Nervous System

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By

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Nervous System

The nervous system is the portion of the body which actually act as a communicator between the external and internal environment. It collects different information from the external environment, processes it via higher neuronal centre and produces necessary motor activities in response to that external stimuli, it is the control centre for the internal environment as well. The higher centre of nervous system was brain which is the control centre for registering sensation, co-relating them with one another, making decision and taking action. It is also the centre for intellect, arrogation, behaviour and memory.

The nervous system is made up of a unite structure called the **neuron**. The study of different aspects of nervous system is called **neurology**. The special branch of physicians dealing with different devices related to nervous system are known as **Neurologist.**

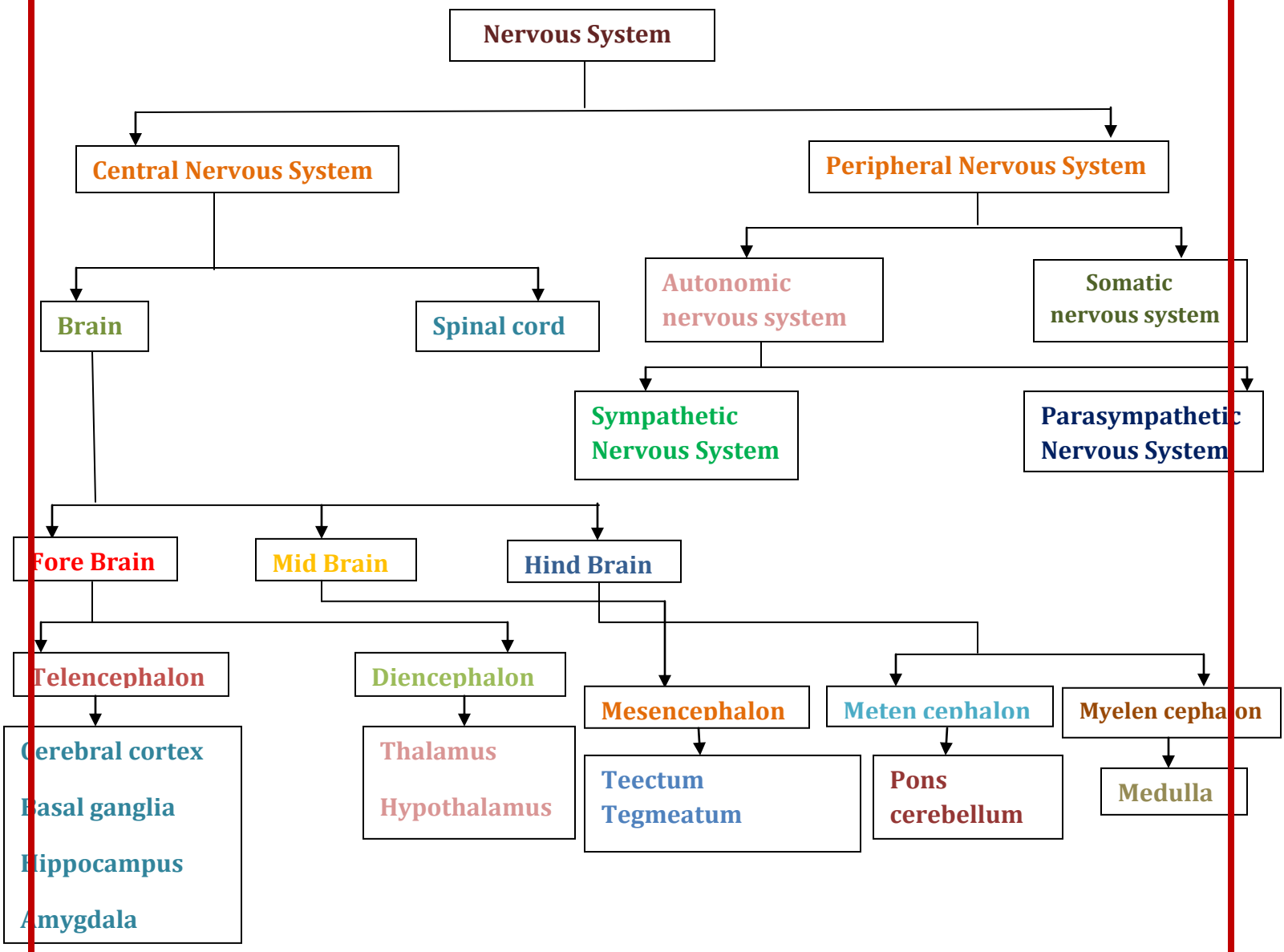
Different parts of nervous system:

The nervous system can be divided in to several sub division depending upon their structural arrangement and functionally and structurally the nervous system can be divided into two classes:

a) Central nervous system

b) Peripheral nervous system

The central nervous system consists of brain and the spinal cord. The peripheral nervous system consists of craniospinal nervous system and the visceral nervous system. Cranial nerves are 12 pairs nerves, and spinal nerves are 81 pairs nerves.


Nervous System
Central Nervous System
Peripheral Nervous System
Brain
Spinal cord
Autonomic nervous system
Somatic nervous system
Sympathetic Nervous System
Parasympathetic Nervous System
Fore Brain
Mid Brain
Hind Brain
Telencephalon
Diencephalon
Mesencephalon
Meten cephalon
Myelen cephalon
Cerebral cortex
Basal ganglia
Hippocampus
Amygdala
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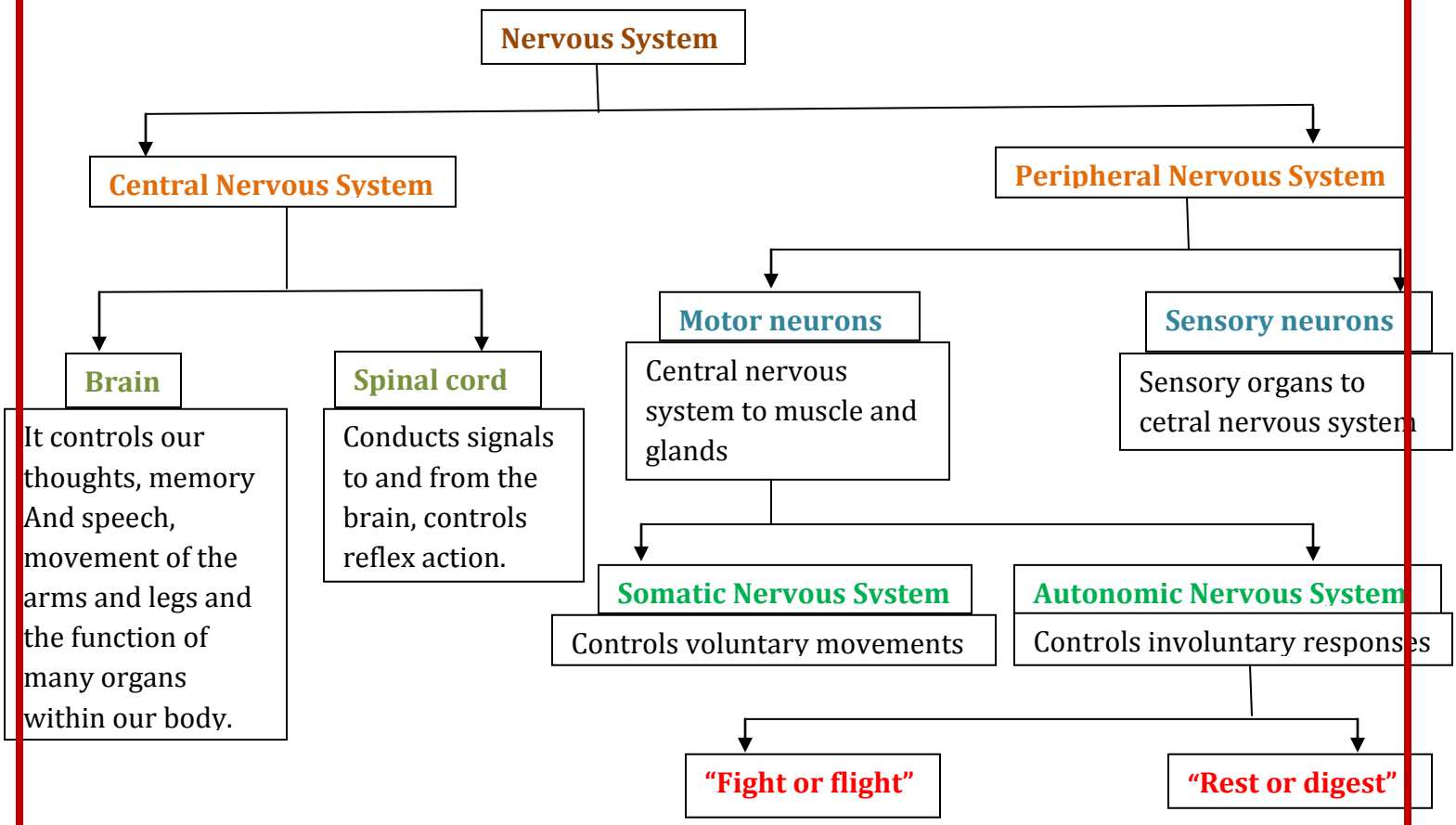
Teectum
Tegmeatum
Pons cerebellum
Medulla



Central Nervous System (CNS):

The central nervous system (CNS) consists of the brain and spinal cord. The brain is the part of the CNS that is located in the skull and contains about 85 billion neurons. The spinal cord contains about 100 million neurons. The CNS processes many different kinds of incoming sensory information. It is also the source of thoughts, emotions, and memories. Most signals that stimulate muscles to contract and glands to secrete originate in the CNS.

Peripheral Nervous System (PNS):

The PNS consists of all nervous tissue outside the CNS. Components of the PNS include nerves and sensory receptors. A **nerve** is a bundle of hundreds to thousands of axons plus associated connective tissues and blood vessels that lies outside the brain and spinal cord. 12 pairs of **cranial nerves** emerge from the brain and 31 pairs of **spinal nerves** emerge from the spinal cord. Each nerve follows a defined path and serves a specific region of the body. The term **sensory receptor** refers to a structure of the nervous system that monitors changes in the external or internal environment. Examples of sensory receptors include touch receptors in the skin, photoreceptors in the eye, and olfactory (smell) receptors in the nose.

The PNS is divided into sensory and motor divisions. The sensory or afferent divisions of the PNS conveys input into the CNS from sensory receptors in the body. This division provides the CNS with sensory information about the somatic senses (tactile, thermal, pain, and proprioceptive sensations) and special senses (smell, taste, vision, hearing, and equilibrium).

The **motor** or **efferent** division of the PNS conveys output from the CNS to effectors (muscles and glands).

Somatic Nervous System (SNS) and Autonomic Nervous System (ANS):

The motor or efferent division of the PNS conveys output from the CNS to effectors (muscles and glands). This division is further subdivided into a somatic nervous system and an autonomic nervous system. The **somatic nervous system (SNS)** conveys output from the CNS to skeletal muscles only. Because its motor responses can be consciously controlled, the action of this part of the PNS is voluntary.

The **autonomic nervous system (ANS)** conveys output from the CNS to smooth muscle, cardiac muscle and glands. Because, its motor responses are not normally under conscious control, the action of the ANS is involuntary. Autonomic system is the part of the nervous system, which controls the viscera. Its actions are generally unconscious and independent like the somatic system it has get a spinal and a cranial outflow. Certain special nerve centres are situated in the medulla, pons and midbrain are included in this system. Higher centres like hypothalamus, thalamus, cerebrum and corpus stratum also control this centre.

- **Classification:**
  This can be classified in 3 ways:
  1. **Anatomical:** According to the situation of outflow:
     a) Craniosacral
     b) Thoracolumbar
  2. **Functional:** According to the nature of function:
     a) Sympathetic
     b) Parasympathetic
  3. **Chemical:** According to the chemical substances liberated at their ends:
     a) Adrenergic
     b) Cholinergic

Neural arrangements:

ANS reflexes are very important in the control of viscera. Like SNS, ANS reflex also contain 3 neurons: afferent, connector and efferent. In ANS the afferent neurons lie in the posterior

horn cell, the connector neurons are found in the lateral horn cells and the efferent neurons are not found in the CNS. They lie outside the CNS. They lie in the form of neuron and ganglia. The presence of peripheral ganglia is the characteristic feature of CNS. In the sympathetic system the ganglia is away from the viscera. Hence, the parasympathetic system exerts a nerve localized action than the sympathetic.

Sympathetic System:

Sympathetic outflow takes place from the thoracic and lumbar region. The connector cells lie in the lateral horn cells of the spinal cord pass out through the anterior root and enter the anterior divisions of the mixed spinal nerve. These fibres are thinly medullated, hence white. They leave the nerve in the form of branch called the **white ramus communicans** and enter the sympathetic ganglion. The effector fibres arise from the sympathetic ganglion and are non medullated. They are called **Grey ramus communicans**.

Parasympathetic System:

Outflow take place from the cranial and spinal region lie in the lateral horn cells. The presence of peripheral ganglia is also a characteristic feature of parasympathetic system. Hence, the ganglia lie in or near the viscera (except Markeli's ganglion and otic ganglion.) Hence, the parasympathetic system exerts a nerve localized action.

Dual supply:

Most of the organs of the body are supplied both by sympathetic and parasympathetic nerves exerting antagnostic actions. The parasympathetic reactions are usually localized reactions and the sympathetic reactions are concerned with mass reactions. The parasympathetic activity results for instance, in slowing of heart rate and increase in the peristaltic and glandular activities of the gut. These conserve the body energies. Sympathetic activities result, for example in constriction of the cutaneous arteries, acceleration of heart rate and increase of BP. Constriction of the sphincters and distending of the peristalsis of the gut. These two are functionally opposite. Broadly speaking, function of the sympathetic are catabolic, while those of parasympathetic are anabolic.

Some of the structures of the body are supplied by sympathetic alone, e.g: ureters, uterus, fallopian tubes, seminal vesicles, While there are certain other structures having parasympathetic supply alone e.g: oesophagus, gastric glands, pancreas including islets of langerhans, lacrimal gland etc.

Neurotransmitters of ANS:

A nerve impulse is transmitted either through the nerve endings or through the synapses. It passes through an intermediate chemical agent. It has been established that certain

chemical substances are actually liberated at the nerve endings which help in the transmission of nerve impulses. These are as follows:

a) Norepinephrine
b) Acetylcholine

The chemical transmitters at most of the postganglionic sympathetic endings are closely similar to epinephrine. The post ganglionic adrenergic fibres secret both epinephrine and norepinephrine, but the relative proportions of their secretion vary from nerve to nerve. Evidences indicate that excepting the nerve fibres to the sweat gland norepinephrine is liberated at all the post ganglionic sympathetic nerve endings.

Acetylcholine is another neurotransmitter of the ANS. It is the acetyl ester of the strong quaternary base, chlorine. Acetylcholine is formed at all parasympathetic nerves and nerve endings. The rate increases on stimulation of the parasympathetic nerves. It is also produced at all the synapses and plays an important role in propagation of nerve impulse. The sympathetic nerve endings supplying the sweat glands and ancestor pilli also produces acetylcholine. Nerve fibres liberating acetylcholine are known as cholinergic fibres.

Control of the ANS:

The ANS is controlled in the following way:

1. Nervous control
2. Hormonal control

The hypothalamus and centres in the brain stem and medulla controls the ANS.

Epinephrine, norepinephrine, and also acetyl choline control the ANS through the activation of certain hypothalamic nuclei.

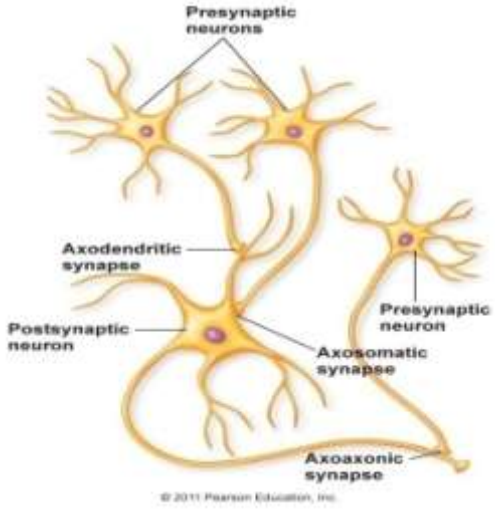
Synapse:

Synapse is the junctional region where the neuron and the other begins. The word 'synapse' is derived from the Greek word "Syn" which means "to clasp" or "join". It is a junction that mediates transfer of information from one neuron to the next or from a neuron to an effector cell.

Types of Synapses:

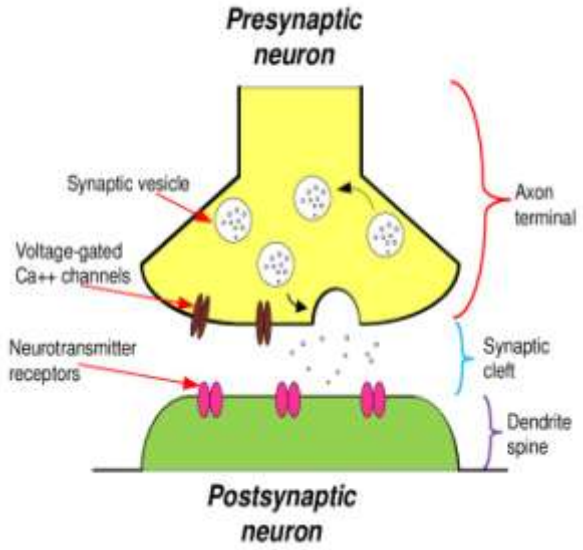
Synapses are of the following types:

a) **Axodendritic synapse:**
The synapses between the axon endings of one neuron and the dendrites of the other neurons are called **axodendritic synapse**.



b) **Axosomatic synapse:**
When axon endings of one neuron joins cell bodies of other neurons, they are called **axosomatic synapse.**

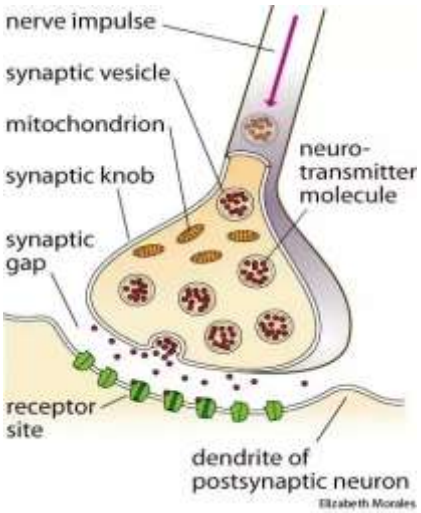
Beside these, there are synapses between the axons (axoaxonic), between dendrite (dendodendritic), or between cell bodies and dendrites (somatodendritic) but these are less common.



The neuron which conducts impulses towards the synapse is called the **presynaptic neuron** and the neuron transmitting the impulse away from the synapse is called the **post synaptic neuron**.

Anatomy of the synapse:

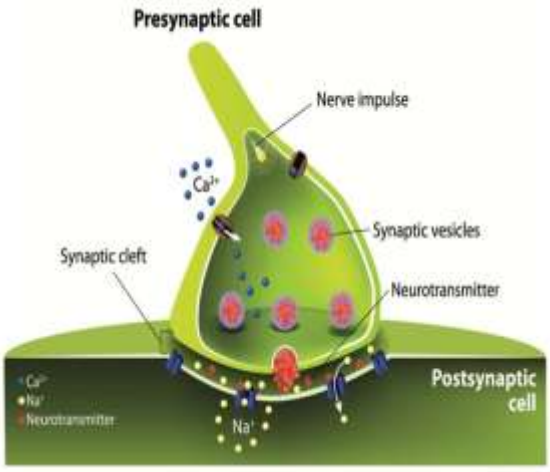
At the synapse, although close to each other, presynaptic and post synaptic membranes are always separated by a fluid filled space, approximately 30-50 mm wide. The space is called **synaptic cleft** . Under electron microscope, it is seen that presynaptic fibres end in an expanded terminal called the **synaptic knob**. The synaptic knobs are separated from the postsynaptic membrane by the synaptic cleft. The synaptic cleft actually represents the real discontinuity of the cell cytoplasm of the synaptic junction. The synaptic knobs contain mitochondria and a large number of synaptic vesicles. The synaptic vesicles are more concentrated towards the sites fronting the synaptic clefts.



The vesicles contain the transmitter material that mediate transmission of impulses from one neuron to the next.

- **Mechanism of Synaptic transmission:**

The transfer of information across the synaptic junction is called **synaptic transmission** and these transmissions are brought about either by chemical or by electrical or by both processes. The transmission of nerve impulse along an axon and across electrical synapses to chemical signals that travel across the synapse to the post synaptic cell, where they are converted back into electrical signals. The following chain of events occur:



- Action potential arrives at the axon terminal and neurotransmission begins at the presynaptic axon terminal.

- The neurotransmitter substances are synthesized and stored in the vesicle of the presynaptic axon terminals. When nerve impulses arrive, Ca^{2+} channels open up, Ca^{2+} floods down its electrochemical gradient from extracellular fluid into the terminal.

- Surge of Ca^{2+} into the axon terminal acts as an intracellular messenger. A Ca^{2+} sensing protein (synaptotagmin) binds Ca^{2+} and interacts with another protein (SNARE) which controls membrane fusion. Under the action of these proteins, the synaptic vesicles fuse with the axon membrane and comply their contents into the synaptic cleft by exocytosis [Ca^{2+} is actively removed by an active Ca^{2+} pump].

- The neurotransmitter diffuses across the synaptic cleft and binds to specific receptors at the post synaptic membrane.

- Binding of neurotransmitter open ion channels creating graded potential. Depending upon the receptor protein the postsynaptic neuron may be either excited or inhibited.
- Neurotransmitter effect is terminated. The binding of a neurotransmitter to its receptor is reversible. As long as the neurotransmitter bound to a post synaptic

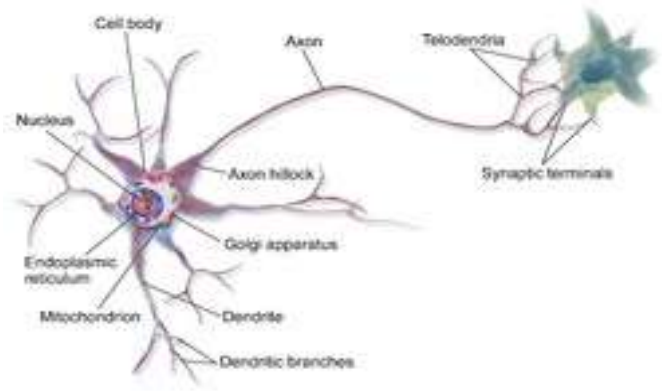
receptor, it continues to affect the membrane permeability. So, it should be renewed which is done by either of the following way –

- ❖ The neurotransmitter is diffused away from the synapse
- ❖ It is degraded by the enzymes
- ❖ It is reuptaken by the astrocytes

Neurons:

Like muscle cells, neurons possess electrical excitability, the ability to respond to a stimulus and convert it into an action potential. A stimulus is any change in the environment that is strong enough to initiate an action potential. An action potential is an electrical signal that propagates (travels) along the surface of the membrane of a neuron. It travels and begins due to the movement of ions (such as sodium and potassium) between interstitial fluid and the inside of a neuron through specific ion channels in its plasma membrane.

Parts of Neuron:



Most Neurons have three parts: a) a cell body b) dendrite c) axon.

a) Cell body:

The cell body contains a nucleus surrounded by cytoplasm that includes typical cellular organelles such as lysosomes, mitochondria and a Golgi complex. Neuronal cell bodies also contain free ribosomes and prominent clusters of rough endoplasmic reticulum, termed **Nissl bodies**. The ribosomes are the sites of protein synthesis. Newly synthesized proteins produced by **Nissl bodies** are used to replace cellular components, as material for growth of neurons, and to regenerate damaged axons in the PNS. The Cytoskeleton includes both **neurofibrils,** composed of bundles of intermediate filaments that provide the cell shape and support, and **microtubules** which assist in moving materials between the cell body and axon. Ageing neurons also contain **lipofuscin**, a pigment that occurs as clumps of yellowish brown granules in the cytoplasm. Lipofuscin is a product of neuronal lysosomes that accumulate as the neuron ages, but does not seem to harm the neuron. A collection of neuron cell bodies outside the CNS is called **Ganglion**.

b) Dendrites:

A nerve fibre is a general term for any neuronal process (extension) that emerges from the cell body of a neuron. Most neurons have two kinds processes: multiple

dendrites and a single axon. Dendrites are the receiving or input portion of a neuron. The plasma membranes of dendrites (cell bodies) contain numerous receptor sites for binding chemical messengers fron other cells. Dendrites usually are short, tapering and highly branched. In many neurons the dendrites from a tree-shaped array of processes extending from the cell body. Their cytoplasm contains Nissl bodies, mitochondria and other organelles.

c) **Axon:**

The single axon of a neuron propagates nerve impulses toward another neuron, a muscle fibre, or a gland cell. An axon is a long, thin, cylindrical projection that often joins to the cell body at a cone-shaped elevation, called **axon hillock**. The part of the axon closest to the axon hillock is the **initial segment.** In most neurons, nerve impulses arise at the junction of the axon hillock and the initial segment, an area called the **trigger zone**, from which they travel along the axon to their destination. An axon contains mitochondria, microtubules and microfibrils. The cytoplasm of axon is called **axoplasm,** is surrounded by a plasma membrane known as **axolemma.** Along the length of an axon, side branches called axon collaterals may branch off, typically at a right angle to the axon. The axon and its collaterals end by dividing into many fine processes called **axon terminals** or **axon telodendria**.

Enteric Nervous System (ENS):

A third branch of the ANS is the ENS, an extensive network of over 100 million neurons confined to the wall of the GI tract. The ENS helps regulate the activity of the smooth muscle and glands of the GI tract.

The fundamental functions of nervous system:

The nervous system is the master controlling and communicating system of the body. It has 3 overlapping functions:

i) There are millions of sensory receptors to monitor changes occurring both inside and outside the body.
The gathered information is called sensory input.

ii) The gathered information is then processed and brain interprets the sensory input and decides what should be done at each moments. This is called **integration.**

iii) It then causes a response called motor output by activating the effector organ for example whenever you see a redlight ahead at the time of driving your foot goes for the break to stop the car. Here the red traffic signal is the sensory input, the brain integrates the input and the motor output draws the drivers feet for the brake:

Histology of the nervous system:

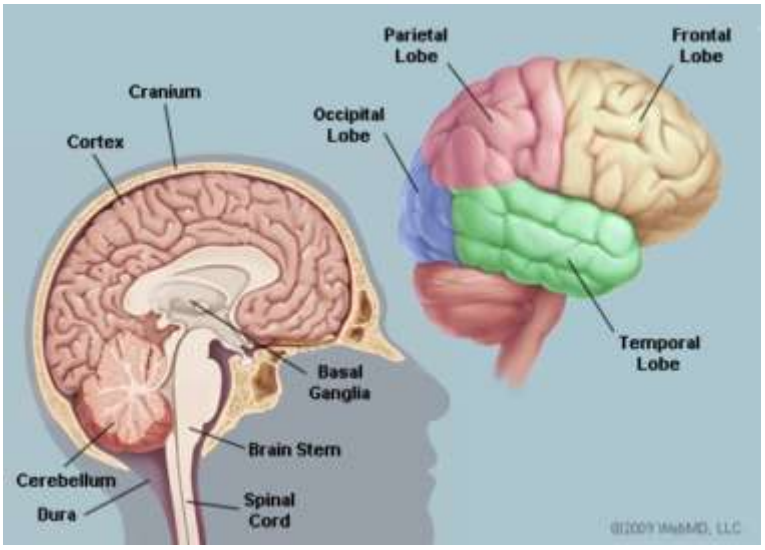
The nervous system consists of nervous tissue. There are two main types of cells present in the nervous system:

The supporting cells or the glial cells and neurons. These cells combine in a variety of ways in different regions of nervous system. The neurons are the original cells which are the unit of nervous system. In addition to forming the complex processing networks within the brain and spinal cord, neurons also connect all regions of the body to the brain and spinal cord. Neurons provide most of the unique functions of the nervous system, such as thinking, sensing, controlling muscle activity, remembering, and regulating glandular secretions.

The neurons are closely associated with much smaller cells called **Neuroglia** or **Glial cells**. There are different types of glial cells present in the nervous system. These cells actually protect, support, nourish the neurons and maintains the interstitial fluid that bathes them. Unlike neurons, neuroglia continue to divide throughout an individual's life time.

Brain:

The brain constitutes the main portion of the nervous system. It is about two good fist fulls of quivering pinkish grey tissue, wrinkled like a walnut and has the consistency of cold. The average adult brain has a mass of 1600 gm.



Human brain remains protected by the bony skull. The skull protects the brain from exterior and the hairs present on skull also increases the magnitude of protection. Meninges is a connective tissue covering which lies beneath the

skull and provides internal protection to the brain. The meninges has got 3 different layers:

i) The outer most covering is a tough cover, called the **dura mater**.
ii) The next layer is known as **arachnoid mater** which forms a loose covering and is richly supply with blood vessels.
iii) The inner most lining is **pia mater** which is made up of delicate connective tissue.

The spaces between the different layers of meninges is the route of CSF flow. The fluid acts as a soft absorber and helps to minimize the sudden blow on the delicate nervous mater of the brain.

What do you mean by Synaptic delay?

A nerve impulse travels at a speed of 150 m/s down the axon, but at the synapse it becomes comparatively slow. It reflects the time required for neurotransmitter to be released, diffuse across the synaptic cleft and bind to receptors. This time taken at the synapses called **Synaptic delay** (which lasts from 0.3-5.0 ms). This is the slowest step (rate limiting) of neural transmission.

What are the different types of Neurotransmitter?

Neurotransmitters are the language of the nervous system – this means by which each neuron communicates with others to process and send messeges to the rest of the body. These are the substances released at the synapses which helps in the transmission of impulses. The neurotransmitters are classified chemically and functionally.

Chemical classification of Neurotransmitter:

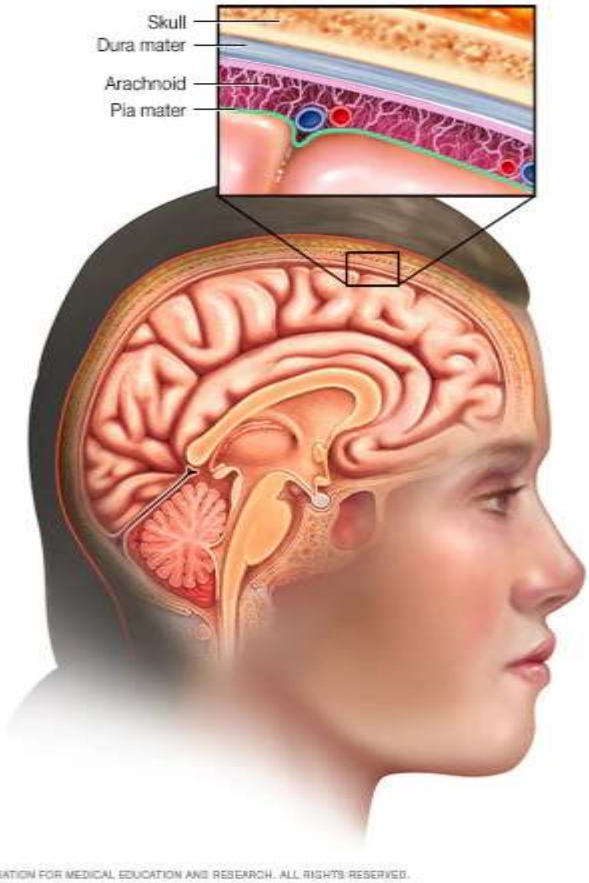
a. **Acetylcholine (Ach):** The first neurotransmitter identified, it is released by all neurons that stimulate skeletal muscle.
b. **Biologic amines :** These amines are mainly distributed in the brain. Ex: Catecholamine (dopamine, epinephrine and norepinephrine), serotonin and Histamine.
c. **Amino acids:** There are some amino acids for which a neurotransmitter role is certain includes glutamate, aspartate, glycine and GABA. (Gaama amino butyric acid).
d. **Peptides:** Endorphin, somatostatin, cholecystokinin are some examples.
e. **Purines:** ATP and adenosine.
f. **Gases and lipids:** NO and CO are some so called gasotransmitter. Brain makes natural neurotransmitter the 'endocannabinoids'.

Classification of Neurotransmitter by function:

1. **Effects:** Some neurotransmitters are excitatory, and some are inhibitory, while others exert both effects depending upon the receptor type. For example, GABA is inhibitory and glutamate is excitatory. Acetylcholine and Norepinephrine exert both the opposite effects. Acetylcholine is excitatory for skeletal muscle but inhibitory for cardiac muscle.
2. **Action:** Some neurotransmitters act directly as they bind to the ion channels. They provoke rapid response. Example: Acetylcholine. There are neurotransmitters that exert power long lasting effects and their action is similar to that of many hormones. Example: biogenic amines, peptides etc.

What is Meninges?

The meninges are three connective tissue membranes that lie just external to the CNS. From external to internal the three layers are:



a. Dura malin:

The word **Dura malin** means "tough mother". It is leathery and is the strongest layer. It is made up of two layered sheet of fibrous connective tissue. In several places, the dura mater extends inward to form partitions that subdivides the cranial cavity.

b. Arachnoid mater:

It is the middle layer of the three layered meninges. It forms a loose covering and separated from the dura mater by a narrow serous cavity which contains a thin layer of fluid . This space is called

subdural space. Beneath the arachnoid membrane is the wide subarachnoid space. There are spider like projection in this space which secure the arachnoid mater with the underlying pia mater. This area continues CSF and large blood vessels.

c. **Pia mater:**
It means 'delicate mother', and is composed of delicate connective tissue and supplied with tiny blood vessels. This layer clings tightly to the brain like atmosphere wray.

Write the functions of meninges.

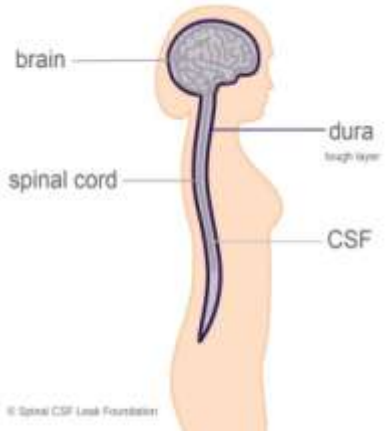
1. Protects and covers the CNS
2. Protects blood vessels and encloses venous sinuses
3. Contains cerebro spinal fluid (CSF).

What is Cerebro Spinal Fluid (CSF)?

CSF is a modified tissue fluid present in and around the brain and spinal cord forming a liquid cushion that gives buoyancy to CNS structures.

The CSF is similar in composition to blood plasma, from where it is formed. It contains less protein than plasma and its ion concentration are also different. It has more Na^+, Cl^-, and H^+ than plasma and less Ca^{2+} and K^+.

Write the functions of CSF.

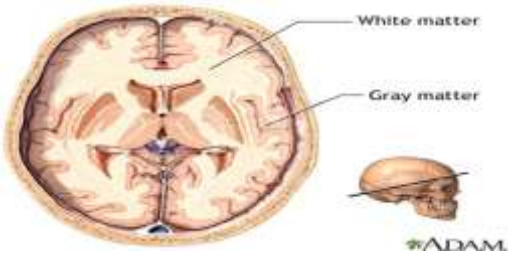


1. Remaining inside and outside the CNS it equalizes mechanical pressure and acts as a cushion between the soft brain tissue and rigid cranium. CSF protects the brain and spinal cord from blows and other trauma.
2. It receives the metabolites from brain.
3. Supplies nutrient and oxygen to the same extent.

What do you mean by grey matter and white matter?

Brain and spinal cord contain dense collection of nerve fibres and nerve cell bodies.

The collection of myelinated fibres are referred to as white matter as they appear white in colour due to the tres concentration of myelin sheath. Grey matter mainly contains nerve cell



bodies and unmyelinated fibres. In cerebral region, the white matter remain deep to the cortical grey matter but in spinal cord (in cross section) the grey matter looks like the letter 'H'.

How the neurons are classified?

Neurons are classified both structurally and functionally:

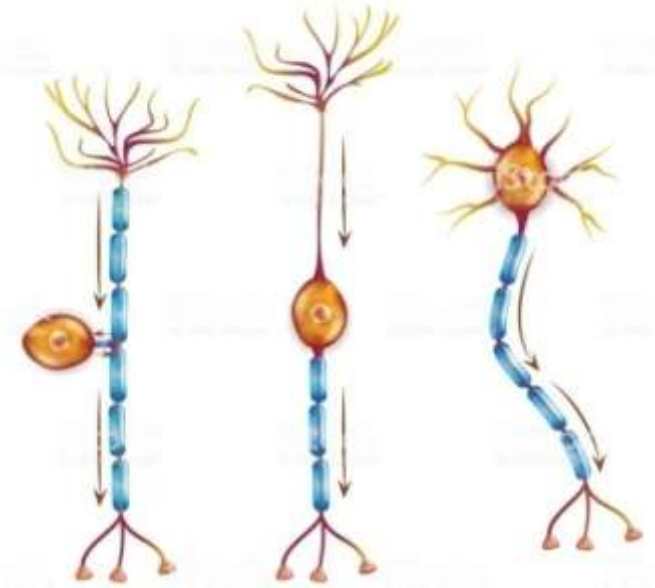
a. **Structural classification:**

Neurons are classified structurally according to the number of processes extending from their cell bodies. They are of following types:

i) **Multipolar Neurons:**
The neurons have three or more processes. One axon and the rest dendrites. They have the most common neuron.

ii) **Bipolar Neurons:**
Have two processes – an axon and a dendrite that extend from opposite sides of the cell body.

iii) **Unipolar Neurons:**
They have a single short process that engages from the cell body and divides T like into proximal and distal branches. These neurons are also referred to as **pseudounipolar neurons**.



b. **Functional classification:**

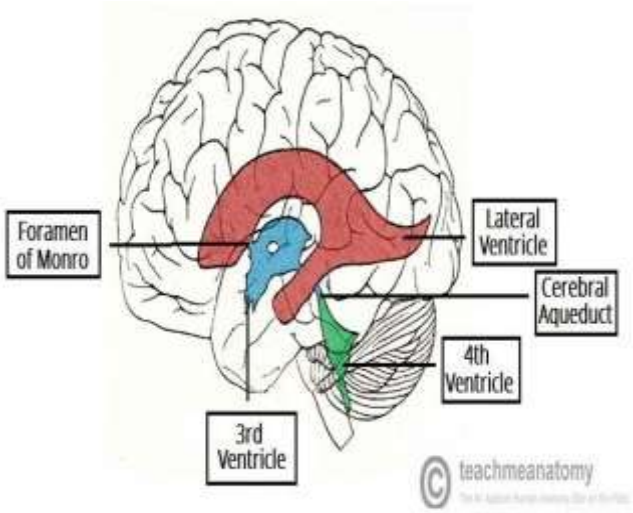
According to this scheme neurons are classified according to the direction in which nerve impulse travels relative to the CNS. They are of the following types:

a. **Sensory or afferent Neurons:**
These neurons transmit impulses from sensory receptors or internal organs towards or into the CNS.

b. **Motor or efferent Neurons:**
Carry impulses away from the CNS to the effector organ of the body periphery.

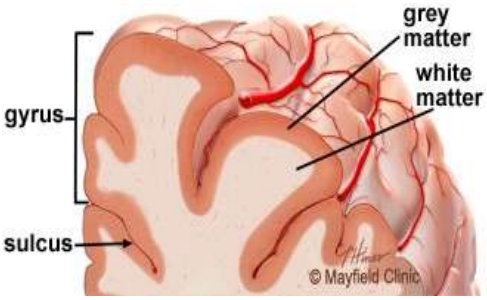
c. **Interneurons or association Neuron:**
These neurons lie between senses and motor neurons in neural pathways and shuttle signals through CNS pathways where integration occurs.

What are brain ventricles?



The interior of the nervous system is hollowed out by four cavities and two canals, all filled up with CSF. The cavities are called **brain ventricles**. If one cavity is present in each cerebral hemisphere, called the **lateral ventricle**. They open into a common central cavity – the third ventricle, through an opening on each side – the **Foramen of Monro**. The third ventricle is continued down through the midbrain as the **Aqueduct of Sylvius**. The aqueduct opens into another decatation in the medulla – the fourth ventricle, which again in continued downwards, as the central canal of the spinal cord.

What do you mean by 'gyri' and 'sulci'?



The human brain looks wrinkled like a walnut . The brain (during developmental phase) grows rapidly than the membraneous skull that contains it, folds upto occupy the available space (average wt 1500 gm).

The elevated ridges of tissues called **gyri** . The shallow grooves separating the ridges are called **sulci**. Deeper grooves are called **fissures**, which separate large region of the brain.

What are cranial nerves?

There are twelve pairs of nerves associated with the brain. These nerves are called the **Cranial Nerves**. The first two pairs are attached to the forebrain and the rest are associated with the brain stem. They are:

I. Olfactory (sensory)
II. Optic (sensory)

III. Oculomotor (motor)
IV. Trochlear (motor)
V. Trigeminal (both motor and sensory)
VI. Abducens (motor)
VII. Facial (both motor and sensory)
VIII. Vestibulocochlear (mainly sensory, to some extent motor)
IX. Glossopharyngeal (both motor and sensory)
X. Vagus (both motor and sensory)
XI. Accessmy (motor)
XII. Hypoglossal (motor)

What are spinal nerves?

The nerves that originate from the spinal cord are called **spinal nerves**. There are 31 pairs of spinal nerves. Spinal nerves are named according to where they issue from the spinal cord. The spinal nerves are all mixed nerves i.e. they serve both sensory and motor functions.

The nerves include:

- 8 pairs of cervical spinal nerves (c_1-c_8)
- 12 pairs of thoracic nerves (T_1-T_{12})
- 5 pairs of lumbar nerves (L_1-L_5)
- 5 pairs of sacral nerves (S_1- S_5)
- 1 pair of tiny coccygeal nerve (CO_1)

Comparison between Parasympathetic and Sympathetic Nervous System:

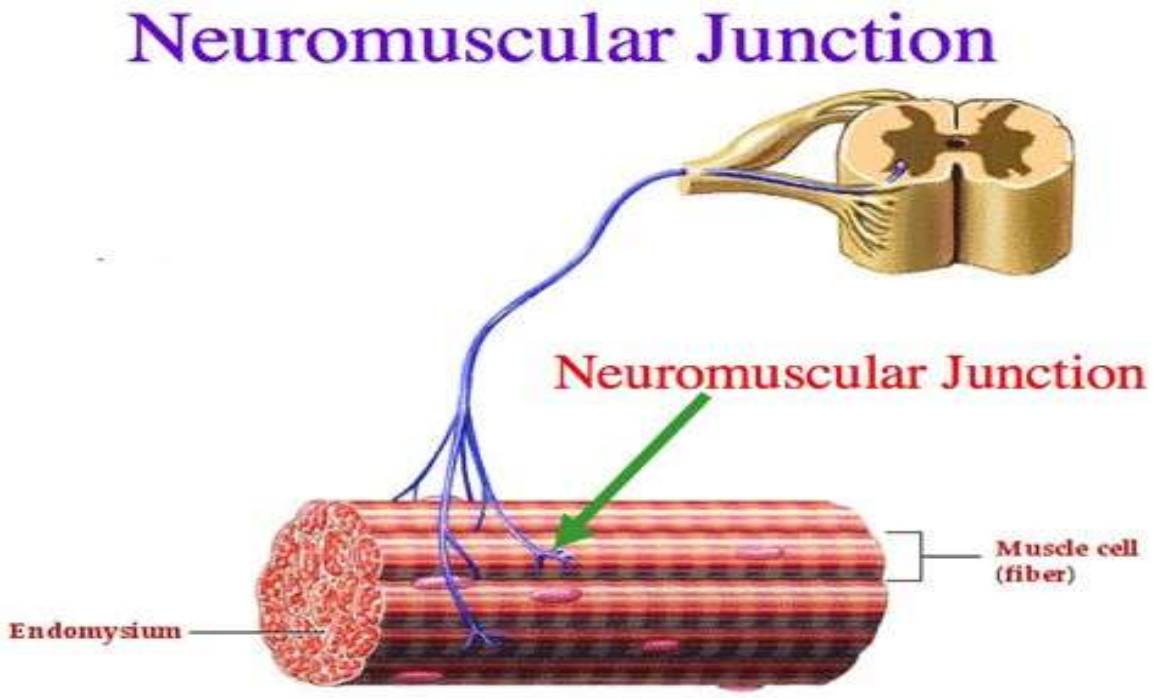
	Parasympathetic Nervous System	Sympathetic Nervous System
Introduction	The parasympathetic nervous system is one of the two main divisions of the Autonomic Nervous System (ANS). Its general function is to control homeostasis and the body rest – and- digest – response.	The sympathetic nervous system is one of the two main divisions of the ANS. Its general action is to mobilize body's fight-or-flight response.
Function	Control the body's response while at rest.	Control the body's response during perceived threat.
Originates in	Several region of the spinal cord, medulla, cranial nerves 3,7,9 and 10.	Thoracic and lumbar region of the spinal cord.

response of	Rest and digest	Fight-or-flight.
Action pathways	Longer pathways, slower system	Very short neurons, faster system
Neural body response	Counter balance, restores body to state calm.	Body speeds up, tenses up, becomes more alert. Functions not critical to survival shutdown.
Cardiovascular system	Decreases heart rate	Increases contraction and heart rate.
Coronary system	Bronchial tube constricts	Bronchial tube dilates
Musculo skeletal system	Muscles relax	Muscles contract
Pupils	Constrict	Dilate
Gastro intestinal System	Increases stomach movement and secretion	Decreases stomach movement and secretion.
Salivary ends	Saliva production increases.	Saliva production decreases.
Renal gland	No involvement	Releases adrenaline
	Parasympathetic Nervous System	**Sympathetic Nervous System**
Glycogen to glucose conversion	No involvement	Increases, converts glycogen to glucose for muscle energy
Urinary response	Increase in urinary output	Decrease in urinary output

Neuromuscular junction (NMJ):

The neuromuscular junction connects the nervous system to the muscular system via synapses between efferent nerve fibres and muscle fibres, also known as **muscle cells**. As an action potential reaches the end of motor neurons, voltage – dependent calcium channels open allowing calcium enter the neuron. Calcium facilitates vesicle binding and subsequent neurotransmitter release from the motor neuron into the synaptic cleft. In

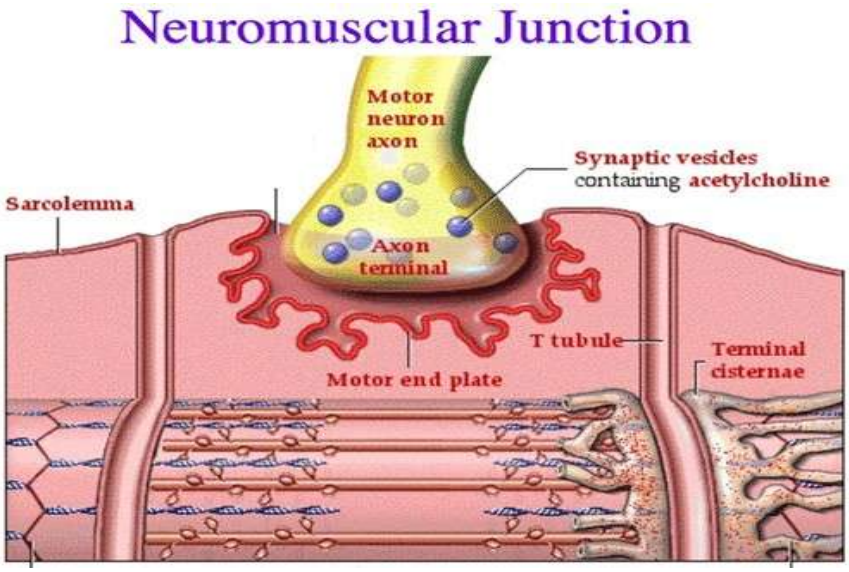
vertebrates, motor neurons release acetylcholine (Ach), a small molecule neurotransmitter, which diffuses through the synapse and binds nicotinic acetyl choline receptors (nAchRs)



on the plasma membrane of the muscle fibre, also known as **Sarcolemma.** nAchRs are ionotopic, meaning they serve as ligand gated ion channels. The binding of Ach to the receptor can depolarize the muscle fibre, causing a cascade that eventually results in muscle contraction.

Structure:

Skeletal muscle cells are stimulated by motor neurons of the somatic nervous system. Although these motor neuron resides in the brain, or spinal cord, their long thread like extension called **axons** travel within nerves, the muscle cells they serve. The axon of each motor neuron divides profoundly as it enters a muscle and each axon ending gives off several short curling branches that form an



elliptical NMJ with a single muscle fibres. As a rule, each muscle fibre has only one NMJ, located approximately midway along its length. Although the axon terminal and the muscle fibres are exceedingly close (1-2 nm apart) they remain separated by a space called **Synaptic cleft**. This space remain filled with a gel like extracellular substances rich in glycoprotein and collagen fibre. The terminal portion of the axons become flattened and round like. These are called **synaptic vesicles**. Within these vesicles there are small membraneous sacs containing neurotransmitter acetylcholine or Ach. The motor endplate is the part of muscle fibres sarcolemma that helps to form the NMJ. This part is highly folded. These junctional folds provide a large surface area for millions of Ach receptors located there.

Mechanism of action:

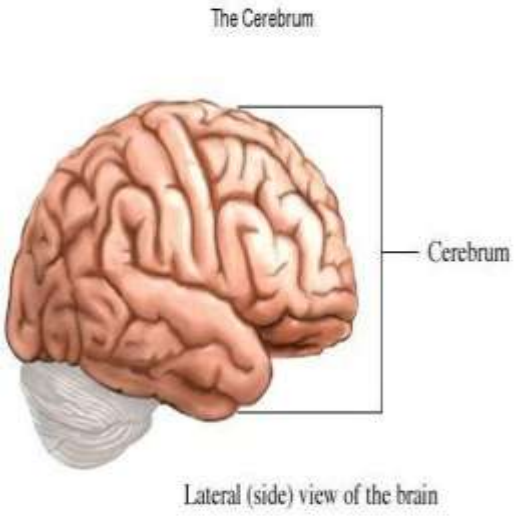
1. Upon the arrival of an action potential at the presynaptic neuron transmit voltage dependent calcium channels open & Ca^{2+} ions flow from the extracellular fluid into the presynaptic neurons cytosol.
2. This influx of Ca^{2+} causes neurotransmitter containing vesicles to lock and fuse to the presynaptic neuron's cell membrane through SNARE proteins.
3. Function of the vascular membrane and with the presynaptic cell membrane results in the emptying of the vesicles contents into the synaptic cleft, a process known as **Exocytosis**.
4. Acetylcholine diffuses into the synaptic cleft and can bind to the nicotinic acetylcholine receptors on the step-end-plate.
5. These receptors are ligand gate ion channel and when they bind to the acetylcholine, they open, allowing Na^{+1} and to flow on and K^{+} to flow it to the muscle cells.
6. Because of differences include chemical gradients across the plasma membrane, more sodium moves in than potassium out, producing a local depolarization of motor end plate known as **end-plate-potential (EPP).**
7. This depolarization spreads across the surface of the muscle fibre and continues the excitation co function coupling to contract the muscle.
8. The action of acetylcholine terminated when Ach diffuses away from the synapse or the enzyme acetylcholinesterase degrades part of Ach.
9. The choline produced by the action of acetylcholinesterase is required – it is transported through , reuptake, back into the presynaptic terminal and where it is how to synthesize new acetylcholine molecule.

Anatomy and different parts of brain:

Cerebrum:

The cerebrum is the 'seat of intelligence'. It provides us with the ability to read, write and speak. It helps us in calculation and compose music.

The cerebrum forms the greater part of the brain. It consists of an outer cerebral cortex, an internal region of cerebral white matter, and grey matter nuclei deep within the white matter.



The cerebral cortex is a region of grey matter, that forms the outer rim of the cerebrum. The cerebral cortex contains billions of neurons arranged in layers. The cortex shows rolls and folds. The folds or convolutions are called **gyri**. The deepest grooves between the folds are called **fissures**. The shallower grooves between folds are called **sulci**.

The most prominent longitudinal fissure, divides those cerebrum into right and left halves. These are called **cerebral hemispheres**. The cerebral hemispheres remain connected by a broad band of white matter called **corpus callosum.**

Each cerebral hemisphere is further divided by three deep fissures into 4 lobes:

i) Frontal lobe ii) Parietal lobe
ii) Temporal lobe iv) Occipital lobe

A central fissure demarcates the frontal lobe from parietal lobe; a parieto-occipital fissure demarcates the parietal lobe from occipital lobe and a sulcian fissure demarcates the frontal and parietal lobe from the temporal lobe.

Each cerebral hemisphere encloses a cavity called **lateral ventricles** or **1st and 2nd ventricles**. They open into the 3rd ventricle by a common aperture called **foramen of monro**.

Functions:

Specific types of sensory, motor and integrative signals are processed in certain regions of cerebral cortex.

The sensory areas receive sensory information and are involved in perception. Motor areas control voluntary movements. Association areas deal with complex integrative functions; such as memory, emotions, judgement, personality etc.

1. **Sensory area:**
   Sensory impulses arrive mainly in the posterior part of the brain, in both the cerebral hemispheres. The following are some important sensory areas:

- **Primary somato sensory area:**
  This area receives nerve impulses for touch, pressure, vibration, itch, temperature, pain and proprioception, This area is located in the parietal lobe. This area allows as to pinpoint where somatic sensation originate.
- **Primary visual area:**
  This area is located in the posterior part of the occipital lobe. It receives visual sensation.
- **Primary auditory area:**
  Located in the superior part of the temporal lobe. Receives information for sound and involved in auditory perception.
- **Primary gustatory area:**
  This is located in the parietal cortex. It receives impulses for taste, & is involved in taste discrimination.
- **Primary olfactory area:**
  Located in the temporal lobe on the medial aspect. It receives impulses for smell.

2. **Motor area:**
   The motor output from the cerebral cortex flows mainly from the anterior part of each hemisphere.

- **Primary motor area:**
  It is located in the frontal lobe. Each region of this area controls voluntary contraction of specific muscles or group of muscles.
- **Broca's speech area:**
  It is located in the frontal lobe. Speaking and understanding language are complex activities. In about 97% of population this language are localized in the left hemisphere. From broca's area nerve impulse control the muscles of larynx,

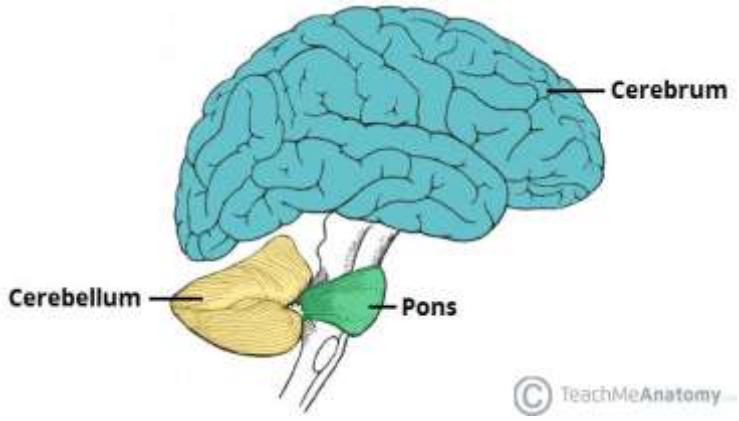
pharynx & mouth. It also control the breathing muscle to control the air flow in the vocal cord.

3. **Association area:**
   The following are some important association areas:

- **Somato sensory association area:**
  It receives sensation from primary somatosensory area as well as from thalamus & other parts of brain . This area permits us to determine the exact shape and texture of an object by feeling it.
- **Visual association area:**
  It is located in the occipital lobe. It relates present and past visual experiences & is essential for evaluating what is seen.
- **Facial recognition area:**
  This area stores information about faces and helps to recognize people by their faces.
- **Auditory association area:**
  It allows us to recognize a particular sound as music, noise or speech.
- **Orbito frontal cortex:**
  This area enables us to identify and discriminate among different odors.
- **Wermiski area:**
  This area interprets the meaning of speech by recognizing spoken words. It also contribute to verbal communication by adding emotional content such as anger or joy to spoken words.
- **Communication integrative area:**
  This area integrates sensory interpretations from association areas & other areas allowing the formation of thoughts based on the variety of sensory inputs.
- **Prefrontal cortex (frontal association):**
  This is an extensive area in the anterior part of the frontal lobe. This is concerned with a person's personality, intellect, complex learning abilities etc.
- **Premotor area:**
  This area is concerned with learned motor activities. This area also include frontal eye field area which include voluntary scanning movements of the eyes.

Cerebellum:

The cerebellum accepts the inferior and posterior part of the cranial cavity. It is only second to the cerebrum in size. Its surface is highly folded and contains



greater numbers of neurons. The cerebellum accounts for 1/10 of brain mass, yet it contains nearly ½ of neurons in brain. A deep groove known as the **transverse fissure** seperates the cerebellum from the cerebrum.

The shape of the cerebellum resembles a butterfly. The central constructed portion is called the **vermis** and the lateral wings or lobes are called **cerebellar hemisphere**. Each hemisphere is further divided into anterior and posterior lobes which govern the subconscious aspect of skeletal muscle movement. The inferior surface (flocculo nodular lobe) contributes to equilibrium & balance.

The superficial layer of cerebellum is known as **cerebellar cortex** which contains grey matter arranged in folds called **facia**. Within the grey matter are tracts of white matter & cerebellar nuclei.

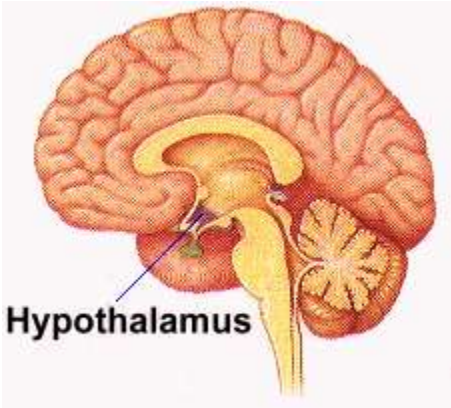
Three paired cerebellar peduncles attach the cerebellum to the brain stem – these are superior, middle and inferior cerebellar peduncles.

Function:

The primary function of cerebellum is to evaluate how well movements initiated by motor area in the cerebrum are actually being carried out. It makes possible all skilled muscular activities from catching a basket ball to speaking. It also serves some non-motor functions such as cognitions and language processing.

Hypothalamus:

The diencephalon forms a central core of brain tissue just superior to the mid brain. It is almost completely surrounded by the cerebral hemispheres. It contains numerous nuclei. Hypothalamus is a small part in diencephalon. It has the following parts:



a) **Mammary region:**
   It is adjacent to the mid-brain.
a) **Tuberal region:**
   It is the widest part of hypothalamus. Besides, various nuclei it contains the stalk like infundibulum which connects it to the pituitary.
b) **Supra optic region:**
   Lies superior to the optic chiasm (point of crossing of optic nerves)
c) **Preoptic region:**
   It lies anterior to the supra optic region.

Functions:

The hypothalamus controls many body activities and is one of the major regulators of haemostasis. Sensory impulses related to both somatic and visceral senses arrive at the hypothalamus. Impulses from receptors for vision, taste and smell also arrives here. Hypothalamus itself monitor osmotic pressure, blood glucose level, concentration of some hormone and body temperature. It has got important connection with the pituitary gland. Important functions of hypothalamus are as follows:

a) **Control of ANS:**
The hypothalamus controls the activities of ANS and thus regulates smooth muscle contraction, contraction of heart & secretion of some glands. The movement of food through the GI tract and contraction of urinary bladder are also controlled by hypothalamus.

b) **Production of hormones:**
Hypothalamus produces releasing and inhibiting hormones which stimulate or inhibit secretion of anterior pituitary hormones. (Axons extend from hypothalamus into the posterior lobe of pituitary. These axons produce oxytocin which is stored and released from posterior pituitary.

c) **Regulation of behavioural pattern:**
The hypothalamus participates in expression of aggression, pain and pleasure.

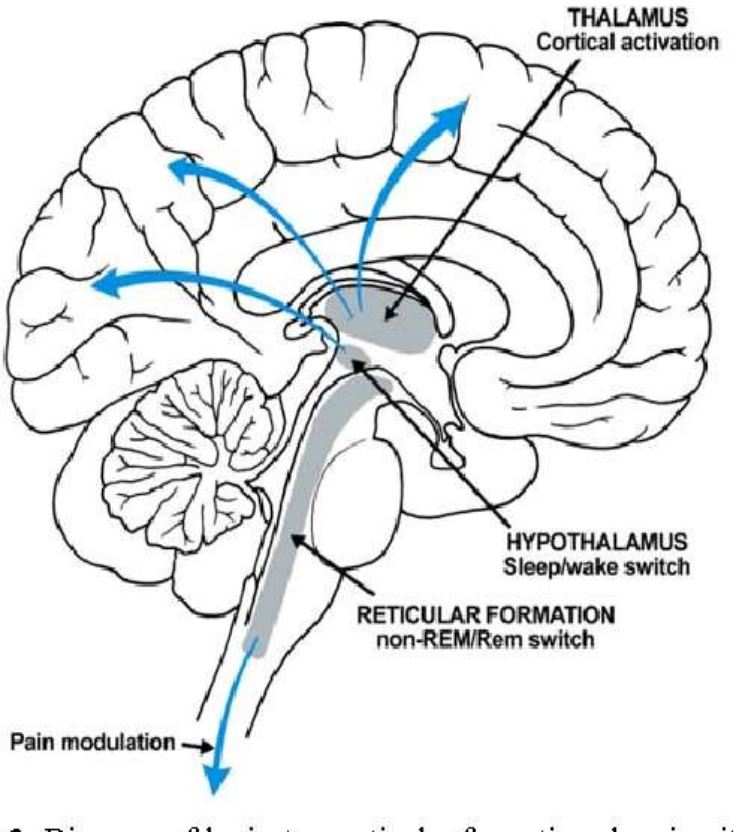
d) **Regulation of eating and drinking:**
The feeding centre in hypothalamus promotes eating and its satiety centre causes a sensation of fullness. It contacts as thirst centre which controls the water intake of an individual by monitoring the osmotic pressure of body fluid.

e) **Regulates body temperature:**
The hypothalamus also function as the body's thermostat. It monitor the temperature of blood flowing through it & promotes heat generation & heat loss depending upon the temperature.

f) **Regulation of circadian Rhythm:**
The hypothalamus serves as the body's internal biological clock.

Reticular formation:

There is a broad region in the brain stem where white matter and grey matter exhibit a net like arrangement. It is known as the **Reticular formation**. It extends from the superior part of spinal cord, through out the brain stem and into the interior part of the diencephalon.



Function:

a) The ascending part of the reticular formation is called the **Reticular Activating System (RAS).** Many sensory stimuli can activate this part of RAS. Visual, auditory stimuli, mental activities, stimuli from pain, touch & pressure receptors keep us aware of the position of our body.
b) The most important function of RAS is consciousness. Visual, auditory, and mental activities can stimulate RAS to maintain the state of consciousness.
c) The RAS is also active during arousal or awakening from sleep.
d) Another important function of RAS is to help maintain alertness and attention.
e) The RAS also prevents sensory overload by filtrating out insigficant information.
f) Inactivation of RAS produces sleep, a state of partial consciousness from which an individual can be aroused. But damage to RAS leads to coma, a state of irreversible unconsciousness.
g) RAS also regulates muscle tone.