon

(ii) Medulla oblongata – Myelencephalon

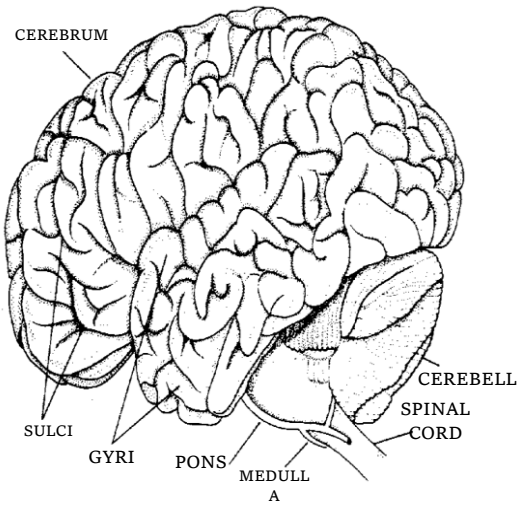


Fig. – Main parts of human brain visible

(1) **Fore brain or Prosencephalon :** It forms anterior two-third of brain and is formed of three parts.

(i) **Olfactory lobes :** These are one pair, small sized, club-shaped, solid, completely covered by cerebral hemisphere dorsally. Each is differentiated into two parts –

(a) **Olfactory bulb :** Anterior, swollen part, and

(b) **Olfactory tract :** Posterior and narrow part which ends in olfactory area of temporal lobe of cerebral hemisphere.

Function : These control the smell.

- It is normal in frog, rabbit and man.
- It is well developed in dog. So power of smell is more in dog.

❑ These are also well developed in dog fish and name dog fish is on the basis of well developed olfactory lobes.

(ii) **Cerebrum :** (a) **Structure** is divided into 5 lobes (i) frontal (ii) parietal, (iii) occipital, (iv) temporal and (v) limbic. A lobe called insula is hidden as it lies deep in the sylvian fissure. The cerebral hemisphere are separated from olfactory lobes by rhinal fissure. The median fissure divides the cerebrum into a right and a left cerebral hemisphere.

A few sulci are well developed and form three deep and wide fissures which divide each cerebral hemisphere into four lobes : anterior frontal lobe, middle parietal lobe, posterior occipital lobe and lateral temporal lobe *e.g.* Fissure lying between the frontal and parietal lobes is central fissure, that lying between the parietal and occipital lobes is parieto-occipital fissure and that demarcating frontal and parietal lobes from the temporal lobe is lateral or Sylvian fissure. Each cerebral hemisphere is with a fluid-filled cavity called lateral ventricle or paracoel.

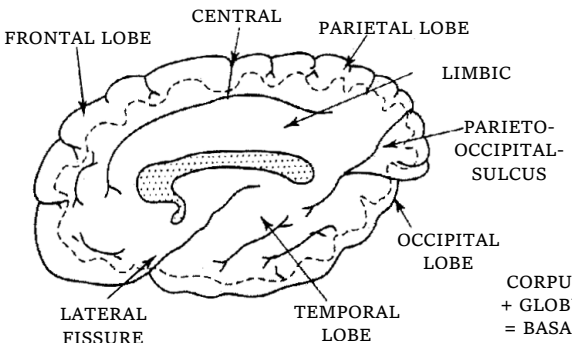


Fig. – Medial surface of

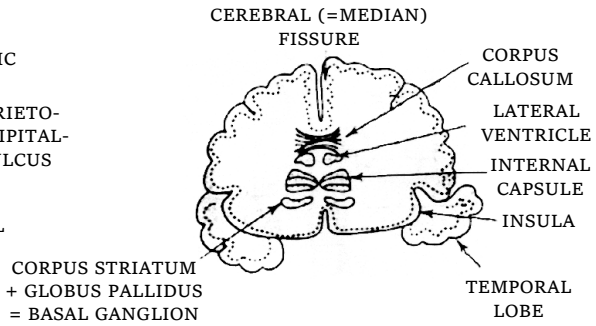


Fig. – Cross section of cerebrum

Two cerebral hemispheres are interconnected by thick band of transverse nerve fibres called corpus callosum. The peripheral portion of each cerebral hemisphere is formed of grey matter and is called cerebral cortex, while deeper part is formed of white matter and is called cerebral medulla. Cerebral cortex is the highest centre for many sensations and activities and is with a number of sensory areas.

Important areas in the human brain

Area	Location	Function
Premotor area	Frontal lobe	The highest centre for involuntary movements of muscles and ANS.
Motor area	Frontal lobe	Controls voluntary movements of the muscle
Broca's area	Frontal lobe	Motor speech area
Somesthetic area	Parietal lobe	Perception of general sensation like pain, touch and temperature
Auditory area	Temporal lobe	Hearing

Olfactory area	Temporal lobe	Sense of smell
Wernicke's area	Temporal lobe	Understanding speech written and spoken
Gustatory area	Parietal lobe	Sense of taste
Visual area	Occipital lobe	Sensation of light

(b) **Histology of cerebrum :** The whole brain possess grey matter outside and white matter inside around ventricle.

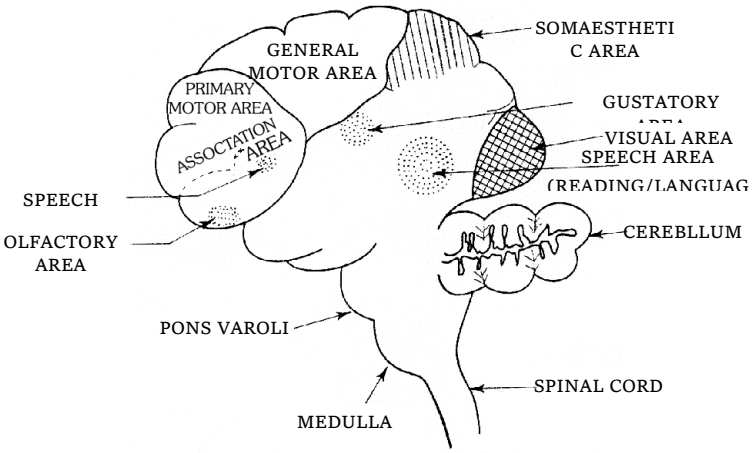


Fig. – Sensory areas of human

(1) **Grey matter :** In cerebrum grey matter is very much developed, it is on an average 3.5 *mm*. thick but at poles its thickness is 1.3 *mm.* It is thickest at pre central gyrus (4.5 *mm* thick). Grey matter of cerebrum is called cortex or pallium. Phyllogenetically or evolutionarily cortex is divided into 3 parts –

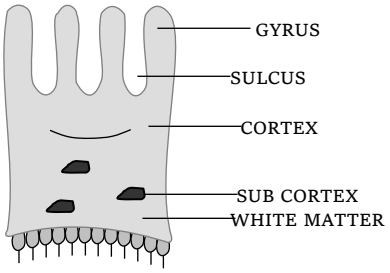
(i) **Allocortex or paleocortex :** It is the

cortex of olfactory area of frontal lobe and olfactory bulbs. In lower vertebrates (cartilagenous fish) olfact lobes occupy most of the part of cerebrum. So in these animals sense of olfection is very-very much developed. Sense of olfaction is oldest sense.

(ii) **Mesocortex :** It is relatively not much older in development.

(iii) **Neocortex or neopallium or isocortex or neencephalon :** It is most recent cortex and is developed maximum only in human. It is in prefrontal cortex or prefrontal region (organ of mind), precentral and precentral gyrus etc. The neocortex is having 6 (six) layer of neurons while remaining cortex possess only 5 layers.

The cerebral cortex is having area of about 2200 cm^2 while the cranial cavity is only 1450 cm^3, so to accomodate cerebrum there appears foldings in the cortex. The ridges are called gyrus (or gyri) or convolution while the depression are called sulcus (sulci in plural).



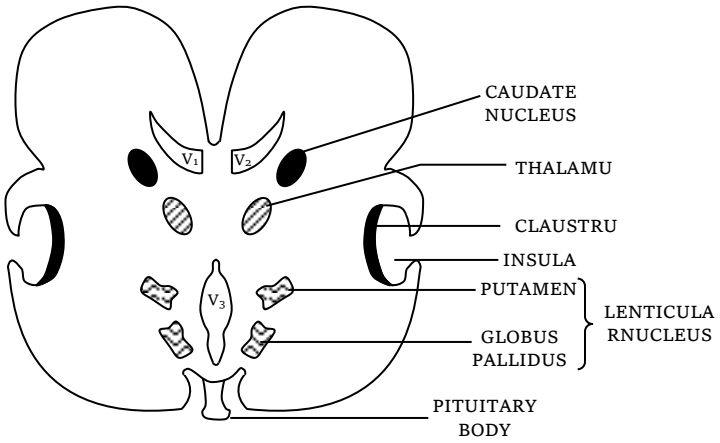
(2) **White matter :** It is inner part of brain. Its fibres are divide into 3 categories –

(i) **Commissural fibers :** These neurons connect gyri of 2 hemispheres, such as corpus callosum. habenular commissure, anterior commissure, posterior commissure.

(ii) **Associate fibres :** They connect gyri of same hemispheres.

(iii) **Projection neuron :** They are infact assending and descending nerve tract, they connect one part of brain to another part of brain or to spinal cord. (In spinal cord they were called as columo).

(c) **Associated structures of cerebrum** : Cerebrum has following specific structure.

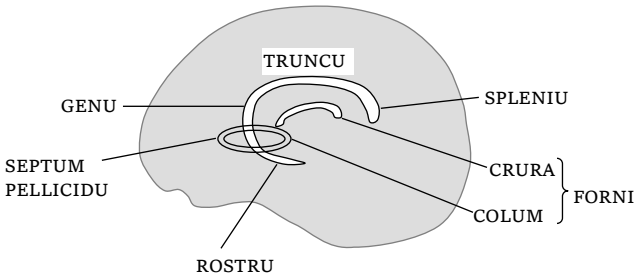


(1) **Sub cortex :** Nuclei on white matter. It is cluster of grey neurons in depth of white matter, they are formed in whole brain and are named differently.

(2) **Basal granules or central nucleus :** Basal ganglia is the name given to many sub cortical structure of walls of paracoel, hypothalamus and mid brain –

(i) **Corpus striatum :** Corpus striatum is the name given to caudate nucleus and lenticular nucleus. Caudate is tail shaped while the lenticular nucleus is lenti shaped. The lenticular nucleus is sub-divided in putamen (outer shell) and globus pallidus (ball).

(ii) **Claustrum :** It is the name given to grey matter present between insula and patamen.



(iii) **Epistriatum or Amygdaloid body :** It is structure present at the end of caudate nucleus.

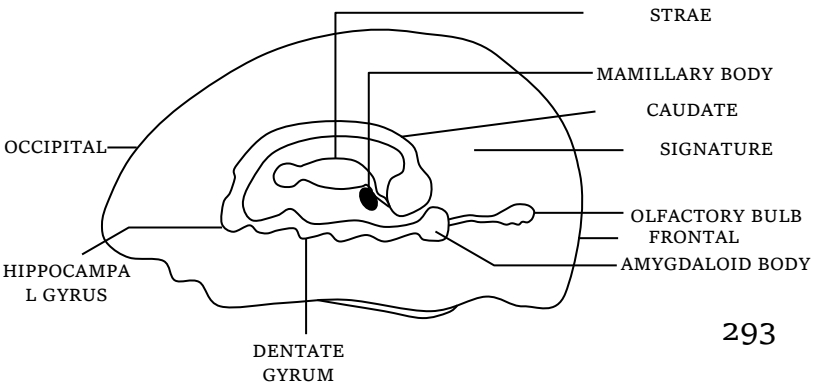
(iv) **Red nucleus** and **substantia nigra** of mid brain.

The basal ganglia controls automatic movements of skeletal muscles like swinging, walking etc.

(3) **Corpus callosum :** It is the band of white neurons present between both cerebral hemisphere and connect them on medial surface. It is present only mammal. It has anterior part genu, middle part trunchus and last part splenium.

Below corpus callosum there are two fused band of white neurons called fornix. There anterior part is called column and posterior part is called crura. Between column and genu a membrane is called septum lucidum or septum pellicidum. Septum lucidum encloses a space called V_5 or Pseudocoel, because it is not possessing C.S.F. *i.e.* why it is called pseudocoel.

(4) **Limbic system :** It is also called emotional brain or animal brain. Limbic system controlling emotion, animal behaviour like chewing, licking, sniffing, rage, pain, plessure, anger, sexual feelings, grooming. It has following structure



(i) **Singulate gyrus :** It is a region of pre central gyrus.

(ii) **Hippocampal gyrus :** It is a region of temporal lobe near colossomarginal sulcus. These two structure are combinely called limbic lobe.

(iii) **Amygdaloid body :** It is the end of caudate nucleus.

(iv) **Olfactory bulb :** They are on the inferior anterior surface of brain. Olfactory nerve ends in these bulb.

(v) **Mammillary body :** They are found in hypothalamus. Olfactory bulb and mammillary body both are centre of olfaction.

From a evolutionary point of view, the cerebral hemisphere are the highly evolved structure and this is manifested by

(a) Great increase in the number of feed back circuits between cerebral cortex and sub cortical elements.

(b) The ability of man and other primates to perform variety of complex function.

(c) The lobe of cerebrum are delineated by fissure and sulci.

(d) A corpus callosum connects the left and right cerebral hemisphere. This is a unique property of mammals as it facilitates flow of information between the 2 hemispheres.

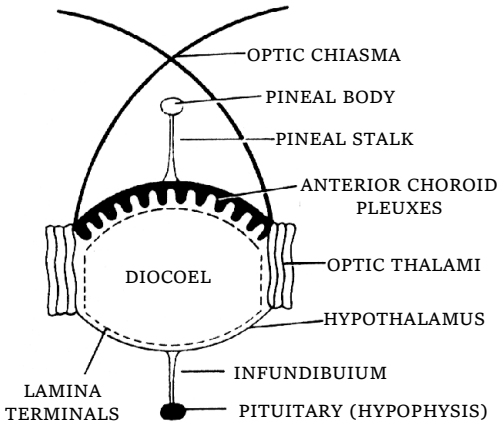


Fig. – Diencephalon

(e) The cortical layer of cerebrum is thrown into folds (= gyri) separate by sulci. All the larger mammalian brains exhibit well developed gyri. The degree of convolutions of the cortex is a fairly reliable indicator of the evolutionary stages of development of brain. The roof of cerebrum is called pallium while the ventrolateral walls are thick and are called corpora striata.

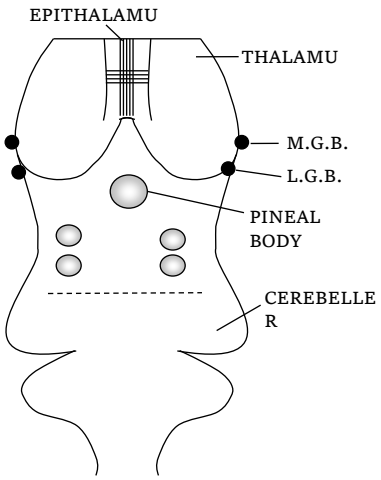


Fig. – Posterior aspect

(vi) **Diencephalon cavity is called, III vertricle or diacoel :** The thin roof of this cavity is known as the epithalamus, the thick right and left sides as the thalami, and floor as the hypothalamus.

(a) **Epithalamus :** The epithalamus is not formed of nervous tissue. It consists of piamater only. Hence, it is of relatively little significance as a nerve centre. Its anterior part is vascular and folded. It is called anterior choroid plexus. Behind this plexus, the epithalamus gives out a short stalk, the pineal stalk which hears a small, rounded body, the pineal body, at its tip.

(b) **Thalami :** A pair of mass of grey matter formes the major part of the wall and floor of diancephalon. Its nuclei have complex connection with the sensory area of the cerebral cortex. It receives and integrates sensory impulses from the eye, ear and skin. It has nerve connection with

motorcortex and act as relay centre. Habenular commissure is a band of nerve fivers connecting two thalami. On the inferior surface of each thalamus there are two rounded bodies of grey matter.'

(1) **Median geniculate body (M.G.B) :** It receives hearing impulse and relay into cerebral cortex.

(2) **Lateral geniculate body (L.G.B) :** They are concern with vision (optic nerve) and relay visual impulse towards cerebral cortex.

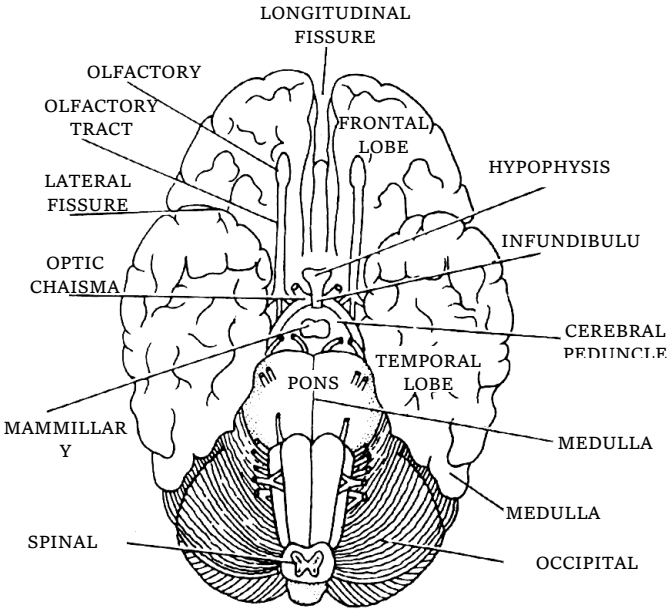


Fig. – Ventral view of brain

(c) **Hypothalamus :** The hypothalamus is visible in the ventral view of the brain and forms the floor of diencephalon. Hypothalamus also gives a nervous process called infundibulum (forms pars nervosa) which meets a rounded non-nervous pharyngeal outgrowth called **hypophysis**. Both collectively form master gland called **pituitary body**. A stalked outgrowth of infundibulum combines with a pouch-like epithelial outgrowth (Rathke's pouch) of the roof of embryonic mouth (= stomodaeum), forming a pituitary gland or hypophysis. Which secretes a number of hormones. In front of hypothalamus, there is cross of two optic nerves called optic chiasma. Behind the hypothalamus, there is one pair of small, rounded, nipple-like bodies called mammilary bodies or corpora mammillares. The hypothalamus consists of many masses of grey matter, called hypothalamic nuclei, scattered in the white matter.

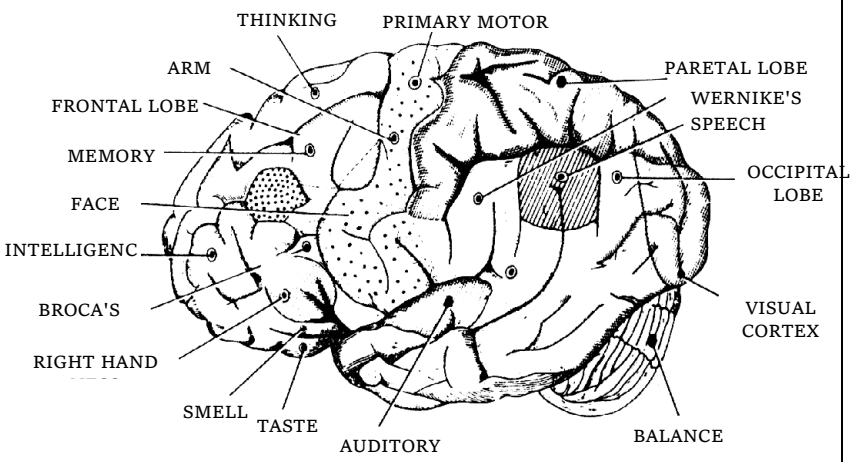


Fig. – Man-different areas in brain(functional and

In man and some other mammals, most fibres of optic nerves cross, but some fibres do not cross and innervate the eyes of their own respective sides. This arrangement enables man and these mammals to have a **binocular vision**. Rabbits simply have a **monocular vision**.

Pineal gland is a pine cone-shaped gland. It is located in the center of brain with which it loses all nerves connection after birth. It is innervated by sympathetic nerves. It has a photosensory role in amphibian and primitive reptiles and is called 'Third eye'. Pinealocytes secretes melatonin. Mammalian pineal does not act as photoreceptor but it produces the hormone called melatonin which is anti FSH, and anti LH. It inhibits reproductive function. Melatonin secretions decrease after puberty.

Function of fore brain

(1) **Olfactory lobe :** It is centre of smell.

(2) **Cerebrum :** Cerebral cortex is made up of grey matter and differentiated into –

(i) Sensory area

(ii) Motor area

(iii) Associated area

Sensory and **associated area** confirm, recognise and evaluate for shape, colour, sound, taste and smell for sensory cells in relation with object.

Broca's area : Known as sensory speech area or motor speech area. Translate thought into speech. Located into frontal lobe towards left side. It is associated with language area and also interpriate translation of written words into speech. Damage or injury in Broca's area (sensory or motor speech area) may result

(i) Aphasia(Inability to speak) (ii) Word deafness, (iii) Word blindness

Cerebrum is a centre for

(i) *Intelligence*	(ii) *Emotion*	(iii) *Will power*
(iv) *Memory*	(v) *Consciousness*	(vi) *Imagination*
(vii) *Experience*	(viii) *Knowledge*	(ix) *Reasoning*
(x) *Voluntary controls*	(xi) *Weeping and laughing*	(xii) *Micturition*

(xiii) *Defecation*

If cerebrum is removed animal becomes *simple reflax animal*.

(3) **Diencephalon :** It is centre for

(i) *Carbohydrate metabolism* (ii) *Fat metabolism*

(iii) It relays impulses from posterior region of brain and also to posterior region of brain.

(iv) Its secretes neurohormone (v) From part of pituitary gland

(vi) Secrete cerebrospinal fluid

Hypothalamus **:** It is floor of diencephalon and centre for

(i) *Hunger*	(ii) *Thirst*	(iii) *Sweating*
(iv) *Sleep*	(v) *Fatigue*	(vi) *Temperature*
(vii) *Anger*	(viii) *Pleasure, love and hate*	(ix) *Satisfaction*

(x) It is also centre to *release factors for endocrine glands*.

(xi) It also control A.N.S (autonomic nervous system)

(xii) Centers for regulation of parasympathetic (cranio-sacral) activity. When stimulated, it causes slowing down of heart beat, contraction of the visceral muscles.

(4) **Mid brain or mesencephalon :** It is also completely covered by cerebral hemisphere. It is formed of two parts –

(i) **Optic lobes :** These are one pair, large sized lobes present on dorsal side. Each is divided transversely into upper and larger superior coliculus and lower and smaller inferior coliculus. So there are four optic lobes, so called optic quadrigemina (only in mammals). In frog these are known as bigemina. **Valve of vieussens** It joins the optic lobe with cerebellum.

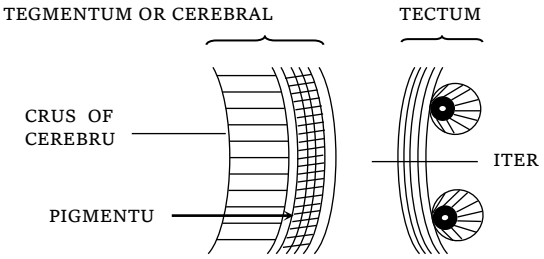
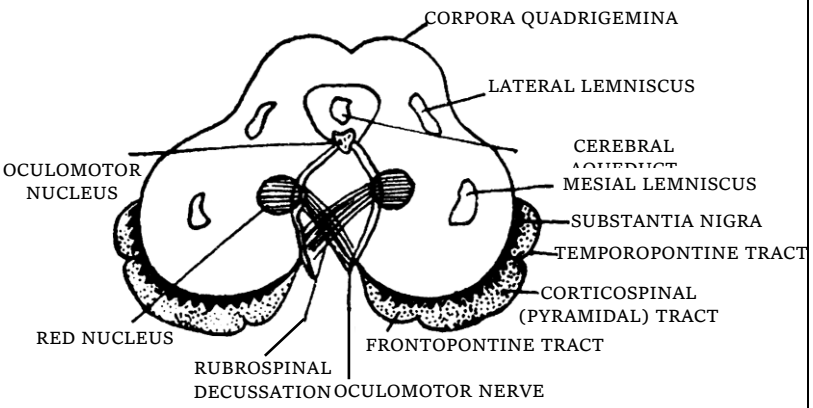


Fig. –Lateral

(a) **Superior optic lobe or superior celliculus :** They are concerned with reflex action of eye, head and neck in response to visual stimulus.

(b) **Inferior calliculus :** They are concerned with movement of head and trunk in response to hearing stimulus.

(ii) **Cerebral peduncle** (crura cerebri) **:** They are the pair of thick bands of longitudinal nerve fiber present on the floor or ventral side of mid brain. The dorsal part of cerebral peduncle (white matter) is called Tagmentum while most ventral part (gray matter) is called crura cerebrae or crus of cerebrum. Dorsal thick wall of mid brain is known as optic tectum. Iter is between tegmentum and tectum. Cerebral peduncle are infect possessing assinding and desending tracts, connecting upper and lower region of brain.



In white matter of cerebral peduncle these are following sub cortical structure

(a) **Red nucleus or rustrum nucleus :** They are red because rich blood supply and iron containing pigment or haemoglobin.

(b) **Substantia nigra :** It is black because of much deposition of melanin.

(c) **Occulomotor nucleus :** It is origin point of 3rd cranial nerve (occulomotor) from this region 4th (Trochlear) nerve also originates.

Reticular activating system : A diffuse network of nerve cell bodies and nerve tracts extends through the brain stem. It is called reticular activating system (RAS). It screens sensory information so that only certain impulses reach the cerebrum. For example, when you are alternatively listening to a lecture in the classroom, you are unaware of rustle of papers from those around you and from the touch of your clothes to the skin. The RAS is also important in overall activation and arousal. When certain neurons in RAS are active, we are awake, when they are inhibited by other neurons, we sleep. The pons

and medulla have sleep centres that cause sleep when stimulated. Midbrain has an **arousal centre** which causes arousal.

Function of Mid brain

(a) Pair of anterior optic lobes (which are also known as superior collici) is related with vision.

(b) Pair of posterior optic lobe (known as inferior collici) related with auditory.

(c) These act as coordination centres between hind and fore brain.

(5) **Hind brain :** Consists of (i) cerebellum and (ii) medulla oblongata (iii) Pons varolii.

(i) **Cerebellum** (Sandwitched brain) **:** *Cerebellum* is highly convoluted and well developed in mammals. It controls the most intricate movements of the body. It coordinates sensory information received from muscles/joints, visual, auditory and equilibrium receptors as well as flow of impulses from cerebral cortex.

Cerebellum is made up of –

(a) Vermis, (b) Cerebellar lobes (= floccular lobes), (c) Lateral lobes, (d) Pons.

The pons is a thick band of transverse nerve fibers. Cerebellum is joined to parts of brain by afferent and efferent fibres. Mid brain, pons and medulla have several similar functions and they constitute the brain stem. Peripheral part is formed of grey matter and is called cerebellar cortex while the central part is formed of white matter and is called cerebellar medulla. The white matter forms a tree-like branching pattern called arbor vitae, so the cerebellum is solid internally.

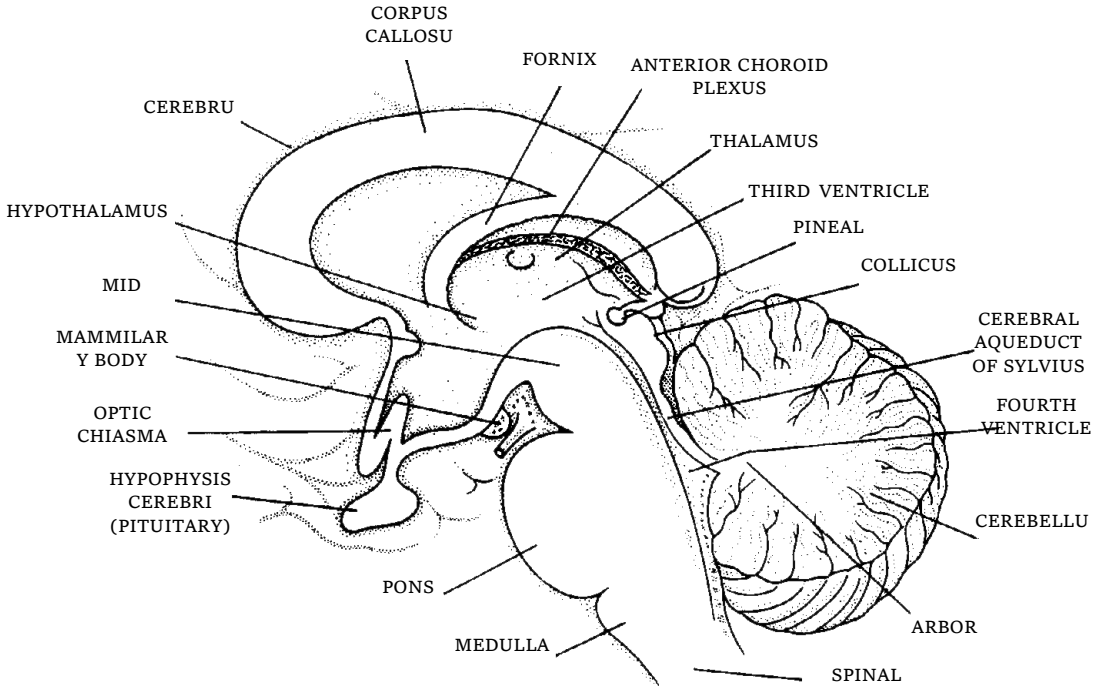
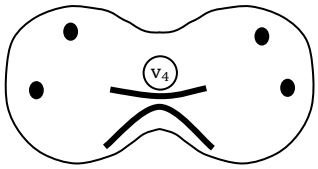


Fig. – Sagittal section of human brain showing the structures around third ventricle and parts of

(ii) **Medulla oblongata**



Medulla oblongata is the hindest and posterior most part of brain. Cavity is known as IVth ventricle (metacoel). Which is continuous with central canal of spinal cord. It has a pair of lateral Foramina of Luschka and a median foramen magendic. Cerebrospinal fluid come in contact by these apertures from internal cavity of the brain to outer fluid of meninges. A arrangement on its ventral surface there are buldgings of ascending and descending tract which are called pyramids. On the ventral surface these pyramids cross each other which is

called deccusatn of pyramids. On the dorsal side of medulla there are two nuclei which are called nucleus gracitis (long) and nucleus cunaeus. On floor of V_4 there is groove called calamus scroptosious.

In the medulla oblongata, most of the sensory and motor fibres cross from one side to the other. Thus, the left cerebral hemisphere controls the right side of the body and *vice versa*. The reason for this is not known. The lower end of medulla passes into the spinal cord. There is no demarcation between the two. However, the medulla is considered to start at the level of the foramen magnum of the cranium.

(iii) **Ponus Varolii :** An oval mass, called the pons varolii, lies above the medulla oblongata. It consists mainly of nerve fibres which interconnect the two cerebellar hemispheres and also join the medulla with highrt brain centres, hence its name pons means bridge. Pons possess pneumotoxic and apneustic areas or centre. From pons 5, 6, 7 and 8th cranial nerve originate.

Function of hind brain

(1) **Cerebellum –**

(i) Poorly developed in frog but well developed in mammal.

(ii) It is centre for co-ordination of muscular movement.

(iii) It is primary centre for balancing, equilibrium, orientation.

(2) **Medulla oblongata contain centre for**

(i) *Heart beats* (ii) *Respiration* (iii) *Digestion*

(iv) *Blood pressure* (v) *Gut peristalsis* (vi) *Swallowing of food*

(vii) *Secretion of gland*

(viii) *Involuntory function – e.g. vomiting, coughing vasoconstrictor, vasodilater, sneezing, hiccouping.*

(ix) It control urination, defecation.

Differences between Cerebrum and Cerebellum

Cerebrum	Cerebellum
(1) It is the largest part of the brain, forming four-fifths of its weight.	(1) It is the second largest part of the brain, forming one-eighth of its mass.
(2) It covers the rest of the brain.	(2) It covers the medulla oblongata only.

(3) It is a part of the forebrain.	(3) It is a part of the hindbrain.
(4) It consists of 2 cerebral hemispheres each comprising 4 lobes : frontal, occipital, parietal, temporal.	(4) It consists of two cerebellar hemispheres and a median vermis.
(5) It encloses 2 lateral ventricles.	(5) It is solid.
(6) White matter does not form arbor vitae.	(6) White matter form arbor vitae.
(7) It initiates voluntary movements, and is a seat of will, intelligence, memory *etc*.	(7) It maintains posture and equilibrium.

Cavities or ventricles the brain : The ventricles consist of four hollow fluid filled space inside the brain and same duct for connection between these ventricte.

(i) Olfactory lobe – Rhinocoel

(ii) Cerebrum – I and II ventricle or lateral ventricle or paracoel.

(iii) Foramen of monero **:** I and II ventricle communicating with IIIrd ventricle by foramen of monero. They are two in human and single in rabbit and frog.

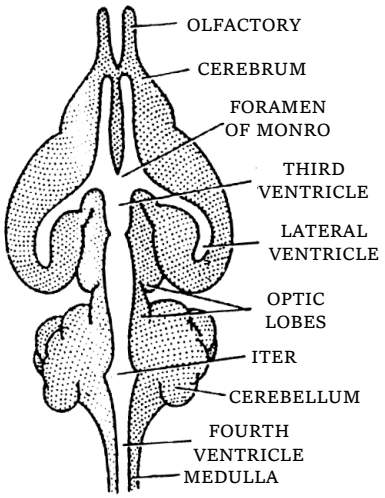


Fig. Ventricles of brain

(iv) Diencephalon **:** Third ventricle or Diocoel.

(v) Iter or cerebral aquiduct or aquiduct of sylvius **:** It is very narrow cavity between III and IV ventricle.

(vi) Optic lobe **:** Optocoel.

(vii) Cerebellum **:** Solid.

(viii) Medulla oblongata : 4th ventricle or metacoel.

Cavities of brain and spinal cord are modified neurocoel. They are lined by low columnar ciliated epithelium called ependyma.

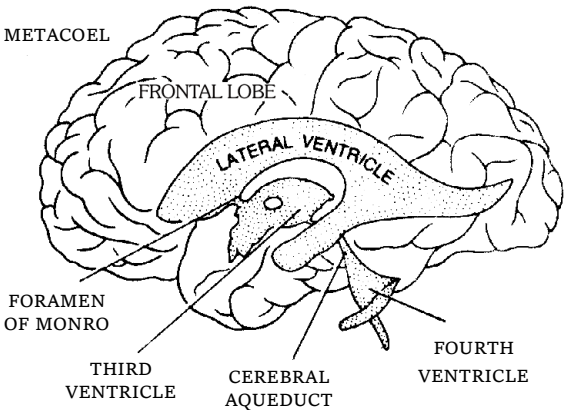


Fig. Diagram showing ventricles of human brain

Subdivisions, parts and associated strcutures of a vertebrate brain

Divisions	Subdivisions	Parts	Cavity	Associated strcutures
	(1) Telencephalon	Rhinencephalon	I Ventricle (*Rhinocoel*)	Olfactory bulbs Olfactory tracts Olfactory lobes Palaeocortex on pallium
		Cerebral hemispheres	II or Lateral Ventricles (*Paracoels*) ↓ Formen of Monro	Corpora striata or basal ganglia Corpus callosum Neocortex on pallium Paraphysis
(I) Prosencephalon (Forebrain)	(2) Diencephalon	Epithalamus (roof)	↓ III Ventricle (*Diacoel*)	Habenulae Pineal apparatus Parapineal or parietal
		Thalamus (sides)		
		Hypothalamus (floor)		Hypothalamic nuclei Optic chiasma Median eminence Infundibular stalk Pituitary Saccus vasculosus Mamillary bodies Anterior choroid plexus
(II) Mesencephalon (Midbrain)	–	Crura cerebri (floor)	*Iter* or *cerebral aqueduct*	Optic lobes / Auditory lobes] Tectum Cerebral peduncles

(III) Rhombencephalon (Hind brain)	(1) Metencephalon	Cerebellum		Trapezoid body Pons
	(2) Myelencephalon	Medulla oblongata	IV Ventricle (*Metacoel*)	Restiform bodies Pyramids

Salient or mammalian features of human brain

The salient or mammalian features in the human brain are

(1) Relatively small, solid olfactory lobes.

(2) Very large cerebral hemispheres divided into lobes and with highly folded surface, fully cover the rest of the brain.

(3) Corpus callosum interconnecting the cerebral hemispheres.

(4) Very small pineal body.

(5) A pair of mammillary bodies joined to hypothalamus.

(6) Relatively small, solid optic lobes divided into 4 corpora quadrigemina.

(7) Large, solid cerebellum, with highly folded surface and divided into lobes.

(8) Pons varolii present anterior to the cerebellum.

Important Tips

- Tela choroidea is the term used for epithalamus and piamater fused.
- Tela choroidea is made up of epithelium and blood vessels.
- Ataxia mean lacks of muscle coordination. Damage to cerebellum is characterized by ataxia.
- Dyslexia involves an inability of an individual to comprehend written language.
- Multiple sclerosis is the destruction of myelin sheath of neurons of CNS.
- An American scientist **Roger Sperry** got Nobel Prize in 1981 for his outstanding work on **split brain theory**.
- Parkinson's disease or **Paralysis agitans** is a defect of brain.
- Parkinsonism is characterised by tremors and progressive rigidity of limbs caused by a degeneration of brain neurons and a neurotransmitter called **dopamine**.
- Avian brain has large sized optic lobes to see the objects on the earth while flying so is called eye brain, while fish brain has large sized olfactory lobes to smell the prey from a distance so is called **nose brain**.
- In fishes : Cerebrum is not differentiated in two cerebral hemispheres.
- Hypothalamus has additional lobes to note pressure changes.
- In reptilian brain, **pineal eye** (parietal body) present in front of pineal body.

- In birds, instictive behaviour is well developed so corpora striata are well developed.
- Grey matter of spinal cord of frog is rectangular white it is butterfly-shaped in mammals.
- Central canal : Cavity of spinal cord.
- Optic bigemina : Two optic lobes in brain and are found from fishes to birds.
- Optic lobes of man are solid and have no optocoel but those of frog have optocoel.
- Optic tectum : Dorsal thick wall of optic lobe.
- Cerebellum is also called **little brain**.
- Thalami of diencephalon act as relay centres as well as gate keepers of brain.
- Optic chiasma is meant for binocular vision.
- Olfactory lobes of human brain have no rhinocoel while those of frog have rhinocoel.
- Man and birds are less dependent upon smell so olfactory lobes are small sized but are large sized in cartilage fishes (dog fish), dogs and reptiles as are more dependent upon smell.
- Cerebellum is large sized in fishes, birds and rabbit due to their multidirectional movements and increased dependency on balance.
- Stimulus for hunger : In February 1998, an American scientist **Dr. Masashi Yanagisawa** reported that a drop of sugar level in blood stimulates the apettite centres of lateral hypothalamus to release **oraxin hormone** (Gr. Oraxis = hunger) which stimulates hunger.
- Nervous disorders

  Agnosia : Failure to recognize;
  Alexia : Failure to read;
  Agraphia : Failure to write;
  Aphasia : Failure to speak (due to injury to Broca's area)
  Analgesia : Loss of sensation of pain;
  Anaesthesia : Loss of feeling;
  Insomnia : Inability to sleep;
  Amnesia : Partial or complete loss of memory;
  Coma : Complete loss of consciousness.
  Aproxia : Inability to carry out purposeful movements.
  Multiple sclerosis : Progressive degenerative disease of CNS and is characterized by many hard scar tissues.
- Caudal equamma : Bundle of roots in last segment of spinal cord.
- Brain stem : Diancephalon + mid brain + pons medulla.
- Cerebro vascular accident (C.V.A) or stroke : Blocking of blood supply of a part of brain.
- Alzeimer : It is the disease appearing usually after 65 year. It is characterized by dementia usually. Usually in this disease is ACH producing neurons of cerebral cortex and hippocampal lobe are degenerated. It is also seen that a amyloid protein is accumulated in the brain. It is the matter of research.
- **Comissure :** The band of neurons connecting similar structure of brain or spinal cord.
- **Connective :** The band of neurons connecting two different structure of brain and spinal cord.
- **Associate fibres :** If joining fiber are joining two similar structure in same halves then, they are

called associate fiber.

Spinal cord : Present in spinal canal or vertebral canal of vertebral column. It is extended from foramen magnum to between I and II lumber vertebra. Spinal cord is swollen in cervical and lumber region which are called cervical and lumber enlargement.

Structure of spinal cord

Conus medullaris : It is last tapering ends of spinal cord, its ciliated central canal is called Vth ventricle.

Cauda equine : Nearly upto birth the length of spinal cord corresponds the length of V.C. but after birth there is vertically no growth of spinal cord but vertebral column grow upto I lumber vertebra in adult. Spinal nerve come out through their respective intervertebral foramen, form horse tail hair like cluster below conus medullaris it is called cauda equine.

Filum terminales : It is extension of piamater below conus up to coccyx. In frog spinal cord also extends upto end of vertebral column.

Cisterna terminalis : It is last dilation of subarachnoid space below 1st lumbar vertebra. It is a proper site for lumber puncture or spinal tap, which is done to drain C.S.F out (5 to 10 *ml*). This C.S.F is used in diagnosing many diseases of CNS like meningitis, cyphalis, inter cranial pressure, menningococcal inferaction etc.

Meninges : Like brain, spinal cord is also enclosed with in three membranes. In this case duramater does not remain attached with the vertebra, instead there is a space between duramater and vertebra called **epidural space**. The epidural space is filled with a fluid. The distribution of duramater and piamater in spinal cord is the same as that of brain.

The cross section of spinal cord reveals the following structures

(1) **Central canal :** In the centre of spinal cord, there is a canal called central canal. It is filled with cerebrospinal fluid.

(2) **Dorsal fissure :** In the mid dorsal line, there is a groove extending throughout its length.

(3) **Ventral fissure :** It is also a groove situated in the mid ventral line throughout the length of spinal cord.

(4) **Dorsal septum :** It is a partition extending from dorsal fissure to central canal.

(5) **Grey matter :** It lies around the central canal in the form of a butterfly.

(6) **Dorsal horns :** It is like horn of grey matter on the dorsal side.

(7) **Ventral horns :** On the ventral side of the grey matter are horn like structures the ventral horns.

(8) **Lateral horns :** These are horns on the lateral side of grey matter.

(9) **White matter :** White matter is present around grey matter. Spinal cord provides pathway for the impulses from the brain and to the brain.

Reflex action

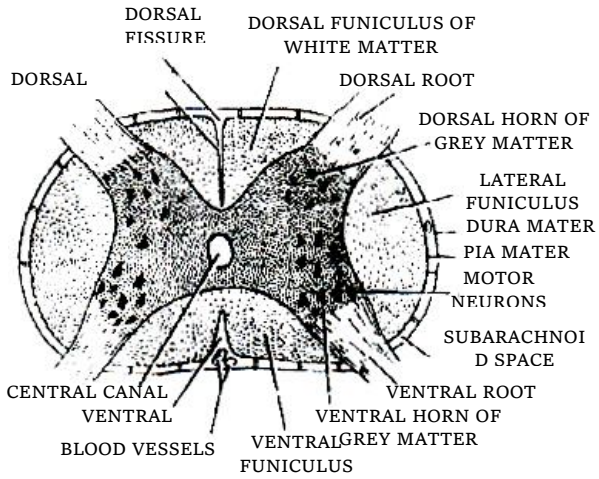


Fig – T.S. of the spinal cord of mammal

First of all Marshal Hall (1833) studied the reflex action. *Best* and *Taylor* defined reflex action "simplest form of irritability associated with the nervous system is reflex actions or a reflex reaction is an immediate involuntary response to a stimulus." The reflex actions are involuntary actions because these are not under the conscious control of the brain. The spinal cord and brain stem are responsible for most of the reflex movements. A few examples of the reflex actions are withdrawal of hand or leg if pricked by a pin, secretion of saliva as soon as one thinks of delicious food or mere its sight causes salivation, if the body part is touched with acid or hot object it is automatically, without thinking and planning is withdrawn, cycling, motor driving etc. Central nervous system is responsible for the control of reflex action.

Reflex arc is formed by the neurons forming the pathway taken by the nerve impulses in reflex action. The simplest reflexes are found in animals involving a single neuron and the following pathway —

$$\text{Stimulus} \rightarrow \text{Receptor} \xrightarrow{\text{Neuron}} \text{Effector} \rightarrow \text{Response}$$

The reflex areas in all the higher animals than coelenterates, include at least two neurons, an afferent or sensory neuron carrying impulses from a receptor towards aggregation of nervous tissue which may be a ganglion, nerve cord or central nervous system and an efferent or motor neuron carrying impulses away from the aggregation to an effector.

(a) **Component of reflex action :** The whole of the reflex are includes six parts –

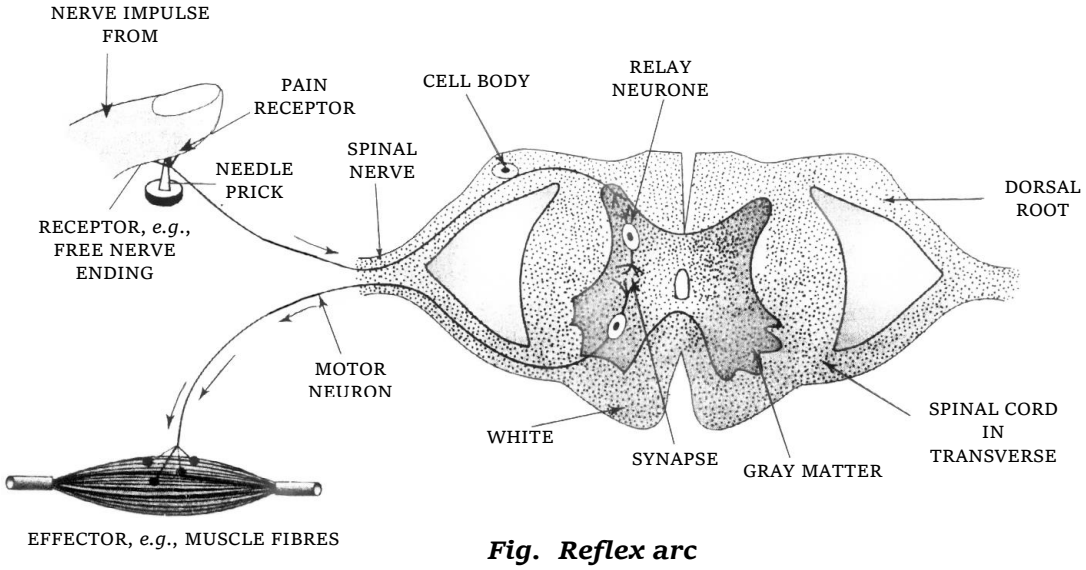


Fig. Reflex arc

(1) **Receptor organs :** Receptors are windows of the body or guards of the body. These are situated on all, important organs, for example – eyes, nose, ear, tongue, integument etc. These perceive the stimuli from out side the body.

(2) **Sensory neurons :** These are also termed afferent neurons. These carry the stimuli from receptors to spinal cord. These neurons are situated in the ganglion on the dorsal side of spinal cord.

(3) **Nerve centre :** Spinal cord is termed as nerve centre. Synaptic connections are formed in it.

(4) **Association neurons :** These are also called intermediate neurons or interstitial neurons. These are found in spinal cord. They transfer the impulses from sensory neurons to motor neurons.

(5) **Motor neurons :** These are situated in the ventral horn of spinal cord. These carry the impulses to effector organs.

(6) **Effector organs :** These are the organs, which react and behave in response to various stimuli, for example – muscles and glands.

(b) **Mechanism of reflex action :** The time taken by a reflex action is too short, for example – in frog it is 0.3 meter per second and in man 5-120 meter per second. Whenever, a part of the body is stimulated by any stimulus, for example – pin pricking, then the stimulus is converted into impulse. This impulse is perceived by the dendrites of sensory neurons. From here, the stimulus reaches the spinal cord through axonic fibres. In the spinal cord, this stimulus passes through synaptic junctions and reaches the intermediate neurons, from where this stimulus reaches the effector organs through visceral motor nerve fibres. As soon as the stimulus reaches the effector organs, it is stimulated and that part of the body is immediately withdrawn. The whole reflex action takes place so rapidly and quickly that we know it when it is completed.

(c) **Type of reflexs :** The reflexes are of following types –

(1) Monosynaptic reflex
(2) Polysynaptic Spinal Reflex
(3) Polysynaptic Spinal/Brain Reflexes
(4) Unconditioned or Simple reflex
(5) Conditioned or Acquired reflexe

(1) **Monosynaptic reflex :** This is the simplest reflex found in vertebrates. The simplest reflex found in vertebrates. The sensory neuron synapses directly on to the motor neuron cell body. In this case the reflex action takes place without the involvement of brain.

(2) **Polysynaptic spinal reflex :** This has at least two synapses situated within the spinal cord. It involves a third type of neuron also – the internuncial or inter-mediate relay neuron. The synapses take place between the sensory neuron and intermediate neuron, and between intermediate neuron and the motor neuron. These two reflex arcs allow the body to make automatic, involuntary, homeostatic adjustments, to changes in the external environment, such as the iris pupil reflex and balance during locomotion, and also in the internal environment such as breathing rate and blood pressure.

(3) **Polysynaptic spinal/brain reflexes :** In this case the sensory neuron synapses in the spinal cord with a second sensory neuron, which passes to the brain. The latter sensory neurons are part of the ascending nerve fibre tract and have their origin in preintermediate neuron synapse. The brain is capable of identifying this sensory information and stores it for further use. The motor activity may be initiated by the brain anytime and the impulses are transmitted down the motor neurons in descending nerve fibre tract, to synapse directly with spinal motor neurons in the postintermdiate synaptic region.

(4) **Simple reflex :** Simple reflex is also known as **unconditioned reflex**. It is inborn, unlearned, reflex to a stimulus. Simple reflex is mostly protective in function. Example of simple reflex are

(a) **Knee jerk** – Tendon of patella tapped.

(b) **Corneal reflex** (blinking reflex) – closing of eyelids.

(c) Rapid withdrawal of hand while burned or pricked.

(d) Quick recovery of balance while falling.

(e) **Scratch reflex** of frog – in pitched frog with acetic acid.

(f) Coughing, sneezing and yawning.

(5) **Acquired reflex :** Acquired reflex is also known as conditioned reflex. It is not inborn, but acquired and dependent on past experience, training and learning. Demonstration of conditioned reflex was first made by Russian physiologist Ivan Petrovitch Pavlov (1846-1936) in hungry dog. Pavlov rang the bell while feeding dog, thus associated the unconditioned response with additional stimulus. Examples of conditioned reflex are learning of dancing, cycling, swimming, singing,, driving, etc. These actions are under cerebral control during learning.

(ii) **Peripheral nervous system :** It is formed of a number of long, thin, whitish threads called nerves extending between central nervous system and body tissues. Each nerve is formed of bundles of nerve fibres, fasciculi, held together by connective tissue and surrounded by a white fibrous connective tissue sheath called epineurium.

The nerve fibres are classified into two categories on the basis of presence or absence of myelin (white fatty) sheath.

(a) Medullated or Myelinated nerve fibres.

(b) Non-medullated nerve fibres.

On the basis of function, the nerves are of three types

(a) Sensory nerve	(b) Motor nerve	(c) Mixed nerve
(1) It contains only sensory nerve fibres.	(1) It contains only motor nerve fibres.	(1) It contains both sensory and motor nerve fibres.
(2) It conducts nerve impulses from sense organs to CNS to produce sensation. *e.g.* Optic nerve, auditory nerve.	(2) It conducts nerve impulses from CNS to some muscles or glands to control their activities. *e.g.* Occulomotor nerve, hypoglossal nerve.	(2) It conducts both sensory and motor impulses. *e.g.* All spinal nerves, trigeminal nerve.

On the basis of their origin, nerves are of two types

(a) Cranial or cerebral nerves which either arise from or end into brain.

(b) Spinal nerves which arise from spinal cord.

(a) **Cranial nerves**

(1) 10 pairs of cranial nerves are present in an anamniote (fishes and amphibians).

(2) Number of cranial nerves found in frog is ten pairs (20).

(3) 12 pairs of cranial nervers are present in an amniote (reptiles, birds and mammals).

(4) Number of cranial nerves found in rabbit and man is 12 pairs (24).

(5) The first 10 pairs are common for frog and rabbit. The additional pairs found in rabbit are spinal accessory and hypoglossal.

(6) The smallest cranial nerbe is trochlear in human beings, but all animals smallest cranial nerve is abducens.

(7) The largest cranial nerve is trigeminal in human beings but vagus is largest cranial nerve in all animals.

(8) Vagus supplies the regions other than head.

(9) The sensory cranial nerves are

I Olfactory	–	Smell
II Optic	–	Vision
VIII Auditory	–	Hearing and equilibrium

(10) The motor cranial nerves are : III, IV, VI, XI and XII.

(11) Extraocular muscle nerves are : III, IV and VI.

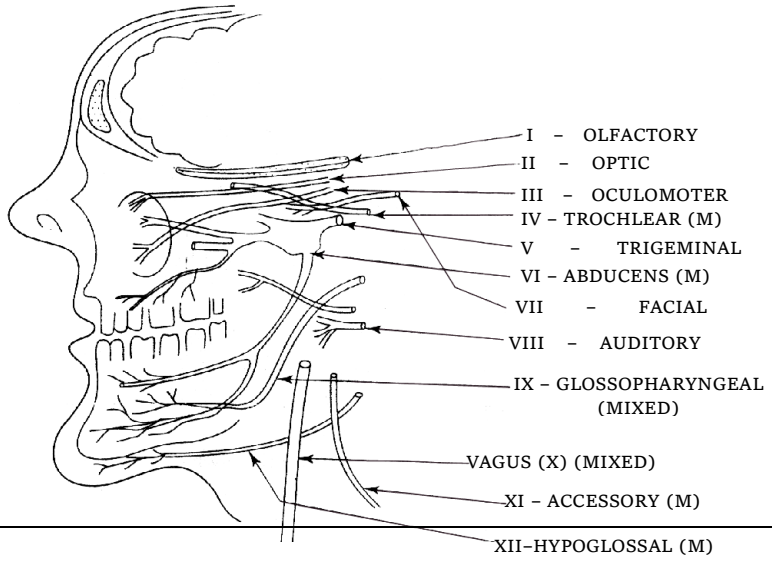
(12) The mixed cranial nerves are : V, VII, IX and X (4 pairs).

Cranial nerves of mammal at a glance

	Name	Nature	Origin	Distribution	Function
(1)	Olfactory Nerves	Sensory	Olfactory lobe	Sensory epithelium of olfactory sacs	Receive stimuli from the sensory epithelium of olfactory sac and carry them to olfactory lobes
(2)	Optic nerves	Sensory	Optic lobes	Retina in Eyes	Stimulus of light is carried to optic lobes
(3)	Occulomotor nerves	Motor	Crura cerebri	Eye ball muscles, except superior oblique muscle	Carry the impulses from crura cerebri to the eye muscles
(4)	Trochlear nerves	Motor	From in between the optic lobes and cerebellum	Superior oblique muscle of eye ball	Carry the impulses from the brain to superior oblique muscles of the eye
(5)	Trigeminal nerves	Mixed	From the gassarion galglia situated on the lateral side of medulla oblongata	—	—
(i)	Ophthalmic nerve	Sensory	,,	Skin of lips	

(ii)	Maxillary	Sensory	,,	Upper lip, skin of nose, lower eye lid.	Carry the stimuli from these organs to brain
(iii)	Mandibular nerve	Mixed	,,	Lower lip and skin of jaw	Carry the stimuli from these organs to brain
(6)	Abducens nerves	Motor	Medulla	Eye muscles	Carry the impulses from the brain (medulla) to eye muscles
(7)	Facial nerves	Mixed	Behind trigeminal nerve, from geniculate ganglion	—	—
(i)	Palatinus	Sensory	—	In the roof of mouth cavity	Carry the impulses from roof of mouth cavity
(ii)	Hyoman dibular	Motor	—	Muscles of low jaw, muscles of neck and pinna (external ear)	Carry the impulses from brain muslces of lower jaws, neck and pinna.
(iii)	Chordotympa ni	Mixed	—	In salivary glands and taste buds	Receives the stimuli from the taste buds and carry the stimulus to salivary gland.
(8)	Auditory nerves	Sensory	Medulla	—	—
(i)	Vestibular nerve	,,	,,	Utriculus, sacculus, semicircular canals and Cochlea.	Receives impulses from the internal ear and carry to brain.
(ii)	Cochlear nerve	,,	,,	Cochlea	—
(9)	Glossopharyn geal nerve	Mixed	,,	Taste buds present in tongue and muslces of oesphagus	Carry sound impulses to brain, to muscles of oesophagus and carry the taste impulse of tongue to the brain

(10)	Vagus nerve	Mixed	After arising from medulla, 9th and 10th cranial nerves unite to form vagus nerve but become separate and divide into branches	—	—
(i)	Superior laryngeal nerve	Motor	—	Glottis	Carry the impulse to muscle of glottis
(ii)	Recurrent laryngeal nerve	Motor	—	Glottis	,,
(iii)	Cardiac nerve	Motor	—	Heart Muscles	From brain to heart muscles
(iv)	Pneumogastric	Motor	—	In the abdominal cavity, in stomach and lungs.	Carry impulse from these organs to brain and from brain to muscles of these organs.
(v)	Depresser nerve	Motor	—	Diaphragm	Carry the impulse to diaphragm
(11)	Spinal accessory	Motor	Medulla	Muscles of neck and shoulders	From brain to muscles of neck and shoulder
(12)	Hypoglossal nerve	Motor	,,	Muscles of tongue and neck	From brain to their muscles



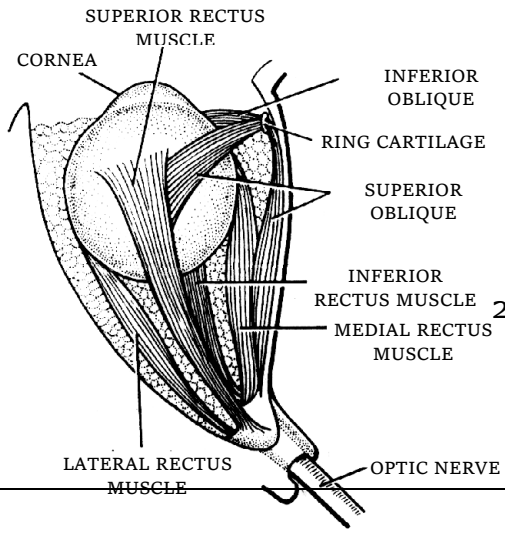


Fig. Diagrammatic presentation of 12 (paired) cranial

Eyeball muscle	Nerve supply
Superior rectus	Oculomotor
Inferior rectus	Oculomotor
Internal rectus	Oculomotor
External rectus	Abducens
Superior oblique	Trochlear
Inferior oblique	Oculomotor

(b) **Spinal nerves :** Spinal nerves arise from gray matter of spinal cord. There are 31 pairs of spinal nerves in man (37 pairs in rabbit). All spinal nerves are mixed. The spinal nerves in man are divided into 5 groups.

(1) Cervical (C) → 8 pairs — in Neck region

(2) Thoracic (T) → 12 pairs — in thoracic region

(3) Lumbar (L) → 05 pairs — upper part of abdomen

(4) Sacral (S) → 05 pairs — lower part of abdomen

(5) Coccygeal (CO) → 01 pairs — represent the tail nerves

31 pairs

Number of spinal nerves in frog is 10 pairs. In some frog like Rana tigrina, 10th pair may reduced or absent. The first pair of spinal nerves in frog is hypoglossal. The last pair of cranial nerves of mammals has the same name. Brachial plexus is formed by 2nd and 3rd spinal nerves in frog. Sciatic plexus is formed by 7, 8 and 9 spinal nerves in frog. Glands of

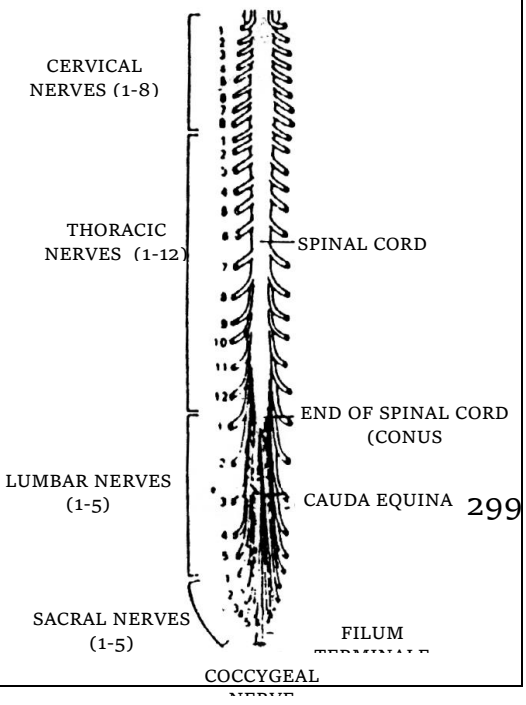


Fig. – Spinal cord and

Swammerdam are calcareous glands found at the places of emerging of spinal nerves in frog.

Spinal nerve formula can be written as : C_8, T_{12}, L_5, S_5, CO_1, Spinal nerves exit via intervertebral foramen. Each spinal nerve arises from spinal cord by 2 roots

(1) *Dorsal* (= *Afferent = Sensory = Posterior*) *root* is a continuation of dorsal horn and is formed of gray matter. It presents a ganglionic swelling in middle, called dorsal root ganglion. These transmit sensory nerve impulses from the sense organs to spinal cord (touch, pain, temperature). They activate involuntary reflexes.

(2) *Ventral* (= *Efferent = Motor*) root are continuation of ventral root and is also formed of gray matter. No ganglion are present. It is formed of only efferent nerve filers. They transmit motor nerve impulses to effector organs *e.g.*, glands and muscles. Each spinal nerve has 3 branches –

(i) **Ramus dorsalis :** Supplies to skin and muscles of dorsal side.

(ii) **Ramus ventralis :** Supplies to skin and muscles of ventral and lateral sides and also to upper

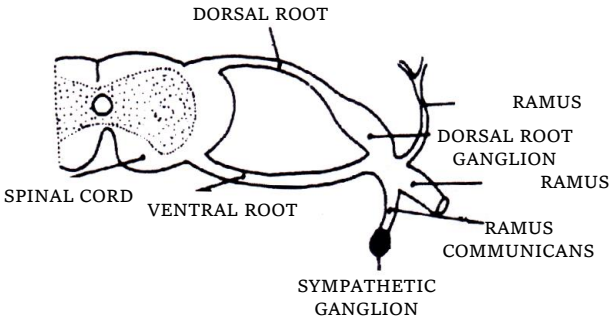


Fig. – Origin and distribution of

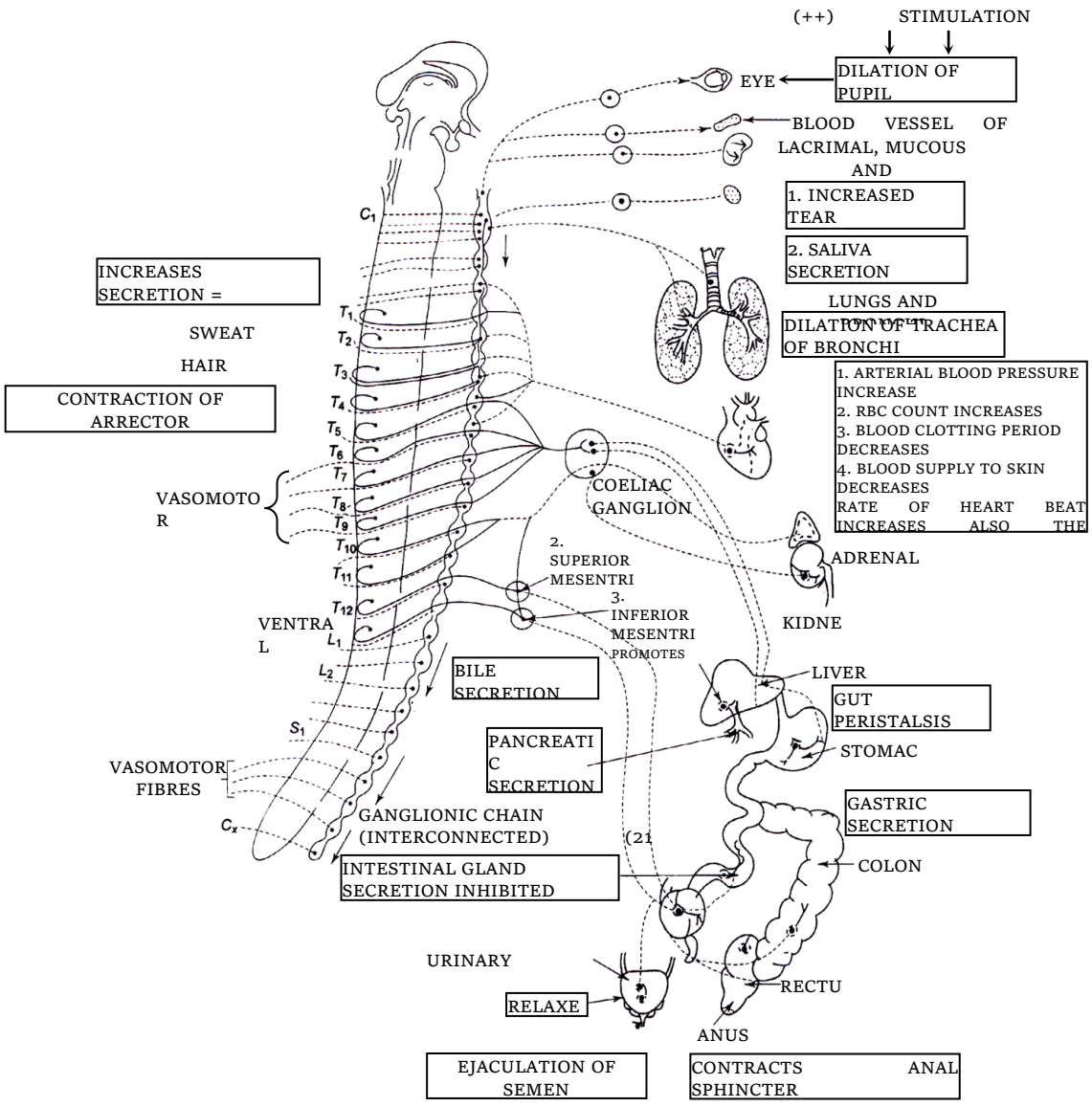


Fig. – Sympathetic nervous system

and lower limbs. Ventral root of certain spinal nerve form 5 nerve plexi on either side, i.e., cervical, thoracic, lumber, sacral, caudd.

(iii) **Ramus communicans :** It joins sympathetic ganglion of autonomic nervous system.

(iv) **Autonomic nervous system :** As mentioned before, the visceral part of peripheral nervous system regulates and co-ordinates the activities of internal or visceral organs. Autonomic nervous system was discovered by **Langley**. Autonomic nervous system (ANS) automatically regulates the activities of **smooth muscles**, cardiac muscles and glands. This co-ordination is involuntary. Autonomic nervous system usually operates without conscious control. Autonomic nervous system is entirely **motor**. All autonomic axons are **efferent fibres**. Efferent neurons are preganglionic with myelinated fibres and postganglionic with unmyelinated fibres. Autonomic nervous system is regulated by centres in brain like cerebral cortex, hypothalamus and medulla oblongata. Autonomic fibres release chemical transmitters at synapse. On the basis of the transmitter produced, these fibres may be classified as cholinergic or adrenergic. Cholinergic fibres release acetylcholine. Adrenergic fibres produce norepinephrine (noradrenaline), also called sympathetin.

Nature of autonomic control : The autonomic nervous system regulates and co-ordinates such vital involuntary activities like heart beat, breathing, maintenance of the composition of body fluids (= homeostasis) and body temperature, gut peristalsis, secretion of glands, etc. For this control, a visceral organ is normally innervated by two, instead of only one, postganglionic fibres having antagonistic excitatory effects; while one fibre promotes the activity of an organ, the other fibre retards it.

Autonomic nervous system consists of two divisions

(a) **Sympathetic** (= Thoracolumbar out flow)

(b) **Parasympathetic** (= Cranio-sacral out flow)

(a) **Sympathetic ANS**

- Thoraco Lumber out flow (all thorocic + 3 lumber)
- Preganglionic nerve small.
- Post ganglionic nerve long.
- Preganglionic nerve secrete acetyl choline.
- Postganglionic nerve secrete **sympathatin**. (*nor-epinephrine*)
- It shows sympathy (generally increase the function).
- Expenditure of energy takes place.
- It increase defence system of body against adverse condition.
- It is active in stress condition, pain, fear and anger.

(b) **Parasympathatic**

- ANS Cranio sacral outflow (cranial-III, VII, IX, X Nerves)-(sacral-II, III, IV Nerves)
- Preganglionic nerve long.
- Postganglionic nerve small.
- Secrete acetyl choline only.
- It provide relaxation, comfort, pleasure, at the time of rest.
- Restoration and conservation of energy takes place.
- Collateral ganglia present in sympathetic nervous system.
- **Horner's syndrome** results from the damage of sympathetic trunk of one side.
- A patient of Horner's syndrome exhibits lack of sweating (on affected side), sunken eyes and constricted pupil.

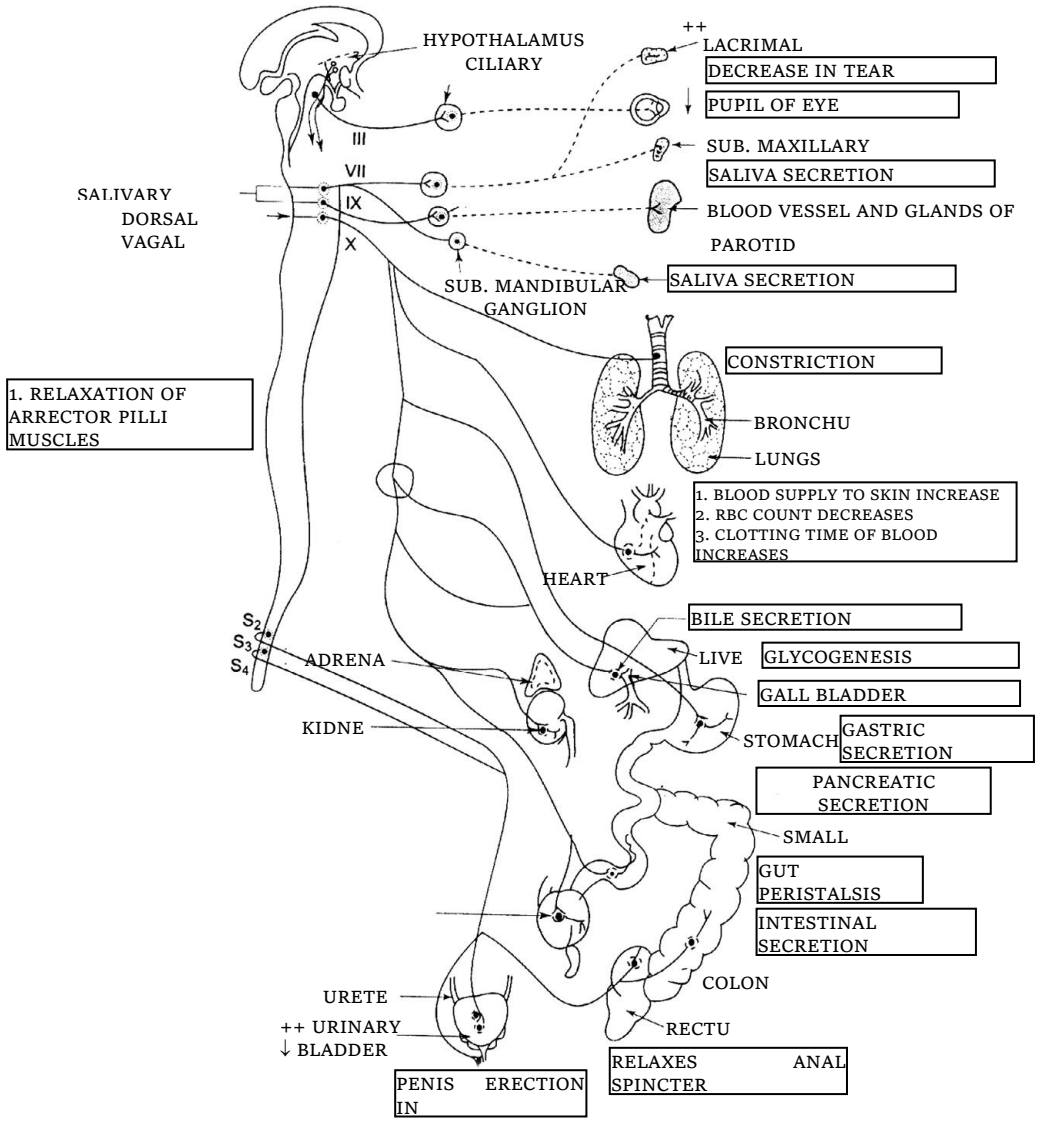


Fig. – Parasympathetic nervous system

S.No.	Name	Sympathetic	Para sympathetic
(1)	Secretion	Acetyl choline and + sympathiatin	Acetyl choline only
(2)	Blood pressure	Increase	Dedrease
(3)	Blood vessel to skin	Constrict	Dilate
(4)	Blood vessel to heart	Dilate	Constrict
(5)	Blood vessel to lung and muscle	Dilate	Dilate
(6)	Pupil	Dilate	Constrict
(7)	Lacrymal glan	Stimulate	Inhibits
(8)	Heart beat	Increase	Decrease
(9)	Adrenal secretion	Stimulate	Inhibit
(10)	Breathing and BMR	Increase	Decrease
(11)	Nostrils	Dilate	Constrict
(12)	Urinary bladder	Relax	Constrict
(13)	Iris	Constrict	Dilate
(14)	Salivary gland	Decrease	Increase
(15)	Digestive gland	Decrease	Increase
(16)	Gut peristalsis	Decrease	Increase

Cutting of sympathetic or parasympathetic nerve to heart will not stop functioning of heart. Heart will beat but without any nervous control. Autonomic nervous system functions rapidaly to alter visceral functions (3-5 seconds). It is activated mainly by centers located in spinal cord, brain stem and hypothalamus. Limbic cortex also influences its function often this system function via visceral reflexes *i.e.* sensory signal $\rightarrow$ enter autonomic ganglia $\rightarrow$ spinal cord $\rightarrow$ brain stem $\rightarrow$ or hypothalamus can elicit reflex responses back to visceral organs to control their activities.

7.4 Biochemical Aspect of Nervous Physiology

Nerve cells (= neurons) : Irritability is a basic characteristic of the "living substance", *i.e.*, the protoplasm. Consequently, every living cell becomes excited when stimulated. However, the nerve cells and muscle fibres are specialized excitable cells of body, capable of transmitting or conducting excitations along their membranes. Of these, muscle cells are further specialized for contraction while nerve cells are further specialized for receiving stimuli (as sensory or receptor cells) and transferring excitations from one to the other.

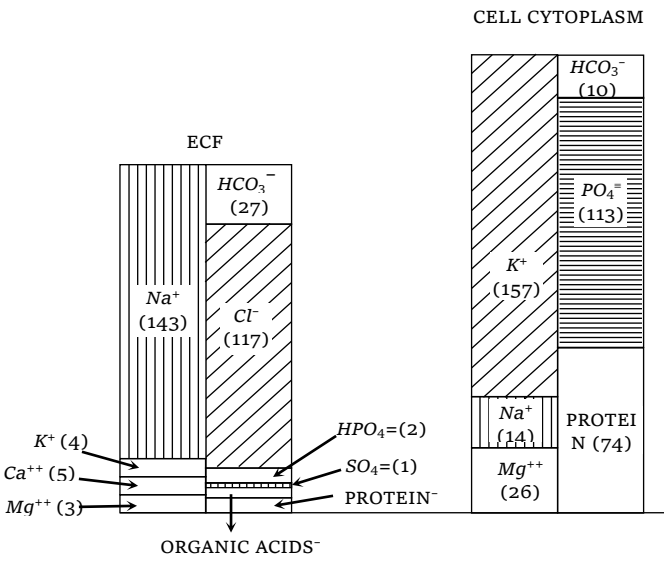


Fig. – Electrolyte composition of ECF and cell cytoplasm figures indicate mEq/litre H_2O for

A typical neuron consists of a nucleated cell body (= cyton, soma or perikaryon), five to seven short, slender and branched (= arborized) dendrites, and a single, relatively thicker and longer fibrous axon. The latter is terminally branched into short telodendria. Each telodendron bears a terminal **knob** or **bouton**. Boutons of one neuron lie upon dendrites or cytons of adjacent neurons (figure), or upon muscle fibres or glands.

Nerve fibres : Although, all parts of a neuron transmit excitations (= impulses), but the transmission is always unidirectional. The dendrites and cytons usually constitute the impulse receiving parts which receive impulses directly from receptors, or from other adjacent neurons. The axons are specialized as fibres conducting impulses away from the receiving parts. Thus, the reaction or response impulses are always carried to the effectors by axons. That is why, the term '**nerve fibres**' is usually applied to the axons. The latter are 0.1 *mm* to one or more (upto 10) *metres* long and about 0.025 *m* thick on an average.

Main properties of nervous tissue : The nervous tissue has two outstanding properties excitability and conductivity.

(1) **Excitability :** It is the ability of the nerve cells and fibres to enter into an active state called the **state of excitation** in response to a stimulus. Excitation arises at the receptors on account of various stimuli such as light, temperature, chemical, electrical or pressure which constantly act on the organisms.

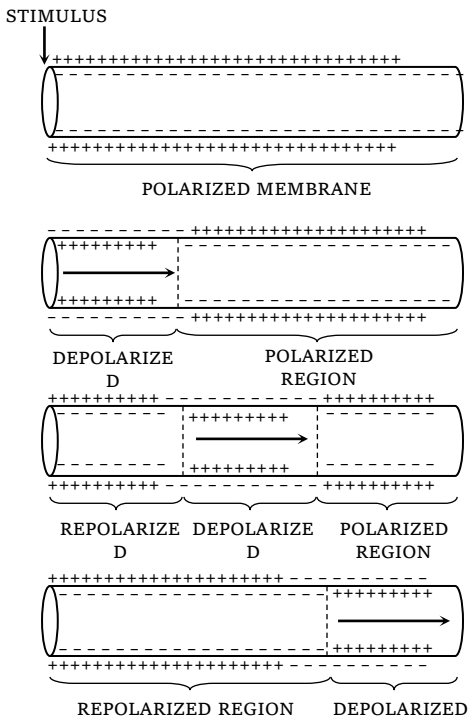
(2) **Conductivity :** The excitation does not remain at the site of its origin. It is transmitted along nerve fibres. The transmission of excitation in a particular direction is called conductivity.

Definition of nerve impulse : A wave of reversed polarity or depolarization (action potential) moving down an axon is called a nerve impulse.

Mechanism of conduction of nerve impulse : Most accepted mechanism of nerve impulse conduction is ionic theory proposed by Hodgkin and Huxley. This theory states that nerve impulse is an

electro-chemical even governed by differential permeability of neurilemma to Na^+ and K^+ which in turn is regulated by the electric field.

(i) **Transmission of nerve impulse along the nerve fibre**



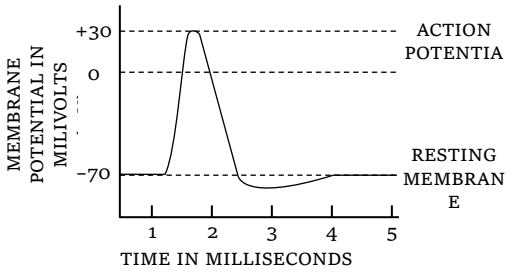
(a) Transmission of nerve

(a) **Polarization (Resting membrane potential-RMP) :** In a resting nerve fibre (a nerve fibre that is not conducting an impulse), sodium ions (Na^+) predominate in the extracellular fluid, whereas potassium ions (K^+) predominate in the intracellular fluid (within the fibre). Intracellular fluid also contains large number of negatively charged (anions) protein molecules. Na^+ are 10 times more outside the neuron and K^+ ions are 25 times more inside the cell. Thus it makes a considerable difference between the ion concentration outside and inside the plasma membrane. It also causes a difference in electrical charges on either side of the membrane. The plasma membrane is electrically positive outside and negative inside. This difference is called potential difference. The potential difference across the plasma membrane is known as resting potential. This potential averages – 70 *mv* (– 60 to – 90 *mv*) in inner side of membrane in respect to outer side.

Due to different concentrations of ions on the two sides of the membrane, sodium ions tend to diffuse into the nerve fibre and potassium ions tend to diffues out of the nerve fibre. The membrane of a resting nerve fibre is more permeable to potassium than to sodium. So potassium leaves the nerve fibre faster than sodium enters it. This results in a higher concentration of cations outside the membrane compared to the concentration of cations inside it. This state of the resting membrane is called polarised state and makes its inner side electronegative to its outerside.

(b) **Depolarization (Action membrane potential or AMP) :** When the nerve fibre is stimulated mechanically, electrically, thermally or chemically a disturbance is felt at the point of stimulation which gives rise to a local excitatory state. The membrane becomes permeable to sodium ions. Suddenly sodium ions rush inside the nerve fibre and potassium ions diffuse out of the axon membrane. Due to the diffusion of ions, more sodium ions enter the axon than potassium ions leave it, so that the positive and negative charges on the outside and inside of the axon membrane are reversed. The membrane is negatively charged on the outside and positively charged on the inside. The membrane with reversed polarity is said to be depolarized. The depolarization of the membrane suddenly passes as a wave along the nerve fibre. Thus the impulse is propagated as a wave of depolarization (reversed polarity). This wave of depolarization travelling down a nerve fibre is called **action potential**. Infact, the action potential "moves" in the manner of a spark moving along a fuse. This "moving" action potential constitutes the **nerve impulse**. The action potential (impulse) is the basic means of communication within the nervous system. The action potential of + 45 *mv* on inner side of axolemma in respect to its outer side is also called spike potential.

(c) **Repolarization :** With the increase of sodium ions inside the nerve cell, the mebrane becomes less permeable to sodium ions whereas the permeability membrane to potassium ions increases. The sodium ions are pumped out of the cell and potassium ions are pumped into the cell until the original resting state of ionic concentration is achieved. Thus this makes the membrane negative on inside and positive on outside. This process is called repolarization.



(b) Record of potential

The last movement of ions is thought to take place by an active transport mechanism called sodium potassium pump (also called sodium potassium exchange pump or sodium pump). The sodium-potassium pump is a process of expelling out sodium ions and drawing in potassium ions against concentration and electrocemical gradient. The entire process of repolarization requires some time during which the nerve cannot be stimulated again. This period is called **refractory period**. During repolarization, as the cell returns to its resting potential, the neuron is ready to receive another stimulus.

(ii) **The synapse :** The synapse is an area of functional contact between one neuron and another for the purpose of transferring information. Synapses are usually found between the fine terminal branches of the axon of one neuron and the dendrites or cell body of another. This type of neuron is called axo-dendrite synapse. Sir Charles Sherrington (1861-1954) was the first person who used the term 'synapse' to the junctional points between two neurons.

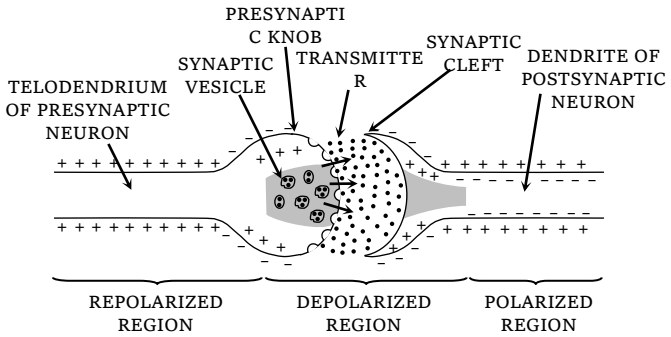


Fig. Impulse conduction at

Structure of synapse : A typical (generalized synapse) consists of a bulbous expansion of a nerve terminal called a pre-synaptic knob lying close to the membrane of a dendrite. The cytoplasm of the synaptic knob contains mitochondria, smooth endoplasmic reticulum, microfilaments and numerous synaptic vesciles. Each vescile contains neurotransmitter (chemical substance) responsible for the transmission of the nerve impulse across the synapse. The membrane of the synaptic knob nearest the synapse is thickened and forms the presynaptic membrane. The membrane of the dendrite is also thickened and is called the post synaptic membrane. These membranes are separated by a gap, the synaptic cleft. It is about 200 *Å* across The post synaptic membrane contains large protein molecules which act as receptor sites for neurotransmitter and numerous channels and pores.

The two main neurotransmitters in vertebrate nervous system are acetylcholine (ACh) and noradrelaine although other neurotransmitters also exist. Acetylcholine (ACh) was the first neurotransmitter to be isolated and obtained by Otto Loewi in 1920 from the endings of parasympathetic neurons of the vagus nerve in frog heart. Neurons releasing acetylcholine are described as cholinergic neurons and those releasing noradrenaline are described as adrenergic neurons.

Mechanism of transmission of nerve impulse at a synapse : The process of chemical transmission across synapses was discovered by Henry Dale (1936). The physiological importance of

synapse for the transmission of nerve impulses was established by McLennan in 1963. A brief description of the mechanism of synaptic transmission is given below

(i) When an impulse arrives at a presynaptic knob, calcium ions from the synaptic cleft enter the cytoplasm of the presynaptic knob.

(ii) The calcium ions cause the movement of the synaptic vesicles to the surface of the knob. The synaptic vesciles are fused with the presynaptic membrane and get ruptured (exocytosis) to discharge their contents (neurotransmitter) into the synaptic cleft.

(iii) The synaptic vesicles then return to the cytoplasm of the synaptic knob where they are refilled with neurotransmitter.

(iv) The neurotransmitter of the synaptic cleft binds with protein receptor molecules on the post synaptic membrane. This binding action changes the membrane potential of the postsynaptic membrane, opening channels in the membrane and allowing sodium ions to enter the cell. This causes the depolarization and generation of action potential in the post-synaptic membrane. Thus the impulse is transferred to the next neuron.

(v) Having produced a change in the permeability of the postsynaptic membrane the neurotransmitter is immediately lost from the synaptic cleft. In the case of cholinergic synapses, acetylcholine (ACh) is hydrolysed by an enzyme acetylcholinesterase (AChE) which is present in high concentration at the synapse.

(vi) The products of the hydrolysis are acetate and choline which are reabsorbed into the synaptic knob where they are resynthesized into acetylcholine, using energy from ATP.

Neuromuscular junction : Impulses are conducted from a neuron to a muscle cell across an area of contact called neuromuscular junction. When a nerve fibre ends on a muscle fibre, it forms motor end plate. The motor end plates have vesicles and mitochondria. The vesicles secrete neurotransmitter. When the motor impulse from the nerve is reveived on the motor end plates, a local depolarization occurs there resulting in the excitation of the muscle fibre.

Neuroglandular junction : It is an area of contact between a neuron and glandular cells. There is also a gap which is bridged at the time of the transmission of the impulse by a neurontransmitter.

Neurotransmitters : As explained in the discussion of synapses, neurotransmitters are chemicals released from a presynaptic neuron that interact with specific receptor sites of a postsynaptic neuron. At least thirty chemicals thought to have the capacity to act as neurotransmitters have been discovered.

Excitory	Inhibitory
(1) Acetylcholine	(1) Gamma amino butyric acid

	(GABA)
(2) Norepinephrine (NE)	(2) Glycine
(3) Serotonin	
(4) 5-hydroxy tryptamine (5-HT)	
(5) Dopamine	
(6) Histamine	
(7) Glutamate	

Synapse, A one-way valve : The synapse cannot transmit an impulse in the reverse direction as the dendrites cannot secrete a neurotransmitter. Thus, the synapse acts as a one-way valve, allowing the conduct of impulse from axon to dendron only.

Synaptic delay : Transmission of an impulse across a synapse is slower than its conduction along a neuron. This is because of the time needed for the release of a neurontransmitter, its diffusion through the synaptic cleft, and its action on the postsynaptic membrane. The difference in the rate is called **synaptic delay**. It amounts to about half a millisecond at body temperature (37^oC).

Synaptic fatigue : Repeated stimulation of the presynaptic knob may deplete the neurotransmitter, and this may fail to stimulate the postsynaptic membrane. This condition of the synapse is termed synaptic fatigue. It lasts for several seconds during which the neurotransmitter is resynthesized. Synaptic fatigue is the only fatigue that affects the nervous tissue. Conduction of the nerve impulse along the neurons is not subject to fatigue.

"All or None law" (Keith Lucas, 1905) : When stimulated, the axon membrane (= axolemma) does not respond for a moment due to its resistance or threshold to stimulation. However, when its threshold is broken, the stimulation is conducted through its whole length as a strong impulse. If the stimulationm is too weak to break the axon's threshold, impulse is not established, but if the intensity of stimulation is much more than the threshold value, impulse conduction remains normal. Thus, the action potential obeys "all or none law". In other words, impulse conduction is such a triggered phenomenon which, though occurs in a twinkling, like an explosion, but only when it reaches "ignition point" or firing level".

Important tips

- ☞ The rate of conduction in myelinated fibre of a mammal is very high because action potential jumps from node to node.
- ☞ The jumping of action potential from node to node (of Ranvier) in a fiber is called saltatory conduction.
- ☞ Nissl's or trigoid granules are present in the neuron and are made up of RNA, ribosome and RER. These granules help is excretion and nutrition.
- ☞ Intelligence quotient (I.Q.) is the ratio of mental age to chronological age multiplied by 100.

- ☞ Corpora striata, genu and splenium is found in cerebrum.
- ☞ Neurons stops dividing after birth.
- ☞ Optocoel is not found in mammalian brain.
- ☞ The pneumotoxic centre is found in medulla.
- ☞ Transmission of nerve impulse can be recorded with the help of oscilloscope.
- ☞ The ramus communicans of the spinal nerve joins the sympathetic chain.
- ☞ Autonomous nervous system has paired chain ganglia.
- ☞ Paralysis of jaw muscles is due to loss of function of Vth cranial nerve.
- ☞ Bipolar nerve cell and ganglia cell are found in the retina.
- ☞ Lateral funiculi have motor type of ganglia.
- ☞ Six separate layers of neurons present in cerebral cortex.
- ☞ Arbor vitae are composed of white matter.
- ☞ IIIrd, IVth and VIth cranial nerves control eye-ball movement.
- ☞ A cavity in the ventricle of a brain is known as cerebral aqua.
- ☞ VII, IX, X, XI and XIIth cranial nerve originating from medulla oblongata.
- ☞ Cycling is an example of conditioned reflex.
- ☞ The ganglia of sympathetic and central nervous system in frog develops from the neural crest cells.
- ☞ Cerebellum of post brain involved in loss of control when a person drinks alcohol.
- ☞ The maximum current required to stimulate a nerve is called rheophase or threshold current or firing level of impulse. It is about 15 mv.
- ☞ A fibres is the largest mammalian fiber.
- ☞ Hyperpolarization of a dendrite is due to presynaptic inhibition.
- ☞ Amygaloid nucleus, hippocampus and fornix is the part of limbic system.
- ☞ Posterioplegia is the paralysis of both lower limb due to damage of spinal cord.
- ☞ Earthworm has both sensory and motor neurons.
- ☞ The glial cells that form the blood brain barrier by lining brain capillaries are the astrocytes.
- ☞ Axo-axentic is the condition when direction of nerve impulse is reversed.
- ☞ Neurocyton is located in cortex of the brain.
- ☞ Cervical swelling is the anterior enlargement of spinal cord.
- ☞ Hydra has false nervous system but not brain.
- ☞ A polar nerve cells are found in vertebrates embryo.
- ☞ Saltatory conduction is found in all vertebrates.
- ☞ In frog, the nerve impulses for hearing start from lagena basilaris.
- ☞ Corpus callosum is absent in the brain of prototherians.
- ☞ Degeneration or imperfect development of corpus callosum in human brain results in a neurological disorder called schizophrenia.
- ☞ γ-amino butyric acid is a neurotransmitter.

- ☞ Acetylcholine is the cardian inhibitor.
- ☞ 5'-hydroxytryph amine is a chemical transmitter.
- ☞ Spike phase of action potential is 2 m. sec.
- ☞ Sylvian fissure divides the brain of rabbit into frontal lobe and temporal lobe.
- ☞ Dorsal root has the ganglion made of unipolar neurons.
- ☞ All cell bodies of afferent fibres lie in the dorsal root ganglion.
- ☞ **EEG - Electro-Encephalo gram :** Electrical tracing of the cerebral cortex is call ECG Berger in 1929 was first to record ECG. Instrument for the recording is Electroencephalograph or cathode ray oscillosco.
- ☞ It is record of brain wave. Brain waves are of following type

  (i) **α–wave :** These are rhythmic waves (10-12 cycles per second. These are produced normal awaking condition. These disappear in sleep.

  (ii) **β–wave ;** 15-16 cycle per second. These are produced when nervous system is active e.g. Mental work

  (iii) **θ–wave :** 5-8 cycle per second. Produced in children.

  (iv) **δ–wave :** 1-5 cycle per second. In normal condition these are produced in awake infants. These are produced in deep sleep. In damage condition of the brain waves may produce in awaking condition in adults.
- ☞ The sensation of sight in human brain is perceived by oceipital lobe.
- ☞ The sensation from skin one perceived in the cerebrum in parietal lobe.
- ☞ Fundamental character of chaordates is the presence of dorsal hollow nerve chord.
- ☞ Somesthatic & test area present in parietal lobe of cerebrum

ASSIGNMENT

MENINGES , CEREBROSPIRAL FLUID AND VENTRICLE

Basic Level

1. The membranes enclosing the brain and spinal cord are known as
   (a) Meninges (b) Meningitis (c) Nephron (d) Axon
2. The outermost layer of brain is called
   (a) Piamater (b) Duramater (c) Pericardium (d) Grey matter
3. The duramater and piamater are referred as
   (a) Peritoneal epithelium (b)Serosa (c) Endothelium (d) Meninges
4. The arachnoid membrane covers the
   (a) Spinal cord (b) Otic capsule (c) Piamater (d) None of the above
5. The innermost meninx surrounding the central nervous system in frog and man respectively are
   (a) Piamater and piamater (b)Arachnoid and piamater
   (c) Piamater and duramater (d)Arachnoid and duramater
6. All the meninges of brain are interrupted at the structure known as
   (a) Neuropore (b) Anterior choroid plexus only
   (c) Posterior choroid plexus only (d) Anterior and posterior choroid plexus
7. The correct sequence of meninges from outer to the inner side is
   (a) Arachnoid – piamater – duramater (b) Arachnoid – duramater – piamater
   (c) Piamater – arachnoid – duramater (d) Duramater – arachnoid – piamater
8. Sub-arachnoid space is found in between arachnoid and
   (a) Piamater (b) Duramater (c) Blastocoel (d) None of the above
9. Which one of the following cells secrete cerebrospinal fluid
   (a) Ependymal cells (b) Neurons (c) Schwann cells (d) Neurilemma
10. Cerebrospinal fluid is produced by
    (a) Ependymal cells (b) Choroid plexus (c) Neuroglial cells (d) Neurons
11. The ventricles of the brain are filled with
    (a) Cerebro-spinal fluid (b) Lymph (c) Blood (d) Amniotic fluid
12. Thirs ventricle is present in
    (a) Heart (b) Brain (c) Kidney (d) Liver
13. Lateral ventricles are found in
    (a) Heart (b) Brain (c) Thyroid (d) Brain and heart
14. Which of the following communicates with the central canal of spinal cord
    (a) Lateral ventricles (b) Third ventricle (c) Fourth ventricle (d) Fifth ventricle
15. Ventricles of brain are lined by the cells called
    (a) Ependymal cells (b) Neurons cells (c) Neuroglea (d) Schwann's cells

16. The medulla oblongata encloses the
(a) Fourth ventricle (b) Second ventricle (c) Optic lobe (d) Otic capsule

17. Third ventricle of rabbit's brain is called
(a) Rhinocoel (b) Rhombocoel (c) Diocoel (d) None of these

18. The iter lies
(a) In the third ventricle (b) In the second ventricle
(c) Between the third and the fourth ventricles (d) In the lateral ventricles

19. Foramen of Monro is
(a) Gap in pelvic girdle of rabbit (b)Foramen in the skull of frog
(c) Space in brain of frog and rabbit (d)Pore in the inter-auricular septum in a mammalian heart

20. Valve of vieussens joins the
(a) Olfactory lobe to cerebrum (b) Cerebrum of diencephalon
(c) Diancephalon to optic lobe (d) Optic lobe to cerebellum

Advance Level

21. In which part of the following, the anterior plexus is situated
(a) Diocoel (b) Metacoel (c) Olfactocoel (d) Optocoel

22. Metacoel is the cavity in the
(a) Cerebral hemispheres (b)Diencephalon (c) Cerebellum (d) Medulla oblongata

23. Foramen of Monro is an aperture between
(a) 2nd and 3rd ventricle (b)Diocoel abnd metacoel
(c) Rhinocoel and diocoel (d)3rd and 4th ventricle

24. Which of the following is not found in mammalian brain
(a) Subdural space (b) Sub-arachnoid space (c) Optocoel (d) Duramater

25. Which of the following connect lateral ventricle to diocoel (third ventricle) in brain
(a) Iter (b) Foramen of Monro (c) Corpus striatum (d) Filum terminale

26. Foramen of Monro provides a passage connecting
(a) Brain and spinal cord (b)Lateral ventricles with third ventricles in brain
(c) Fourth ventricles with optic ventricle (d)Middle ear with pharynx

27. Cerebral aqua is
(a) A cavity in the ventricle of a brain (b)A fluid filled in the posterior chamber of eye
(c) A fluid filled in the sacculus of ear (d)An aperture in the auricle of heart

28. In the anatomy of man aqueduct of sylvius occurs in
(a) Ventricle of heart (b) Eye
(c) In between middle and internal ear (d) Brain

29. Most important function of CSF is

(a) Drainage of metabolities (b) Supply of nutrition
(c) Mechanical buffer (d) O_2 supply

30. The roof of the third and fourth ventricle of the brain contains a structure called
(a) Anterior and posterior choroid plexus (b) Mammillary body
(c) Meninges (d) Corpus albicans

31. The space between the cranium and duramater of the brain is called
(a) Sub-arachnoid (b) Sub-dural (c) Epidural (d) Foramen of Monro

32. Third ventricle lies in
(a) Medulla oblongata (b) Mid brain (c) Diencephalon (d) Cerebrum

33. Iter is located in
(a) Spinal cord (b) Forebrain (c) Midbrain (d) Hindbrain

34. Aqueduct of Sylvius connects the
(a) Paracoels with 3rd ventricle (b) Paracoels with 4th ventricle
(c) Paracoels with mesocoel (d) Diacoel with myelocoel

35. Aqueduct of Sylvius is another name for
(a) Aqueous chamber (b) Central canal (c) Foramen of Monro (d) Iter

36. Thin and vascular and folded roof of medulla oblongata is termed as
(a) Pallium (b) Anterior choroid plexus
(c)Posterior choroid plexus (d) Optic thalami

37. Pineal stalk is a fine tubular outgrowth from
(a) Roof of fourth ventricle (b)Roof of third ventricle
(c) Roof of lateral ventricle (d) Floor of third ventricle

FOREBRAIN

Basic Level

38. Brain is
(a) Ectodermal (b) Mesodermal (c) Endodermal (d) Mesendodermal

39. Corpus callosum is found in the brain of
(a) Elephant (b) Pigeon (c) Crocodile (d) Frog

40. The nervous strip connecting both the cerebral hemispheres in the rabbit is
(a) Corpus callosum (b) Corpus albicans (c) Corpus stratum (d) Corpus spongiosum

41. In mammals, the corpus callosum connects
(a) Bone to a muscle (b) Bone to a bone
(c) The two cerebral hemispheres (d) The two optic lobes

42. Mammalian brain differs from an amphibian brain in possessing
(a) Olfactory lobe (b) Hypothalamus (c) Corpus callosum (d) Cerebellum

43. If a person has lost his memory in an accident, the following part of the brain have got injured

(a) Diencephalon (b) Medulla oblongata (c) Cerebellum (d) Cerebrum

44. Learning is related to which part of the human brain

(a) Medulla oblongata (b) Hypothalamus (c) Cerebrum (d) Cerebellum

45. Cerebral hemisphere is the centre of

(a) Thinking (b) Will power (c) Reasoning (d) All of these

46. Cerebral hemispheres are the centres of

(a) Thinking (b) Balance (c) Smell (d) Taste

47. Which part of human brain is more developed in comparison to others

(a) Medulla oblongata (b) Cerebrum (c) Cerebellum (d) Optic lobes

48. Which is correct about human brain

(a) It is covered by two membranes

(b) There is no blood-brain barrier

(c) Largest number of cranial nerves originate from cerebral hemisphere

(d) Cerebral cortex is highly developed

49. The largest number of neurons are found in

(a) Brain (b) Retina (c) Spinal cord (d) Tongue

50. Which part of the human brain controls homeostasis

(a) Cerebrum (b) Cerebellum (c) Medulla oblongata (d) Hypothalamus

51. The control of blood sugar level, osmoregulation and thermoregulation are the function of

(a) Medulla oblongata (b) Cerebellum (c) Hypothalamus (d) Diencephalon

52. The apetite and satiety centres in the brain of man are located in the region of the

(a) Cerebral hemisphere (b) Cerebellum (c) Medula oblongata (d) Hypothalamus

53. The thermoregulatory centre is situated in

(a) Spinal cord (b) Pituitary body (c) Cerebellum (d) Hypothalamus

54. In homeotherms, the brain centre which regulates body temperature is

(a) Cerebellum (b) Cerebral lobes (c) Hypothalamus (d) Medulla oblongata

55. Diencephalon is not a control centre of

(a) Heart beat (b) Anger (c) Hate (d) Love

56. An injury to diencephalon may result in

(a) Loss of understanding (b)Loss of learning

(c) Loss of intelligence (d) Loss of heat sensation

57. Neurohypophysis secretes

(a) Vassopressin and estrogen (b) Oxytocin and estrogen

(c) Oxytocin and vassopressin (d) Vassopressin and growth hormone

58. Other name of diencephalon is

(a) Thalamencephalon (b) Telencephalon (c) Rhombocephalon (d) Metencephalon

59. Which of the following structures is in the diencephalon

(a) Cerebral cortex (b) Olfactory bulb (c) Hypothalamus (d) Basal ganglia

60. Which of the following is not a part of forebrain

(a) Rhinencephalon (b) Rhombencephalon (c) Diencephalon (d) Telencephalon

61. Pineal stalk arise from

(a) Ventral surface of diencephalon (b)Dorsal surface of diencephalon

(c) Both dorsal and ventral surfaces of diencephalon (d)Anterio-ventral surface of diencephalon

62. Which part of brain controls emotions like love, anger and pleasure

(a) Medulla oblongata (b) Hypothalamus (c) Cerebrum (d) Cerebellum

63. Which of the following brain structures is not considered to be part of limbic system

(a) Amygaloid nucleus (b) Hippocampus (c) Corpora quadrigemina (d)Fornix

64. Corpus callosum is absent in the brain of

(a) Prototherians (b) Eutherians (c) Metatherians (d) All of the above

65. A person feels no sensation when he puts his hand over flame; the part of the brain which has damaged is

(a) Cerebellum (b) Medulla oblongata (c) Diencephalon (d) Hypothalamus

66. Nearly 80% of the human brain is made up of

(a) Cerebellar cortex (b) Cerebral cortex (c) Medulla oblongata (d) Meninges

67. Pallium is

(a) Thick walled (b) Thin walled (c) Non-nervous (d) None of the above

68. The sensation of sight in human brain is perceived by

(a) Optic lobes (b) Occipital lobes

(c) Association area of frontal lobes (d) Somaesthetic area of parietal lobes

69. Sensations from skin are perceived in the cerebrum in

(a) Occipital lobe (b) Temporal lobe (c) Parietal lobe (d) Frontal lobe

70. Floor of third ventricle is known as

(a) Optic thalami (b) Pallium (c) Hypothalamus (d) Epithalamus

71. One of the fundamental characters of chordates is

(a) Presence of limbs (b)Presence of dorsal and hollow nervous system

(c) Presence of haemoglobin (d)Presence of heart

72. Broca's motor speech area occurs in

(a) Temporal lobe (b) Medulla oblongata (c) Frontal lobe (d) Diencephalon

73. The location of filum terminale is

(a) In the skull (b) In the thorax

(c) In the lumbar vertebrae (d) In the pelvic girdle

74. Rathke's pouch is

(a) Infundibulum (b) Hypophysis (c) Pituitary body (d) None of the above

75. Crus cerebrum is

(a) The posterior part of cerebrum (b) The anterior part of cerebrum

(c) The part of mesencephalon (d) None of the above

76. Somaesthetic or post-central area is responsible for

(a) Initiation of motor impulses for voluntary muscles

(b) Initiation of motor impulses for involuntary muscles

(c) Perception of pain, touch and temperature (d) Coordination of speech

77. Premotor area ocurs in

(a) Frontal lobe (b) Parietal lobe (c) Occipital lobe (d) Temporal lobe

78. Premotor area of brain is the highest centre of

(a) Thinking (b) Autonomous nervous system

(c) Movements of involuntary muscles (d) Both (b) and (c)

79. Grey matter is composed of

(a) Ependymal cells (b) Nerve cells (c) Nerve fibres (d) Nissl granules

80. The function of nervous tissue is

(a) Irritability (b) Sensitivity (c) Responsiveness (d) Contraction

81. 'Brain sand' is found normally in

(a) Pituitary (b) Hypothalamus (c) Pineal gland (d) Thalamus

82. In a new born, spinal cord ends at

(a) L_1 (b) L_2 (c) L_3 (d) L_4

83. 70% of body heat is lost through skin. This heat control is done by

(a) Corpuscles of the skin (b)Dermis of skin (c) Hypothalamus (d) Medulla oblongata

84. Somaesthelic area is present in……..of cerebral hemisphere

(a) Temporal lobe (b) Frontal lobe (c) Parietal lobe (d) Occipital lobe

85. Taste area lies in the

(a) Frontal lobe (b) Occipital lobe (c) Temporal lobe (d) Parietal lobe

86. Cholesterol content is maximum in

(a) Grey matter of brain (b) White matter of brain (c) Kidney (d) Liver

87. Weight of the human brain is approximately

(a) 2.5 *Lbs* (b) 3.5 *Lbs* (c) 4.0 *Lbs* (d) 4.5 *Lbs*

88. Tela choroidea is made up of

(a) Nervous tissue (b) Epithelium and blood vessels

(c) Epithelium only (d) (a) and (b) both

89. The pineal body is considered as

(a) An endocrine gland (b) An organ concerned with voluntary actions

(c) An organ concerned with vision (d) A vestige of third eye and endocrine gland

90. Tela choroidea is the term used for

(a) Fused piamater and grey mater (b) The middle coat of eye

(c) Epithalamus and piamater fused (d) None of the above

91. Genu and splenium are

(a) Anterior and posterior ends of corpus callosum

(b)Posterior and anterior ends of corpus callosum

(c) Anterior and posterior ends of corpora striata (d) Posterior and anterior ends of corpora striata

Advance Level

92. Broca's area in human brain controls

(a) Movement of tongue (b)Breathing and hiccup

(c)Movement of vocal cords (d) Both (a) and (c)

93. How many separate layers of neurons are present in the cerebral cortex

(a) 1 (b) 3 (c) 6 (d) 10

94. The centre for sense of smell in brain is

(a) Cerebellum (b) Cerebrum (c) Olfactory lobes (d) Midbrain

95. Which part of the brain can distinguish the perfume smell

(a) Olfactory lobe (b) Olfactory bulb (c) Olfactory tract (d) Temporal cortex

96. The anterior choroid plexus in the brain of man covers

(a) Corpora bigemina (b) Medulla oblongata (c) Diencephalon (d) Mesencephalon

97. The genu and splenium in brain are associated with

(a) Cerebellum (b) Cerebrum (c) Medulla oblongata (d) Vermis

98. Corpora striata is found in

(a) Paracoel (b) Metacoel (c) Cerebrum (d) Diocoel

99. Olfactory lobe of rabbit is

(a) Fused and solid (b) Fused and hollow (c) Free and solid (d) Free and hollow

100. The nervous system and endocrine glands are

(a) Antagonistic (b) Synchronous (c) Independent (d) Interdependent

101. Wernike's centre in brain is related with

(a) Hearing (b) Vision

(c) Understanding speech (d) Speech making

102. Which of the following divides the brain of rabbit into frontal lobe and temporal lobe

(a) Hippocampal fissure (b) Sylvian fissure (c) Central sulcus (d) Rhinal fissure

103. Neopallium forms the dorsal wall of

(a) Medulla (b) Cerebellum (c) Cerebrum (d) Diencephalon

104. Hypothalamus is the principal intermediary between

(a) Nervous system and muscles (b) Endocrine system and chromatophores

(c) Nervous system and endocrine system (d) Nervous system and the conscious state of the body

105. Broca's area in cerebrum is concerned with

(a) Maintenance of balance (b) Learning and memory

(c) Translation of thought into speech (d) Perception of speech, music or noise

106. Which of the following is not a function of hypothalamus

(a) Hunger and satiety (b) Thermoregulation

(c) Libido (d) Creative thinking and consciousness

107. Identify the part of forebrain in humans which contains the auditory centre

(a) Temporal lobe (b) Parietal lobe (c) Occipital lobe (d) Hippocampal lobe

108. Hypothalamus contains regulatory center for

(a) Feeding and satiety (b) Thermoregulation and water balance

(c) Sex drives ('libido') (d) All of the above

109. Each cerebral hemisphere is divided into lobes…..in number by sulci

(a) 3 (b) 4 (c) 5 (d) 6

110. Degeneration or imperfect development of corpus callosum in human brain results in a neurological disorder called

(a) Somnabulism (b) Annorexia nervosa (c) Parkinson's disease (d) Schizophrenia

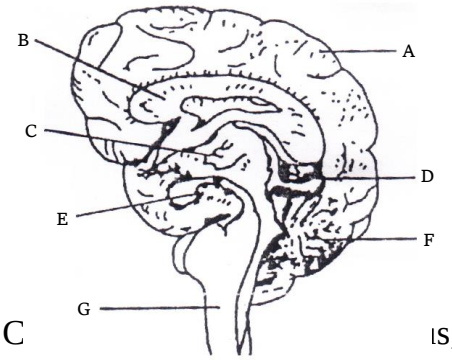
111. Match the pairs of the human being listed under Column I with the functions given under Column II; choose the choice which gives the correct combination of the alphabets of the two column

	Column I (Parts of the brain)		**Column II (Functions)**
A	Cerebral hemisphere	*p*	Relaying impulses
B	Thalamus	*q*	Posture and balance
C	Cerebellum	*r*	Movement of heart, stomach, lungs, etc.
D	Medulla oblongata	*s*	Reflex actions
		t	Voluntary control, intelligence, hearing, speech, etc.

(a) A = t, B = q, C = p, D = s (b) A = t, B = p, C = q, D = s

(c) A = r, B = s, C = q, D = t (d) A = r, B = q, C = p, D = s

112. In the diagram of section of brain given below, different parts are indicated by alphabets; choose the answer in which these alphabets have been correctly matched with the parts they indicate



(a) A = Cerebral hemisphere, B = C ıs, D = Pineal gland, E = Cerebellum, F = Pituitary, G = Medulla oblongata

(b) A = Cerebral hemisphere, B = Thalamus, C = Corpus callosum, D = Pineal gland, E =Pituitary, F = Medulla oblongata, G = Cerebellum

(c) A = Corpus callosum, B = Cerebral hemisphere, C = Pituitary, D = Pineal gland, E =Thalamus

(d) A = Cerebral hemisphere, B =Corpus callosum, C = Thalamus, D = Pineal gland, E =Pituitary, F =Cerebellum, G = Medulla oblongata

MID AND HIND BRAIN

Basic Level

113. Main function of cerebellum is

(a) Balancing (b) To see (c) To hear (d) Remembering

114. In which part of the following, the vomitting centre is situated

(a) Cerebrum (b) Cerebellum (c) Medulla oblongata (d) Hypothalamus

115. Which of the following is not correctly matched

(a) Rhinocephalon – Olfaction (b) Hypothalamus – Pituitary

(c) Cerebellum – Balance (d) Medulla oblongata – Temperature regulation

116. In rabbit, optic lobes are small because the eye sight is controlled by

(a) Temporal lobe (b) Occipital lobe (c) Frontal lobe (d) Parietal lobe

117. Medulla oblongata controls

(a) Blood pressure (b) Synapse (c) High temperature (d) Low temperature

118. Which part of the brain is directly concerned with the control of heart

(a) Cerebrum (b) Diencephalon (c) Pons verolii (d) Medulla oblongata

119. Breathing is controlled by

(a) Lungs (b) Trachea (c) Medulla oblongata (d) Hypothalamus

120. Ventilation is controlled by

(a) Cerebellum (b) Medulla oblongata (c) Cerebrum (d) Mesencephalon

121. Refluxes for maintaining vital functions like blood pressure are localised in

(a) Hind brain (b) Mid brain (c) Fore brain (d) Cerebrum

122. Crura cerebrae is found in

(a) Hind brain (b) Fore brain (c) Mid brain (d) Spinal cord

123. The branched tree like structure present in cerebellum is

(a) Arbor vitae (b) Arboreal (c) Archenteron (d) Areole

124. Cerebellum coordinates

(a) Creative thinking and consciousness (b) Hand-eye movement

(c) Peristalis of gastrointestinal tract (d) Pupil constriction in response to dim light

125. Hind brain consists of

(a) Olfactory lobe and frontal lobe (b)Occipital and parietal lobe

(c) Cerebellum and medulla (d) Hippocampal lobe and diencephalon

126. Cerebellum controls and coordinates

(a) Knee-jerk reaction (b) Blinking of eye

(c) Muscle function (d) Dilation and constriction of pupil

127. In human brain, central sulcus is found between

(a) Occipital and temporal lobe (b) Temporal and parietal lobe

(c) Frontal and parietal lobe(d) Occipital and parietal lobe

128. Which part of the brain controls involuntary breathing

(a) Diencephalon (b) Hypothalamus (c) Medulla oblongata (d) Cerebellum

Advance Level

129. Foramen of magendie is situated in

(a) Right auricle (b) Base of skull

(c) Medulla oblongata of brain (d) Posterior end of humerus

130. Which brain structure in rabbit is directly vision related

(a) Corpus albicans (b) Hippocampal lobe (c) Corpus callosum (d) Corpora quadiregemina

131. Which part of the brain is involved in loss of control when a person drinks alcohol

(a) Cerebellum (b) Cerebrum (c) Medulla oblongata (d) Pons varoli

132. Which part of the mammalian brain controls muscular co-ordination

(a) Cerebrum (b) Medulla oblongata (c) Cerebellum (d) Corpus callosum

133. Hearing is controlled by

(a) Cerebral lobes (b) Hypothalamus (c) Temporal lobe (d) Cerebellum

134. The cerebellum is concerned with the

(a) Co-ordination of muscular movements (b) Perception

(c) Memory (d) Vision

135. The hind brain consists of

(a) Pons + cerebellum (b) Hypothalamus + cerebellum

(c) Medulla oblongata + cerebellum (d) Medulla oblongata + cerebellum + pons

136. The part of brain without its ventricle is

(a) Cerebrum (b) Cerebellum (c) Medulla (d) Diencephalon

137. Identify the correctly matched pair

(a) Cardiac centre – medulla oblongata (b) Thermoregulatory centre – cerebellum

(c) Respiratory center – hypothalamus (d) Hunger – olfactory lobe

138. Which of the following is a structure in the mesencephalon

(a) Inferior colliculi (b) Thalamus (c) Cerebellum (d) Mammillare body

139. Arbor vitae is composed of

(a) Gray matter (b) White matter (c) Neuroglia cells (d) Pons varolii

140. Which of the following is not a structure of the hindbrain

(a) Medulla oblongata (b) Thalamus (c) Cerebellum (d) Pons

141. The habernular commissure joins the two

(a) Optic thalami (b) Olfactory lobes (c) Optic lobes (d) Optic chiasma

142. Crura cerebri consist of

(a) Longitudinal bands of nerve fibres (b) Transverse bands of nerve fibres

(c) Oblique bands of nerve fibres (d) Bands of nerve fibres that cross each other

143. Optic thalami are

(a) Optic lobes (b) Optocoels

(c) Lateral thick walls of diencephalon (d) None of these

144. Vermis is

(a) A tiny worm (b)Cavity of medulla

(c) The large median lobe of cerebellum in mammals (d)A portion of mid brain

SPINAL CORD AND REFLEXES

Basic Level

145. Which one of the following occurs without the help of brain

(a) Cranial reflex (b) Spinal reflex (c) Efferent reflex (d) Afferent reflex

146. Simple two neuron reflex arc involves

(a) Sensory neuron (b) Spinal cord (c) Effector neuron (d) All the above

147. When no intervention is done by the brain, the response is due to

(a) CNS (b) Voluntary actions (c) Spinal reflex (d) Cerebral reflex

148. Which one is not a reflex action

(a) Closing of eye lids against fricking (b) Release of saliva seeing sweets

(c) Perspiration due to heat (d) Obeying the order

149. Pioneer work on conditioned reflex was done by

(a) Karmer (b) Pavlov (c) Darwin (d) Lamark

150. Reflex action in a vertebrate is an essential display exhibited by

(a) Sympathetic nerve (b) Motor nerve (c) Sensory nerve (d) Autonomic response

151. Which of the following is an example of reflex action

(a) To shoot the bird after aiming (b)Watering of the mouth on seeing good edibles

(c) To obey the order (d)To read the story

152. Effect of the reflex action due to the taste of food is the release of

(a) Vagal impulse (b) Appetite juice (c) Alakaline mucosa (d) Spasm of stomach

153. Reflex action immediately involves

(a) Spinal cord (b) Cerebellum (c) Medulla oblongata (d) Optical lobe

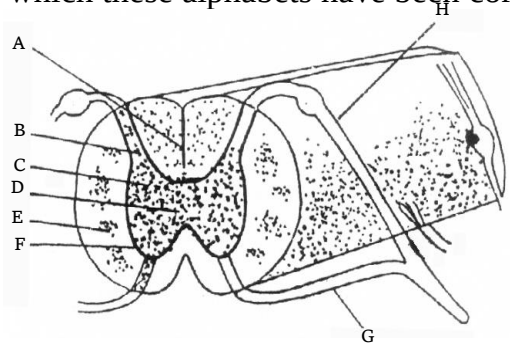
154. Spinal cord is located in

(a) Cranium (b) Optic vesicle (c) Otic capsule (d) Vertebral column

155. Lateral funiculi possess ganglia

(a) Sensory (b) Motor (c) Both (a) and (b) (d) None of these

156. In the diagram of T.S. of the spinal cord given above, certain parts have been indicated by alphabets; choose the answer in which these alphabets have been correctly matched with the parts of which they indicate



T.S. of spinal cord

(a) A = Dorsal septum, B = Dorsal horn, C = Grey mater, D = Central cavity, E = White mater, F = Ventral horn, G = Ventral root, H = Dorsal root and ganglion

(b) A = Dorsal septum, B = Dorsal horn, C = Central cavity, D = Grey mater, E =Ventral horn, F = White mater, G = Dorsal root and ganglion, H = Ventral root

(c) A = Dorsal septum, B = Dorsal horn, C = Grey mater, D = White mater, E = Central cavity, F = Ventral root, G = Dorsal root and ganglion

(d) A = Dorsal septum, B = Dorsal horn, C = Central cavity, D = Grey mater, E = Ventral horn, F = White mater, G = Dorsal root and ganglion, H = Ventral root

157. The sensory ganglion concerned in spinal reflex arc is located in

(a) Cutaneous sense organ (b)Gray matter of spinal cord

(c) Dorsal root of spinal nerves (d)Ventral root of spinal nerves

158. Brain of a mammal differs from that of frog in having

(a) No corpus callosum

(b) A well developed medulla oblongata with pons varoli

(c) Large cerebral hemispheres divided into lobes by means of fissures

(d) Hollow olfactory lobes

159. Each spinal nerve in a mammal arises from the spinal cord by two roots, a dorsal and a ventral. Of these the ventral root is composed of

(a) Somatic motor and visceral motor fibres (b) Somatic sensory and visceral motor fibres

(c) Somatic motor and visceral sensory fibres (d) Somatic sensory and visceral sensory fibres

160. Which of the following is a richly vascular layer with lots of blood capillaries

(a) Durameter of brain (b) Piamater of spinal cord

(c)Epidermis of skin (d) Epithelial lining of trachea

161. Dorsal root ganglion are

(a) Mixed (b) Motor (c) Sensory (d) None of these

162. The spinal cord extends from the brain through

(a) Foramen magnum (b) Iter

(c) Anterior commissure (d) Foramen of Monro

163. The ramus communicans of the spinal nerves

(a) Joins the sympathetic chain (b) Joins the parasympathetic chain

(c) Remains independent (d) Joins the brachial plexus

164. What is found in the periphery of spinal cord

(a) Grey matter (b) Myelinated nerve (c) White matter (d) Notochord

165. The dorsal root of spinal cord contains

(a) Somatic motor fibres (b)Visceral motor fibres

(c) Somatic sensory fibres (d)Visceral sensory fibres

166. Which one of the following is responsible for the control of reflex action

(a) Sensory nerves (b) Motor nerves

(c) Sympathetic nervous system (d) Central nervous system

Advance Level

167. If frog's brain is crushed, even then it's leg moves in pinpointing. It is called

(a) Simple reflex (b) Conditional reflex

(c) Neurotransmitter function (d) Autonomic nerve condition

168. Conditioned reflexes are different than unconditioned reflexes in that

(a) Conditioned reflexes are limited to brain (b) Unconditiond reflexes are limited to brain

(c) Both (a) and (b) (d) None of the above

169. Which of the following is an example of conditioned reflex

(a) Cycling (b) Withdrawal of hand on touching a hot plate

(c) Watering of mouth at smell of food (d) Flowing of tears while cutting onions

170. The cytons of reflex in central nervous system and autonomal nervous system is

(a) Sensory (b) Mixed (c) Motor (d) All of these

171. Which is a wrong relation

(a) Conditioned reflex – *Hodgkins* (b)Blood circulation – *W. Harvey*

(c) DNA double helix model – *Watson and Crick* (d) None

172. One common example of simple reflex is

(a) Tying your shoe laces while talking to another person and not looking at them

(b) Watering of mouth at the sight of a favourite food

(c) Climbing up a stairs in dark without stumbling

(d) Closing of eyelids when an object suddenly approaches the eye

173. In reflex action the reflex arc is formed by

(a) Brain – spibnal cord – muscles (b)Receptor – spinal cord – muscles

(c) Muscles – receptor – brain (d)Muscles – spinal cord – muscles

174. A boy learns typewriting and harmonium at the same time. He finds harmonium more easy to learn. This is

(a) Conditioned reflex (b) Short term homeostasis

(c)Long term homeostasis (d) Residual learning

175. Anterior to enlargement of spinal cord is known as

(a) Filum terminate (b) Conus terminate (c) Cervical swelling (d) Cauda equina

176. From which part of spinal cord, motor root originates

(a) Ventral root (b) Dorsal root (c) Gray matter (d) White matter

177. Glands of Swammerdam are

(a) Ganglia of sympathetic nervous system (b)Glands which are secreting hormone

(c) Calcareous bodies protecting the ganglia in frog (d)None of these

178. The reflex action was discovered by

(a) Marshall (b) Best (c) Taylor (d) Pavlov

179. Foramen magnum is the exit point for

(a) Filum terminale (b) Cranial nerves (c) Spinal nerves (d) Spinal cord

180. Spinal cord is covered by highly vascularised

(a) Epithelial layer (b) Arachnoid (c) Piameter (d) Durameter

181. In a frog, the connection between brain and spinal cord is severed. The leg of such a frog is pricked by a sharp needle. Then it is most likely that the animal will

(a) Not show any reaction (b)Move the leg that is pricked

(c) Move the leg and feel the pain (d)Do not move that leg but feel the pain

182. One of the following is not a reflex action

(a) Knee jerk (b) Boxing (c) Coughing (d) Eye lid closing

183. Immediate involuntary response to stimulus is

(a) Reflex action (b) Autonomic response (c) Action control (d) None of these

184. In vertebrates, simple reflex action is

(a) Trisynaptic (b) Monosynaptic (c) Polysynaptic (d) Bisynaptic

185. An H-shaped region present around the central canal of spinal cord is made up of

(a) White matter (b) Grey matter (c) Sensory fibres (d) Motor fibres

186. Foramen of Magendie is

(a) Another name of foramen of Monro (b) An aperture of myelocoel

(c) An aperture of metacoel (d) An aperture of mesocoel

187. The filum terminale is composed of

(a) Piamater (b) Duramater (c) Ganaglion cells (d) White matter

188. What is called the end of the spinal cord

(a) Cauda equina (b) Conus medullaries (c) Filum terminale (d) Funiculus

CRANIAL AND SPINAL NERVES

Basic Level

189. The eighth cranial nerve (auditory) of vertebrates leads from brain to

(a) Ear (b) Eye (c) Nose (d) Tongue

190. The number of spinal nerves in rabbit is

(a) 27 pairs (b) 31 pairs (c) 37 pairs (d) 47 pairs

191. The cranial nerve which brings impulses from the internal ear is

(a) Hyomandibular (b) Vagus (c) Auditory (d) Trochlear

192. Which of the cranial nerve is mixed

(a) Optic (b) Olfactory (c) Vagus (d) Trochlear

193. The second cranial nerve is

(a) Optic (b) Trigeminal (c) Olfactory (d) Abducens

194. Heart is innervated by

(a) Trigeminal (b) Vagus (c) Glossopharyngeal (d) Facial

195. IV, V and IX cranial nerves are

(a) Olfactory, spinal accessary and vagus (b) Trigeminal, vagus and glossopharyngeal

(c) Occulomotor, trigeminal and hypoglossal (d) Pathetic, trigeminal and glossopharyngeal

196. Twelve pairs of ribs and twelve pairs of cranial nerves are found in

(a) Fish (b) Frog (c) Lizard (d) Man

197. The site from which the nerve impulse for hearing originates

(a) Ear ossicles (b) Cochlea (c) Auditory nerve (d) Ear drum

198. Vagus nerve is

(a) Spinal nerve (b) Sympathetic nerve

(c) X-cranial nerve (d) Parasympathetic nerve

199. Pneumogastric nerve is known as

(a) Vagus (b) Glossopharyngeal (c) Spinal accessory (d) Hypoglossal

200. Which of the following are the two extra cranial nerves found in rabbit

(a) Glossopharangeal and hypoglossal (b) Glossophyrangeal and spinal accessory

(c) Spinal accessory and hypoglossal (d) Pneumogastric and hypoglossal

201. Which of the following cranial nerve of man is both sensory and motor

(a) Olfactory (b) Trigeminal (c) Optic (d) Auditory

202. The number of spinal nerves in man is

(a) 27 pairs (b) 31 pairs (c) 37 pairs (d) 47 pairs

203. The vagus nerve innervates the

(a) Eyes (b) Reproductive organs (c) Ears (d) Heart

204. How many cranial nerves found in the amniota

(a) 6 pairs (b) 8 pairs (c) 12 pairs (d) 10 pairs

205. Name the cranial nerves of humans being viz. II, VII, VIII, IX

(a) Optic, auditory, facial, hypoglossal

(b) Oculomotor, auditory, abducens, hypoglossal

(c) Optic, facial, auditory, glossopharyngeal (d) Optic, facial, abducens, glossopharyngeal

206. Fifth cranial nerve of frog is called

(a) Optic nerve (b) Vagus nerve (c) Trigeminal nerve (d) Opthalmic nerve

207. Dicondyllic skull and 10 pairs of cranial nerves are found in

(a) Reptilia (b) Aves (c) Amphibia (d) All of these

208. The vagus neve is the cranial nerve numbering

(a) 10 (b) 9 (c) 7 (d) 5

209. Which is a sensory nerve

(a) Trigeminal (b) Vagus (c) Opthetic nerve (d) Auditory nerve

210. The nerve related with diaphragm is

(a) Vagus (b) Phrenic (c) Trigeminal (d) Glossopharyngeal

211. Which cranial nerve carries in excitation from the ear

(a) Optic (b) Auditory (c) Olfactory (d) Trigeminal

212. The cranial nerves which are exclusively sensory in function are

(a) Olfactory and optic (b) Optic and oculomotor

(c) Hypoglossal and optic (d) Hypoglossal and olfactory

213. The lungs, heart, intestine etc. are supplied by cranial nerve

(a) Trigeminal (b) Vagus (c) Abducens (d) Oculomotor

214. A motor nerve carries impulses from

(a) CNS to the effectors (b)Effectors to the CNS (central nervous system)

(c) Cranial nerves to the effectors (d)Effectors to the cranial nerves

215. Purely motor nerve is

(a) Optic (b) Abducens (c) Opthalamic (d) Palatinus

216. The number of cranial nerves in rabbit/mammal is

(a) 10 pairs (b) 12 pairs (c) 24 pairs (d) 36 pairs

217. The largest cranial nerve of the body is

(a) Hypoglossal (b) Vagus (c) Glossopharyngeal (d) Olfactory

218. The smallest cranial nerve is

(a) Trochlear (b) Opthalmic (c) Abducens (d) Vagus

219. The only cranial nerve which does not supply the cranial region but to visceral region is

(a) Vagus (b) Trigeminal (c) Hypoglossal (d) Abducens

220. Which of the following cranial nerve controls facial expression and mastication of food, etc.

(a) Fourth (b) Fifth (c) Seventh (d) Ninth

221. Heart muscles are innervated by

(a) Vagus (b) Trigeminal (c) Abduncens (d) Accessory

222. Which of the following is not a motor nerve

(a) Trochlear (b) Spinal accessory (c) Abducens (d) Olfactory

223. Facial nerve is

(a) Sensory (b) Mixed (c) Motor (d) None of the above

224. Vagus and trigeminal are

(a) Motor nerve (b) Sensory (c) Mixed (d) All of the above

225. Cranial nerve which supplies regions of body other than the head and is longest

(a) Auditory (b) Oculomotor (c) Vagus (d) Trochlear

226. Tongue is under the control of

(a) Trigeminal (b) Facial (c) Autonomic system (d) Glossopharyngeal

227. Which nerve is exclusively motor in function

(a) Trigeminal (b) Facial (c) Vagus (d) Spinal accessory

Advance Level

228. How many pairs of cranial nerves in mammals are purely sensory

(a) Five (b) Four (c) Three (d) Two

229. Glands of Swammerdams which are calcareous glands, are found

(a) Below the cerebrum in brain

(b) In the liver of the vertebrates

(c) At the junction of medulla oblongata and spinal cord

(d) At the places of emerging of spinal nerves

230. Paralysis of jaw muscles is due to loss of function of which cranial nerve

(a) III (b) V (c) VII (d) X

231. The trigeminal nerve (V cranial nerve) arises from brain in the region of

(a) Cerebellum and divides into palatine, chorda tympani and hyomandibular

(b) Medulla and divides into palatine, chorda tympani and hyomandibular

(c) Cerebellum and divides into ophthalmic, maxillary and mandibular

(d) Medulla and divides into ophthalmic, maxillary and mandibular

232. In man which one of the following cranial nerve is associated with the sense of body balance

(a) VI (b) VII (c) VIII (d) IX

233. The largest of the spinal nerves is constituted by the

(a) First pair (b) Brachial nerves (c) Third pair (d) Fourth pair

234. The hypoglossal nerves are the…….of the spinal nerves

(a) Second pair (b) Ventral roots (c) First pair (d) Twelfth pair

235. The spinal cord terminates in

(a) Corpus terminale (b) Coput terminale (c) Cauda terminale (d) Filum terminale

236. Which of the following nerve innervates upper jaw of frog

(a) Maxillary (b) Pathetic (c) Palatine (d) Occulomotor

237. Which cranial nerves has the highest number of branches

(a) Trigeminal (b) Facial nerve (c) Vagus nerve (d) None of these

238. The 3rd, 6th and 11th cranial nerves are
(a) Occulomotor, trigeminal, spinal (b) Optic, facial, spinal
(c) Occulomotor, abducens, spinal (d) Trichlear, abducens, vagus

239. Which of the following cranial nerves is present in the rabbit but absent in the frog
(a) Glossopharyngeal (b) Hypoglossal (c) Olfactory (d) Optic

240. The cranial nerves which control eye-ball movement are
(a) 4, 6 and 7 (b) 3, 4 and 6 (c) 2, 3 and 5 (d) 5, 8 and 9

241. If the sympathetic nerve to the heart is cut-off, the heart beat will
(a) Increase (b) Decrease (c) Remains same (d) Stop

242. Cranial nerves originating medulla oblongata are
(a) III, VII, IX (b) IX, X, XI, XII, III (c) VII, VIII, IX, X (d) VII, IX, X, XI, XII

243. VI cranial nerve of rabbit is
(a) Abducens (b) Optic (c) Olfactory (d) Oculomotor

244. The second cranial nerve in human originates from
(a) Ciliary muscles of eye (b)Retina only
(c) Retina and lens (d)Occular muscles of eye

245. Gasserian ganglion is formed by the
(a) Vagus nerve (b) Trigeminal nerve (c) Trochlear nerve (d) Cervical nerve

246. All spinal nerves are
(a) Motor (b) Sensory (c) Mixed (d) None of the above

247. The mixed nerve is
(a) Auditory (b) Occulomotor (c) Facial (d) Abducens

248. Which of the following cranial nerves are involved in the movement of eye
(a) Optic, occulomotor, abducens (b) Occulomotor, abducens, trochlear
(c) Trochlear, abducens and optic (d) Abducens, optic, trochlear, occulomotor

249. Total number of sensory cranial nerves in rabbit is
(a) Eight (b) Six (c) Three (d) Four

250. The number of cranial nerves in a mammal including rabbit is
(a) 10 (b) 12 (c) 24 (d) 36

251. Number of cranial nerves in frog is
(a) 10 (b) 12 (c) 24 (d) 20

252. Select the correct statement regarding spinal nerves
(a) Dorsal root is sensory and ventral root is motor (b)Dorsal root is motor and sensory both
(c) Dorsal root is motor and ventral root is sensory (d)Ventral root is sensory and motor both

253. How many pairs of spinal nerves are present in *Rana tigrina*
(a) 9 (b) 11 (c) 12 (d) 8

254. Superior oblique muscle of the human eye is innervated by

(a) Trochlear (b) Abducens (c) Oculomotor (d) Optic nerve

255. Which of the following is not a branch of the trigeminal nerve

(a) Opthalmic (b) Glossopharyngeal (c) Mandibular (d) Maxillary

256. The following cranial nerve plays an important role in regulating heart beat

(a) IX (b) VII (c) X (d) VIII

257. Which one of the following is spinal nerve

(a) Hypoglossal (b) Trigeminal (c) Olfactory (d) None of these

258. Seventh cranial nerve enters

(a) Jugular ganglion (b) Geniculate ganglion (c) Gasserian ganglion (d) Femoral ganglion

259. Jacobsons nerve is a branch of……cranial nerve

(a) V (b) VIII (c) IX (d) X

260. Musicians nerve is

(a) Axillary (b) Median (c) Ulnar (d) Radial

261. Thickest nerve of the body

(a) Radial (b) Median (c) Sciatic (d) Axillary

262. Labourer's nerve is

(a) Median (b) Ulnar (c) Radial (d) Sciatic

263. Vagus nerve is composed mainly of parasympathetic fibres. The preganglionlc fibres form a network in the walls of the organs. This network is known as

(a) Choroid plexus (b) Nervous plexus (c) Auerbach plexus (d) Brachial plexus

AUTONOMOUS (SYMPATHETIC & PARASYMPATHETIC) N.S

Basic Level

264. Which is activated in stress condition

(a) Sympathetic (b) Parasympathetic (c) Somatic (d) Whole *ANS*

265. The autonomic nervous system has control over

(a) Reflex action (b) Skeletal muscles (c) Sense organs (d) Internal organs

266. If parasympathetic nerve of the rabbit is cut then heart beat

(a) Unaffected (b) Decreases (c) Increases (d) Stop

267. Contraction of involuntary muscles, secretion of digestive glands and rate of heart beats are under the control of

(a) Cranial system (b) Reflex system

(c) Autonomic nervous system (d) Central nervous system

268. Increase in gastro-intestinal secretion and movement after ingestion of food is mainly brought about by

(a) Sympathetic nervous system (b) Parasympathetic nervous system

(c) Central nervous system (d) Hormone secreted by thyroid

269. Which one is the function of parasympathetic nervous system in mammals

(a) Acceleration of heart beat (b) Constriction of pupil

(c) Stimulation of sweat glands (d) Contraction of arrector pilli muscles

270. The self governing nervous system is known as

(a) Central nervous system (b) Peripheral nervous system

(c) Autonomic nervous system (d) Sympathetic nervous system

271. Two systems which exert opposite influence on the same organs or set of organs are

(a) Endocrine and exocrine gland systems (b) Muscular and nervous system

(c) Endocrine and nervous system (d) Sympathetic and parasympathetic systems

272. The following hormones are neurotransmitters

(a) Acetylcholine and secretin (b) Cholecystokinin and acetylcholine

(c) Adrenalin and acetylcholine (d) Cholecystokinin and adrenalin

273. Parasympathetic nervous system

(a) Increases heart beat (b) Decreases heart beat

(c) Originates heart beat (d) Has no effect upon heart beat

274. Neural stimulation in visceral organ in human being is done by

(a) Sympathetic and parasympathetic nerves and is under involuntary action

(b) Sympathetic nerves and is under voluntary action

(c) Sympathetic and parasympathetic nerves and is under voluntary action

(d) Parasympathetic nerves and is under voluntary action

275. Preganglionic fibre is long in

(a) Sympathetic (b) Parasympathetic (c) Equal in both (d) None of above

276. Conservation of energy takes place by

(a) Sympathetic (b) Parasympathetic (c) Reflex action (d) All of above

277. Identify the chemical which is antagonistic to adrenaline in relation to heart beat

(a) Serotonin (b) Melatonin (c) Inhibin (d) Acetylcholine

278. Contraction of blader is regulated by

(a) Parasympathetic system (b)Sympathetic system

(c)Spinal cord (d) Medullary nerve center

279. Axons of preganglionic neurons in the human sympathetic nervous system emerge from which regions of the spinal cord

(a) Cranial and sacral (b) Thoracic and lumber (c) Cranial and thoracic (d) Lumber and sacral

280. What will happen if the heart is perfused by acetyl choline

(a) Heart beat stops completely (b) Acceleration of heart beat occurs

(c) Heart beat becomes erratic (d) Pace setter is destroyed

281. What should be administered to a person who complains of sinking heart and has a dangerously low blood pressure

(a) Adrenaline (b) Insulin (c) Glucagon (d) Acetylcholine

Advance Level

282. Sympathetic nerves in mammals arise from

(a) Sacral region (b) Cervical region

(c) Thoraco-lumbar region (d) 3rd, 7th, 9th and 10th cranial nerves

283. Function of sympathetic system is to

(a) Decrease heart beat (b) Increase heart beat

(c) Contract respiratory organ (d) Secrete saliva

284. The sympathetic nervous system is other wise called

(a) Visceral system (b) Mesenteric system

(c) Thoraco lumber system (d) Cervico-sacral system

285. Autonomic nervous system is

(a) Paired chain ganglia (b) Brain and spinal cord (c) Sense organs (d) Cerebral hemispheres

286. Parasympathetic nervous system increases the activity of

(a) Gut, iris and urinary bladder (b) Heart, adrenal and sweat gland

(c) Heart, pancreas and lachrymal gland (d) Lachrymal gland and sweat gland

287. Spot out the parasympathetic effect

(a) Increasing blood pressure (b) Dialating pupil

(c) Secretion of digestive juice (d) Increasing cardiac output

288. Parasympathetic nerves increase the mobility in

(a) Small intestine (b) Heart (c) Brain (d) None of the above

289. Preganglionic sympathetic fibres are

(a) Adrenergic (b) Cholinergic (c) Synergic (d) Hypergonic

290. Cholinergic neurons secrete at their nerve terminal

(a) Acetyl CoA (b) Acetylcholine (c) Adrenaline (d) Prostaglandin

291. Damage of sympathetic trunk of one side of the body results in

(a) Turner's syndrome (b) Horner's syndrome (c) Cushing syndrome (d) Simmond's disease

292. On stimulation, sympathetic nervous system

(a) Increases sweat secretion (b) Increases tear secretion

(c) Decreases saliva (d) All of these

293. Sympathetic fibres of the autonomic nervous system

(a) Stimulate the function of a visceral organ by secreting epinephrine

(b) Inhibit the function of a visceral organ by secreting epinephrine

(c) Stimulate the function of a visceral organ by secreting acetylcholine

(d) Inhibit the function of a visceral organ by secreting acetylcholine

294. Which of the following is not a neurotransmitter

(a) *Y*-aminobutyric acid (b) 5'-hydroxy tryptamine (c)Acetylcholine (d) Melatonin

295. Which of the following is a neuro transmitter

(a) Melatonin (b) Thymosin (c) *Y*-amino butyric acid (d)Interleukin I

296. Parasympathetic nervous system also termed as

(a) Visceral (b) Thoraco-lumber (c) Cranio-sacral (d) Meseuteric

297. Autonomous nervous system regulates all except

(a) Blood circulation (b) Respiration

(c) Excretion (d) Learning and memory

298. Sympathetic nervous system

(a) Promotes glycogen formation (b)Promotes sugar release

(c) Contract gall bladder (d)Dilates arferies

299. Post ganglionic parasympathetic fibers are colinergic and thus secrete

(a) Noradrenaline (b) Acetylcholine (c) Thyroxine (d) Insulin

300. Each sympathetic chain consists of

(a) 19 ganglia (b) 21 ganglia (c) 20 ganglia (d) 22 ganglia

301. Collateral ganglia are present in

(a) Sympathetic nervous system (b) Parasympathetic

(c) Both (a) and (b) (d) None of the above

PHYSIOLOGY OF NERVOUS SYSTEM

Basic Level

302. The rate of conduction of impulses in motion nerve of a mammal is

(a) 4 *m*/*sec* (b) 10 *m*/*sec* (c) 50 *m*/*sec* (d) 100 *m*/*sec*

303. Resting potential of the membrane is

(a) – 60 to – 70 mV (b) – 100 to – 10 mV (c) 50 to 100 mV (d) – 20 to – 30 mV

304. When an impulse passes, the membrane is depolarized and the charge of the cells is

(a) Outside positive and inside negative (b) Inside positive and outside negative

(c) Both sides have zero potential (d) Both sides are electronegative

305. The potential difference in the membrane which is responsible for the conduction of an impulse is brought about by a change in the membrane

(a) Permeability (b) Structure (c) Anions (d) Concentration

306. Conduction of an impulse along the axon is associated with the

(a) Resting potential (b) Cl^- concentration

(c) Strength of an impulse (d) Action potential

307. In a resting nerve there is a mechanism known as sodium pump which results in

(a) Na^+ being pumped out (b) Na^+ being pumped in

(c) Exchange of Na^+ and K^+ (d) Na^+ being pumped into the cell

308. During the transmission of nerve impulse, which of the following takes place

(a) Flux of Na^+ inwards and K^+ outwards (b) Flux of K^+ inwards and Na^+ outwards

(c) Flux of K^+ inwards and Na^+ inwards (d) Flux of K^+ outwards and Na^+ outwards

309. Na^+ concentration is about 10X higher 'outside' the cell then inside when the neuron is in

(a) Resting phase (b) A state of constant impulse transmission

(c) Refractory phase immediately after transmitting nerve impulse (d) Polarised state

310. Transport of Na^+ and K^+ across the neuronal membrane after depolarisation to restore potential difference is facilitated by

(a) Passive diffusion (b) ATP directed Na^+ and K^+ pump

(c) Facilitated diffusion (d) Osmosis

311. Identify the correct statement

(a) The period during which a nerve does not respond to stimuli is called critical period

(b) Electrogenesis in nerve cells is due to influx of K^+

(c) The permeability of Na^+ increases during depolarisation

(d) Na^+ acts is a chelator

312. Identify the correctly matched pair

(a) Spike phase of action potential – 2 $m\ sec$ (b) Control of reflex action – hippocampal lobe

(c) Non-reflexive action – swallowing of food (d) Non-myelinated fibers – saltatoric conduction

313. Depolarization of a stimulated nerve is maintained by

(a) Ca^{++} (b) Cl^- (c) Mg^{++} (d) K^+

314. In a nerve if sodium is blocked; which of the following is most likely to happen

(a) Na^+ outside the nerve will increase (b) K^+ inside the nerve will increase

(c) Na^+ inside the cell will increase (d) Na^+ and K^+ will increase outside the cell

315. Preparation of the type of stimulus depends on the

(a) Strength of the nerve impulse (b) Specificity of connection to receptor organs

(c) Rate of the nerve impulse (d) Ionic change moving in and out of the nerve

316. Which set of ions are required during conduction of the nerve impulse

(a) *Na* and *Ca* (b) *Ca* and *Mg* (c) *Na* and *K* (d) *Na* and *Mg*

317. The action potential of a nerve cell is

(a) 45 *mV* (b) 55 *mV* (c) 80 *mV* (d) 75 *mV*

318. The conduction of nerve impulse is a

(a) Biochemical phenomenon (b) Electrochemical phenomenon

(c) Physical phenomenon (d) Bio-physiological phenomenon

319. The potential difference between outside and inside of a nerve before excitation is known as

(a) Resting potential (b) Action potential (c) Spike potential (d) Reaction potential

320. The dendrite carries impulses

(a) Towards the cyton (b) Away from cyton

(c) Across the body (d) From one neuron to another

321. During conduction of nerve impulse

(a) Na^+ moves into axoplasm (b) Na^+ moves out of axoplasm

(c) K^+ moves into axoplasm (d) Ca^{++} moves into axoplasm

322. Nerve impulse initiates with the movements of

(a) K^+ (b) Mg^+ (c) Ca^+ (d) Na^+

323. Nerve impulse travels by steps

(a) Chemical in nature (b) Chemical and electric in nature

(c) Physical in nature (d) None of the above

324. Neuron becomes an electrically charged cell by the diffusion of

(a) *K* (b) *Na* (c) *P* (d) *Ca*

325. The energy required during transmission of impulse is provided by

(a) Brain (b) Nerve fibre (c) Liver (d) Stimulating agent

326. Axon part of the neuron is highly modified for which of the following function

(a) Reception of stimuli from neurons (b) Conduction for neuron

(c) Reception of internal stimuli (d) Conduction of impulse away from neurons

327. During transmission of nerve impulse the potential inside membrane has the following type of charge

(a) First positive, then negative and back positive

(b) First negative, then positive and back negative

(c) First positive then negative and remain negative

(d)First negative then positive and remain positive

328. The mineral necessary for nervous conduction is

(a) Iron (b) Sodium (c) Phosphorus (d) Magnesium

329. Consider the following statements

Assertion (*A*): Transmission of the nerve impulse across a synapse is accomplished by neurotransmitters

Reason (*R*): Transmission of the nerve impulse across a synapse usually required neurotransmitters because there is a small space, *i.e.*, synaptic cleft that separates one neuron from another

Now select your answer from the answer given below

(a) Both *A* and *R* are true and *R* is the correct explanation of *A*

(b) Both *A* and *R* are true but *R* is not the correct explanation of *A*

(c) *A* is true but *R* is false

(d) *R* is true but *A* is false

Advance Level

330. Sodium-potassium pump is

(a) A hormone (b) An enzyme (c) A protein carrier (d) An organelle

331. For visual sense, the nerve impulse generated by

(a) Depolarisation (b) Repolarisation

(c) Hyper polarisation (d) Depolarisation and repolarisation

332. Match the following

(A) Reflex action (1) Reflex action

(B)Multipolar (2) Neuron

(C)Na^+ and K^+ ions (3) Parasympathetic nervous system

(D)Increases secretion of saliva and digestive juices (4)Involuntary action

(E) Knee jerk (5) Active transport

The correct pairing sequence is

(a) 4, 2, 5, 3, 1 (b) 1, 4, 3, 5, 2 (c) 2, 4, 3, 5, 1 (d) 2, 3, 5, 1, 4

333. Which has the highest speed of nerve impulse

(a) Medullated nerve (b) Non-medullated nerve (c) Cranial nerve (d) Spinal nerve

334. When a nerve fibre is stimulated the inside of the membrane becomes

(a) Negatively charged (b) Positively charged

(c) Depolarised (d) Filled with acetylcholine

335. On nerve fibres to prevent leakage of an impulse layer of……is found

(a) Schwann cells (b) Neurilemma (c) Axons (d) Myelin sheath

336. Saltatory conduction occurs in

(a) Myelinated nerve fibres (b) Non-myelinated nerve-fibres

(c) Both myelinated and non-myelin nerve fibres (d) Skeletal muscle fibres

337. Saltatory conduction is in

(a) Invertebrates (b) Lower vertebrates (c) All vertebrates (d) None of these

338. The minimum current required to stimulate a nerve is called

(a) Rheobase or threshold current (b) Spike

(c) Action potential (d) None of these

339. When the direction of nerve impulse is reversed the condition is

(a) Axo-axentic (b) Axo-dendrite (c) Axo-axendendrite (d) None of these

340. Hyperpolarization of a dendrite is due to

(a) Excitatory synapse (b) Presynaptic inhibition

(c) Post-synaptic inhibition (d) Prolonged refractory time

341. The potential difference across the resting axonal membrane is

(a) + 60 *mv* (b) + 90 *mv* (c) – 60 *mv* (d) 0

342. The physiological importance for the transmission of nerve impulse was established by

(a) Charles Sherrington (b) Mclennan (c) Tothlin (d) Ranvier

343. Nerve impulse in a physiochemical phenomenon was suggested by

(a) Gothlin (b) Charles Sherrington (c) Mclennan (d) Ranvir

344. Propagation of action potential is very fast in nerve fibres which have

(a) Large fibre diameter (b) Small fibre diameter

(c) Covering of myelin sheath (d) (a) and (c) both are correct

345. Transmission of nerve impulse can be recorded with the help of

(a) Oscilloscope (b) Microscope (c) Spirometer (d) Microdensitometer

346. The jumping of action potential from node to node (of Ranvier) in a fibre is called

(a) All or none principle (b)Threshold stimulus (c) Nodal conduction (d) Saltatory conduction

347. The weakest current strength that can excite a tissue is called

(a) Chronaxia (b) Rheobase (c) Saltatory (d) Reflex arch

348. The rate of conduction in myelinated fibre of a mammal is very high because

(a) Synapses are less frequent (b) Action potential is faster and numerous

(c) Action potential jumps from node to node (d) Membrane is depolarised faster

349. An axon has four terminal ends connected with dendrites of four different neurons. Its nerve impulse will

(a) Become weak due to distribution into four

(b) Travel in all the four neurons with equal strength

(c) Pass onto one neuron only

(d) Travel to none because the movement of impulse is from dendrite to axon

350. White matter is composed of

(a) Nerve cell with blood vessels (b) Myelinated nerve fiber

(c) Ependymal cells (d) Non myelinated nerve fiber

351. Myelin sheath is the covering of

(a) Muscle cell (b) Axon (c) Blood vessels (d) Osteocytes

352. Saltatory conduction is superior to uninterrupted conduction because of

(a) Less energy required (b)More speed (c) Less Na^+ and K^+ pump (d) All the above

353. Anaesthetics reduce pain by blocking nerve conduction due to

(a) Blocking neurotransmitter receptor (b) Blocking Na^+ channels

(c) Blocking K^+ channels (d) All the above

354. Conus medullaris is also known as

(a) V_5 (b) V_4 (c) V_2 (d) V_3

355. The chemical causing the transmission of nerve impulse across synapses is

(a) Acetylcholine (b) Cholinesterase (c) Choline (d) Acetic acid

356. Which one of the following statement in regard to nerve activity is true

(a) The synaptic cleft does not prevent direct propagation of action potential from presynaptic neuron to post synaptic cell

(b) Information across the synaptic cleft is transmitted by means of a chemical neurotransmitter in small vescile

(c) Combination of neurotransmitter with receptor site changes membrane potential without changing membrane potentially

(d) In tetanus the excitatory impulse to muscles are inhibited leading to lock jaw

357. Junction of two nerve fibres is called

(a) Synapse (b) Junction (c) Connection (d) None of these

358. The enzyme required for the conduction of nerve impulses across synapse is

(a) Peroxidase (b) Choline acetylase

(c) Ascorbic acid oxidase (d) Succinic dehydrogenase

359. Acetylcholine is

(a) Chemical messenger (b) Chemical transmitter across the synapse

(c) Antistress hormone (d) Digestive enzyme

360. Synaptic fatigue is due to

(a) Exhaustion of neurotransmitter (b) Release of more acetylcholine

(c) Release of more adrenaline (d) None of these

361. After the transmission of one impulse from the synapse, it cannot transmit another impulse because one of the following chemical is active there

(a) Choline (b) Acetic acid (c) Acetylcholine (d) Acetycholinesterase

362. The neurotransmitter which communicates between two neurons or between a neuron and a muscle is

(a) Acetylcholine (b) Globulin (c) Rennin (d) ATP

363. Acetylcholine is released at

(a) Synapse (b) Axon (c) Dendron (d) Cyton

364. 5'-Hydroxytrypt amine is a

(a) Hormone (b) Cardiac stimulant

(c) Chemical transmitter (d) Cardiac inhibitor

365. Chemical transmission of nerve impulses from one neuron to another is by

(a) Adrenaline (b) Acetylcholine (c) Dopamine (d) All of these

366. Neurons at the synapse show

(a) No continuity (b) Partial continuity (c) Complete continuity (d) Chemical continuity

367. Chemical synapse are present in

(a) Cray fish (b) Pheretima (c) Eutypheus (d) Mammalian brain

368. Identify the chemical which acts as hormone as well as neuro-transmitter

(a) *Y*-aminobutyric acid (b) Acetylcholine (c) 5'-hydroxy tryptamine (d)Adrenaline

LOCATION AND STRUCTURE OF NERVE CELL

Basic Level

369. Bipolar nerve cells and ganglion cells are found in the

(a) Sclerotea (b) Cochlea (c) Retina (d) Cristae

370. Which of the following has non-myelinated nerve fibres

(a) Optic nerves (b) Cranial nerves (c) Spinal nerves (d) Autonomic nerves

371. The Nissle's granules of nerve cell are made up of

(a) Ribosome/RER (b) SER (c) DNA (d) Golgi bodies

372. When degeneration of nerve cells occur which will be affected first

(a) Dendrites (b) Motor end plates (c) Nissl granules (d) Schwann cells

373. Nissl's granules are present in the…..and are made up of…….respectively

(a) Muscle cells and deoxyribo nucleic acid (b) Mast cells and RNA

(c) Osteocytes and DNA (d) Neuron and RNA

374. Bundles of nerve fibres are enclosed in a sheath called

(a) Fascicle (b) Endoneurium (c) Epineurium (d) Perineurium

375. The efferent process of neuron is known as

(a) Axon (b) Dendrites (c) Cyton (d) Neurofibrilae

376. The chief functional units of the nervous system are

(a) Neuroglia (b) Axon (c) Neurons (d) Dendrites

377. The nerves leading to the central nervous system are called

(a) Efferent (b) Afferent (c) Motor (d) None of these

378. Unipolar nerve cells can be traced in

(a) Spinal ganglion cells (b)Retina cells

(c) Motor neurons of spinal cord (d)Vertebrate embryo

379. A polar nerve cells are found in

(a) Brain (b) Retina (c) Vertebrate's embryo (d)Cochlea

380. Axoplasm is found in

(a) Out of nerve fibre (b) Inside nerve fibre

(c) Around the nucleus of smooth muscle fibre (d) Around the nucleus of neuron

381. Which of the following animal has a false nervous system but not brain

(a) Hydra (b) Amoeba (c) Cockroach (d) Earthworm

Advance Level

382. White matter is composed of

(a) Ependyma (b) Nerve cells

(c) Medullated Nerve fibres (d) None of these

383. Afferent nerve fibres carry impulses from

(a) Central nervous system to muscles (b) Central nervous system to receptors

(c) Effector organs to central nervous system (d) Receptors to central nervous system

384. Nodes of Ranvier are

(a) The point in which the axon is exposed

(b) The contact point found over the non myelinated nerve fibres

(c) Area in which the axons swell up

(d) Area where the neurilemma touches the axon

385. The medullary sheath of the nerve fibre is interrupted at intervals by

(a) Septa (b) Node of Ranvier (c) Synapses (d) Glia

386. Largest cell in body is

(a) Lymph (b) Osteoctyte (c) Neuron (d) Chromatophore

387. Which one of the following is essential for the formation of myelin sheath

(a) Zinc (b) Sodium (c) Iron (d) Phosphorus

388. White matter consist of

(a) Nerve fibres with myelinated sheath (b) Nerve fibres without myelinated sheath

(c) Scattered areolar tissue (d) Nerve fibres with blood vessels

389. Some cell in our body can be over a feet long. They are

(a) A muscle cell (b) The bone cell (c) Nerve cell (d) Gland cell

390. Nerve impulse is

(a) Carried by afferent and efferect fibres (b)Is not carried by any afferent or efferent fibres

(c) Is carried away by afferent fibres and brought about by efferent fibres

(d) Is brought by afferent fibres and carried by efferent fibres

MISCELLANEOUS PROBLEMS

Basic Level

391. Cutaneous stimulus is received by

(a) Axodendrite-cholinergic (b) Dendrodendronic-adrenergic

(c) Motor nerve (d) Sensory nerve

392. Corpus callosum is seen in

(a) Brain (b) Ovary (c) Pituitary (d) Corpus luteum

393. Which one of these processes is found in animals only

(a) Nervous system (b) Hormonal control (c) Respiration (d) Diffusion

394. Brain depends on blood for the supply of

(a) Oxygen and ATP (b) Oxygen and electrolytes

(c)Oxygen and glucose (d) ATP and glucose

395. If the mental age of a 6 years old child is 4, his mental age when he will be 15 years old should be

(a) 8 (b) 9 (c) 10 (d) 12

396. Power of regeneration is lowest in

(a) Brain cell (b) Liver cell (c) Bone cell (d) Muscle cell

397. Which one of the following organs in the human body is most affected due to shortage of oxygen

(a) Kidney (b) Brain (c) Intestine (d) Skin

398. Response to contact is known as

(a) Thigmotaxis (b) Chemotaxis (c) Galvanotaxis (d) Thermotaxis

399. Which one of the following is not essentially a part of nervous system

(a) Cyton (b) Axon (c) Myelinated (d) Intermedin

400. What is not true for the brain of humans

(a) Absence of pineal gland (b) Corpora quadrigemina present

(c) Largest cerebral hemisphere (d) Presence of sulci and gyri

401. Cell bodies of motor and interneurons are present in

(a) White matter of brain (b)Gray matter of brain

(c) White matter of spinal cord (d) White matter of brain and spinal cord

402. Earthworm and cockroach have which of the following thing common

(a) Ventral nerve chord (b) Closed blood vascular system

(c) Nephridia (d) Cocoon

403. In frog, the nerve impulses for hearing start from

(a) Fenestra ovalis (b) Columella auris

(c) Lagena basillaris (d) Membranous labyrinth

404. Which cell stops dividing after birth

(a) Neuron (b) Glial (c) Epithelium (d) Liver

405. The neuron terminates in the muscles, the terminal part is known as

(a) Button (b) Synapse (c) End plate (d) Terminal plate

406. The example of homeostasis is

(a) Response to dim light (b)Learning and memory (c)Drinking water (d) All of the above

407. The stomach pain impulses are received by receptors known as

(a) Proprioreceptors (b) Exteroreceptors (c) Free nerve ends (d) Chemoreceptors

408. Where the Nissl's granules are found and what is their function

(a) In nerve cells and helps in excretion and nutrition

(b)In blood and helps in excretion and nutrition

(c) In sarcoplasm and helps in contraction (d) In mucous cells and secret mucous

409. Which of the following is the immediate covering of a nerve fibre

(a) Sarcoplasm (b) Perineurium (c) Epineurium (d) Endoneurium

Advance Level

410. The venom of cobra affects the

(a) Digestive system (b) Circulatory system (c) Nervous system (d) Respiratory system

411. The ganglia of sympathetic and the central nervous system in frog develops from the

(a) Neural cell (b) Notochordal cells (c) Neural plate cells (d) Neural crest cells

412. Parkinsonism is related with

(a) Brain (b) Spinal cord (c) Cranial nerves (d) Spinal nerves

413. Intercellular communication in human takes place by

(a) Cytoplasm (b) Nerves only

(c) Hormones only (d) Nerves and hormones

414. The pneumotaxis centre in the body is

(a) Heart (b) Lung (c) Medulla (d) Liver

415. Secretion of which of the following is under neurosecretory nerve axons

(a) Pineal (b) Adrenal cortex (c) Anterior pituitary (d) Posterior pituitary

416. Intelligence quotient (I.Q.) is the ratio of mental age to

(a) Chronological age (b) Chronological age multiplied by 10

(c) Chronological age multiplied by 100 (d) Chronological age divided by 100

417. You are riding a bicycle and take a sudden turn around a sharp corner. The organs involved in the maintenance of balance is

(a) Medulla oblongata (b) Semicircular canals (c) Cerebrum (d) Optic chiasma

418. What are the largest mammalian fibres called as

(a) A fibres (b) B fibres (c) C fibres (d) All above

419. Chromaffin cells are neurons of autonomic nervous system found in

(a) Gonads (b) Lungs

(c) Medulla of adrenal gland (d) Heart

420. Paralysis of both lower limbs due to spinal cord damage and not the upper limbs is called

(a) Hemiplegia (b) Quadriplegia (c) Posterioplegia (d) Paraplegia

421. In Parkinson's disease, there is degeneration of a neurotransmitter named

(a) Acetylcholine (b) Adrenaline (c) Dopamine (d) GABA

422. Neurocyton is located

(a) Cortex of the brain (b) Outside the brain (c) Outside the spinal cord (d)White matter

423. The glial cells that form the blood-brain barrier, by lining brain capillaries are the

(a) Schwann cells (b) Astrocytes (c) Oligodendrioglial cells (d)Ranvier cells

424. In earthworm neurons are

(a) Motor (b) Sensory (c) Both above (d) Absent

425. White matter is composed of

(a) Nerve fibres (b) Nerve cells (c) Ependyma (d) None of these

426. According to the accepted concept of hormone action, if receptor molecules are removed from target organs, then

(a) The target organ will continue to respond to the hormone but will require higher concentration

(b) The target organ will continue to respond to the hormone but in the opposite way

(c) The target organ will continue to respond to the hormone without any difference

(d) The target organs will not respond to the hormone

427. Purkinje cells are found in

(a) Cerebellar cortex (b) Mammalian heart (c) Voluntary cells (d) Semicircular canal

428. Who was first to record EEG

(a) Pavlov (b) Berger (c) Marshall Hall (d) Ranvier

429. Which of the following is recorded in EEG during deep sleep

(a) Alpha waves (b) Beta waves (c) Theta waves (d) Delta waves

430. Alpha waves are most prominent during

(a) Tension (b) Sleep (c) Rest (d) Happiness

ANSWER

ASSIGNMENT (BASIC AND ADVANCE LEVEL)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	b	d	c	a	c	d	a	a	b	a	b	b	c	a	a	c	c	c	c
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
a	d	a	c	b	b	a	d	c	a	c	c	c	d	d	c	b	a	a	a
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
c	c	d	c	d	a	b	d	a	d	c	d	d	c	a	d	c	a	c	b
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
b	b	c	a	d	b	a	b	c	c	b	c	c	b	c	c	a	d	b	a
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
c	c	c	c	d	d	b	d	d	c	a	d	c	c	d	c	b	c	c	d
101	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
c	b	c	c	c	d	a	d	b	d	b	d	a	c	d	b	a	d	c	b
121	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**
a	c	a	b	c	c	c	c	c	d	a	c	c	a	d	b	a	a	b	b
141	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**	**160**
a	a	c	c	b	d	c	d	b	d	b	b	a	d	d	a	c	c	a	b
161	**162**	**163**	**164**	**165**	**166**	**167**	**168**	**169**	**170**	**171**	**172**	**173**	**174**	**175**	**176**	**177**	**178**	**179**	**180**
c	a	a	c	c	d	a	a	a	c	a	d	b	a	c	a	c	a	d	c
181	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**194**	**195**	**196**	**197**	**198**	**199**	**200**
b	b	a	c	b	c	a	b	a	c	c	c	a	b	d	d	b	c	a	c
201	**202**	**203**	**204**	**205**	**206**	**207**	**208**	**209**	**210**	**211**	**212**	**213**	**214**	**215**	**216**	**217**	**218**	**219**	**220**
b	b	d	c	c	c	c	a	d	b	b	a	b	a	b	b	b	a	a	c
221	**222**	**223**	**224**	**225**	**226**	**227**	**228**	**229**	**230**	**231**	**232**	**233**	**234**	**235**	**236**	**237**	**238**	**239**	**240**
a	d	b	c	c	b	d	c	d	b	d	c	b	d	d	a	c	c	b	b
241	**242**	**243**	**244**	**245**	**246**	**247**	**248**	**249**	**250**	**251**	**252**	**253**	**254**	**255**	**256**	**257**	**258**	**259**	**260**
b	d	a	b	b	c	c	b	b	c	d	a	a	a	b	c	d	b	c	c
261	**262**	**263**	**264**	**265**	**266**	**267**	**268**	**269**	**270**	**271**	**272**	**273**	**274**	**275**	**276**	**277**	**278**	**279**	**280**
c	a	c	a	d	c	c	b	b	c	d	c	b	a	b	b	d	a	b	a
281	**282**	**283**	**284**	**285**	**286**	**287**	**288**	**289**	**290**	**291**	**292**	**293**	**294**	**295**	**296**	**297**	**298**	**299**	**300**
a	c	b	c	a	a	c	a	b	b	b	d	b	d	c	c	d	b	b	b

301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
a	d	a	b	a	d	c	a	d	b	c	a	d	a	d	c	a	b	a	a
321	**322**	**323**	**324**	**325**	**326**	**327**	**328**	**329**	**330**	**331**	**332**	**333**	**334**	**335**	**336**	**337**	**338**	**339**	**340**
a	d	b	b	b	d	b	b	a	c	d	a	a	b	d	a	c	a	b	b
341	**342**	**343**	**344**	**345**	**346**	**347**	**348**	**349**	**350**	**351**	**352**	**353**	**354**	**355**	**356**	**357**	**358**	**359**	**360**
c	b	b	d	a	d	b	c	b	b	b	d	d	a	a	b	a	b	b	b
361	**362**	**363**	**364**	**365**	**366**	**367**	**368**	**369**	**370**	**371**	**372**	**373**	**374**	**375**	**376**	**377**	**378**	**379**	**380**
d	a	a	c	d	d	d	d	c	d	a	c	d	d	a	c	b	a	c	b
381	**382**	**383**	**384**	**385**	**386**	**387**	**388**	**389**	**390**	**391**	**392**	**393**	**394**	**395**	**396**	**397**	**398**	**399**	**400**
a	c	d	a,d	b	c	b	a	c	d	d	a	a	c	c	a	b	a	d	a
401	**402**	**403**	**404**	**405**	**406**	**407**	**408**	**409**	**410**	**411**	**412**	**413**	**414**	**415**	**416**	**417**	**418**	**419**	**420**
b	a	c	a	c	c	c	a	d	c	d	a	d	c	d	c	b	a	c	c
421	**422**	**423**	**424**	**425**	**426**	**427**	**428**	**429**	**430**										
c	a	b	c	a	d	a	b	d	c										

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