Udai Pratap (Autonomous) College, Varanasi

E-learning Material

Module/Lecture	01
Subject	Zoology
Year/Semester	B.Sc. II Semester
Unit	VII
Topic	Animal Physiology
Sub-topic	Nervous System of Mammals
Key-Words	
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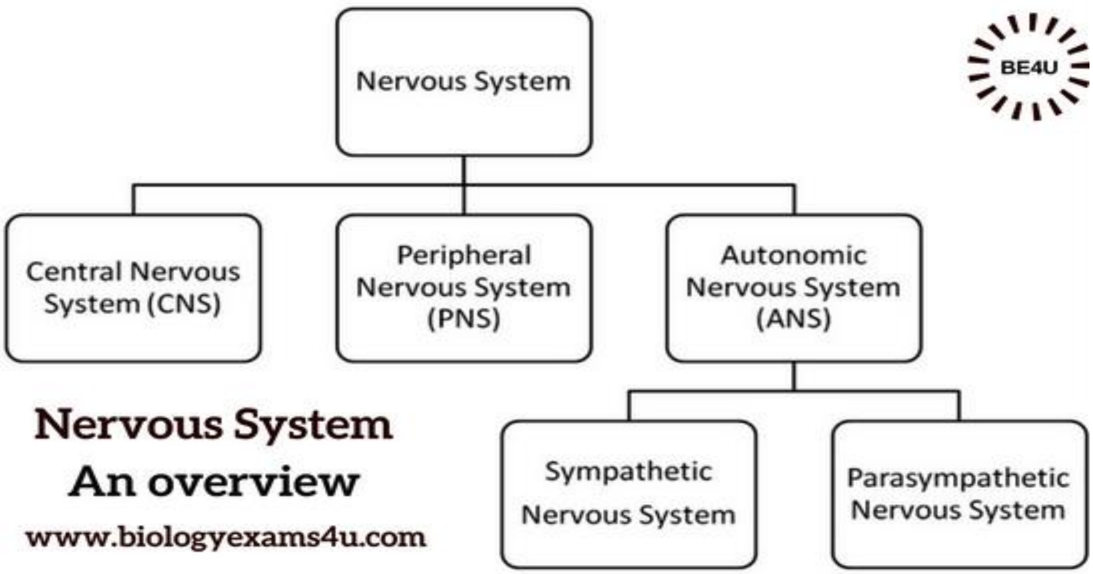
Nervous system of a mammals :

The nervous system of a mammal is based on the brain and the spinal cord, which sends and receive signals from the rest of the body. Signals from the body are sent through nerve endings or receptors to the brain, where neurotransmitters send a signal to allow all mammals to feel pain or other sensory information


Nervous System
Central Nervous System (CNS)
Peripheral Nervous System (PNS)
Autonomic Nervous System (ANS)
Sympathetic Nervous System
Parasympathetic Nervous System
Nervous System An overview
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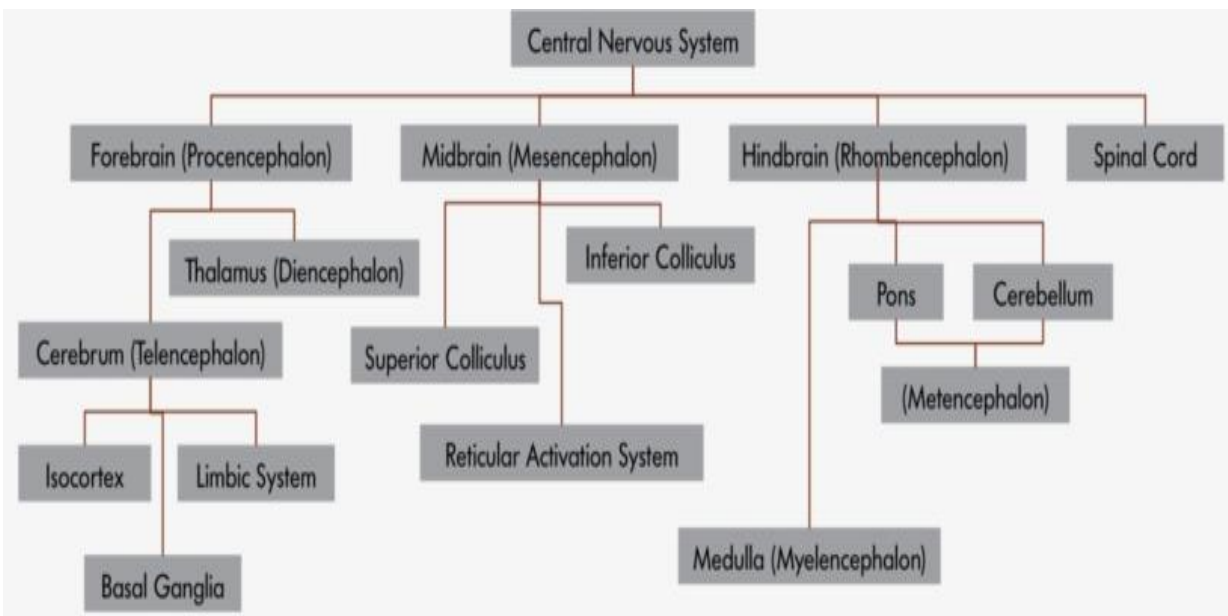
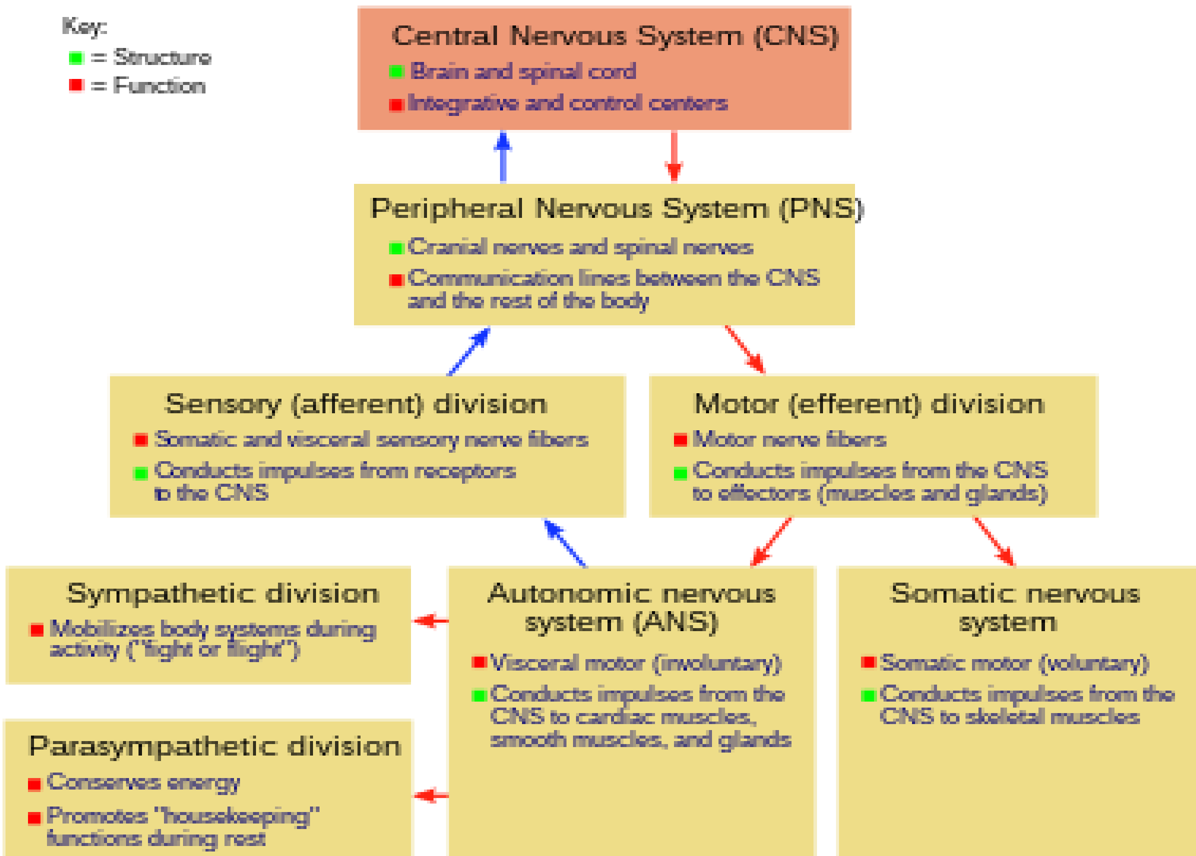

Central Nervous System
Forebrain (Procencephalon)
Midbrain (Mesencephalon)
Hindbrain (Rhombencephalon)
Spinal Cord
Thalamus (Diencephalon)
Inferior Colliculus
Pons
Cerebellum
Cerebrum (Telencephalon)
Superior Colliculus
(Metencephalon)
Isocortex
Limbic System
Reticular Activation System
Basal Ganglia
Medulla (Myelencephalon)



The nervous system of mammals including human beings consists of three main systems-

1. **Central nervous system (CNS) :**

   CNS forms Brains and Spinal card.

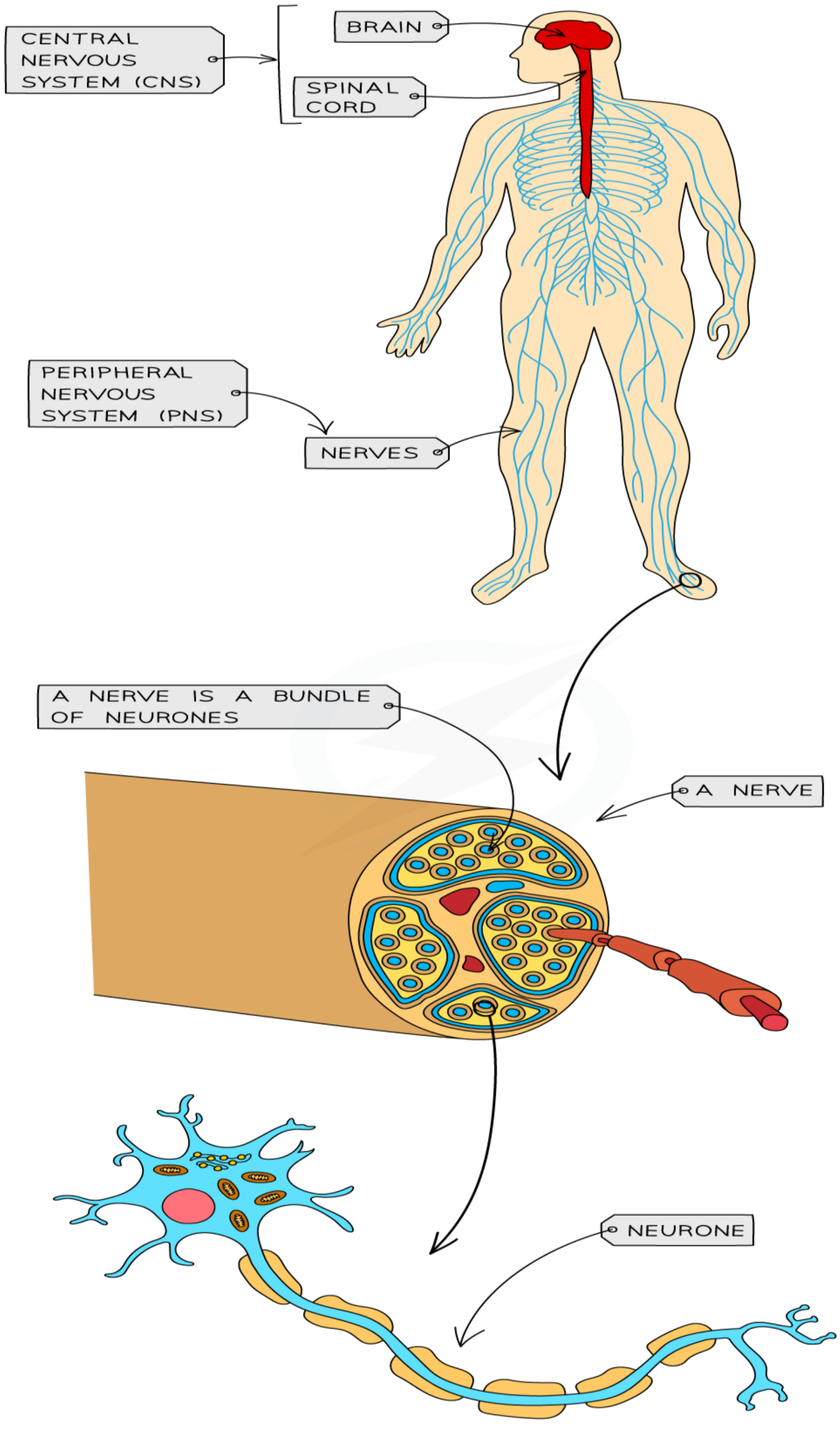
2. **Peripheral nervous system (PNS) :**

   Cranial nerves and spinal nerves.

3. **Autonomic nervous system (ANS) :**

   Sympathetic nerves and parasympathetic nerves.

In embryonic condition this system is derived from neuroectodermal cells such as Neuroblasts and spongioblosts or neuroglial cells in which neruoblasts cells are form apolar, unipolar, bipolar and multipolar neurons while spongioblasts cells performs functions of support and protection.

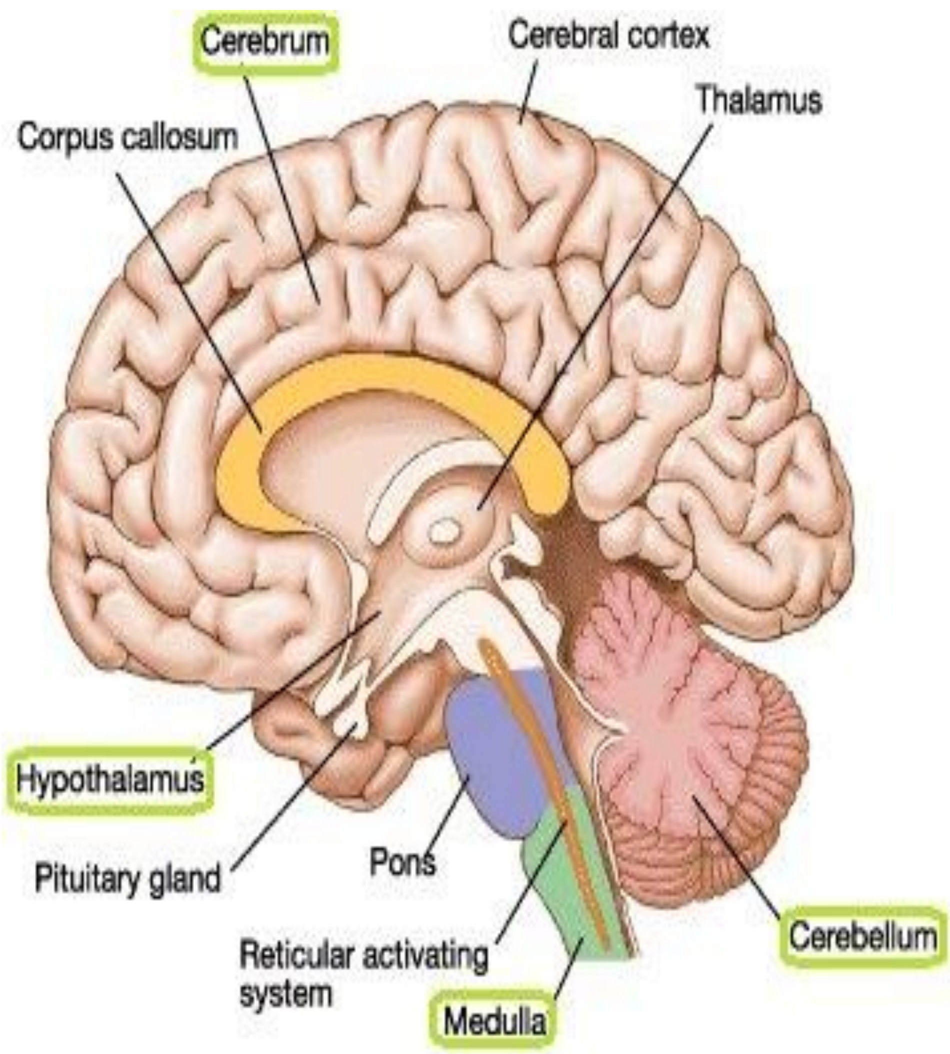

CENTRAL NERVOUS SYSTEM (CNS)
BRAIN
SPINAL CORD
PERIPHERAL NERVOUS SYSTEM (PNS)
NERVES
A NERVE IS A BUNDLE OF NEURONES
A NERVE
NEURONE

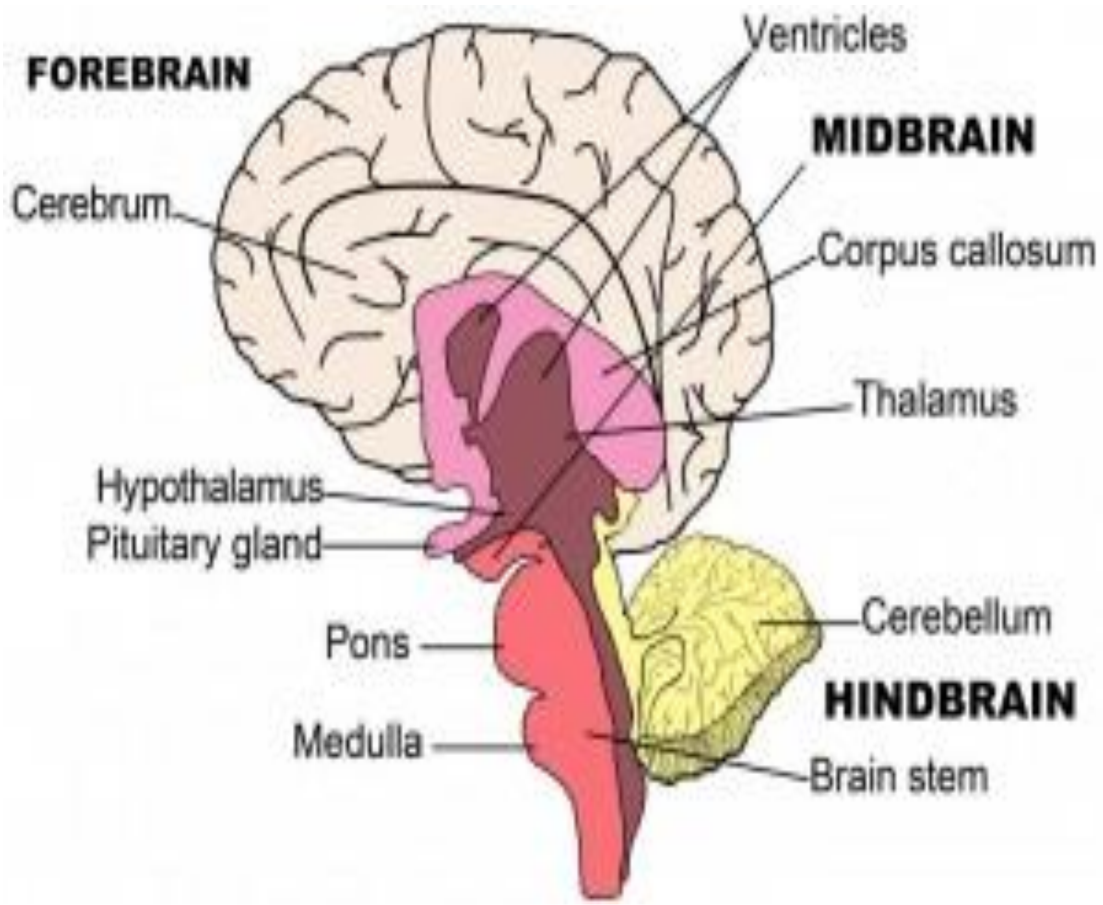
The brain and spinal cord are protected by a membrane known as **meanings (menix).**

- Cyclostomes have one menix & fishes have one menix.
- Amphibians and Reptiles and Birds have two menix an outer Duramater and Inner Piamater.
- In mammals three menix outer duramater, arachnoid and piamater.

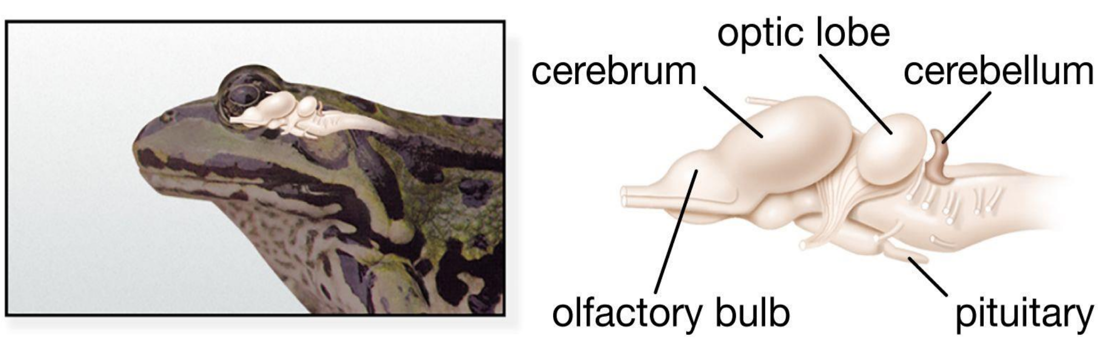
Brain :

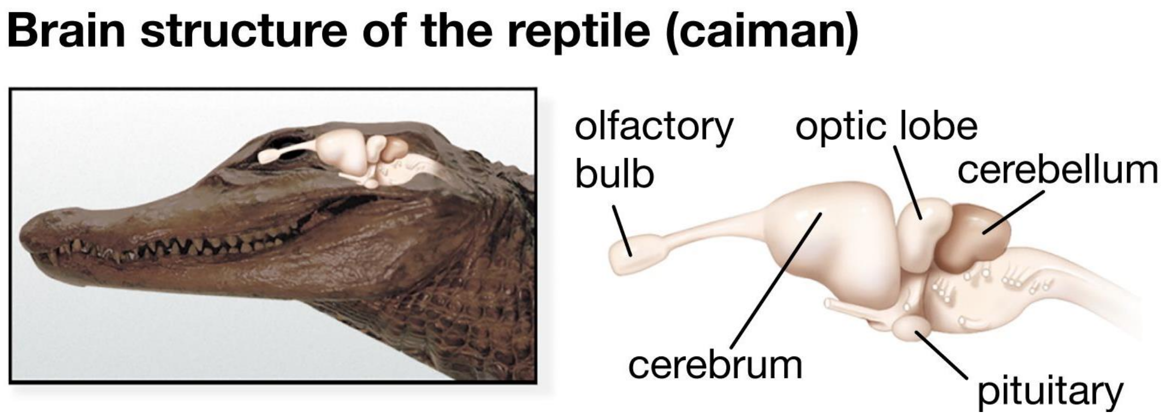
The **brain** has several key parts: the **medulla oblongata**, the **cerebellum**, the **cerebrum** and the **hypothalamus**.

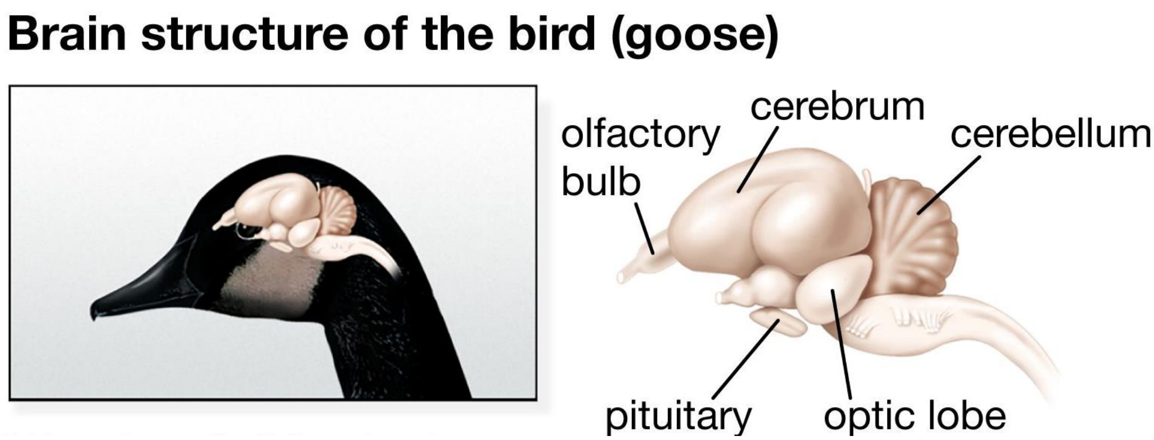




Brain structure of the amphibian (frog)







1. **Hypothalamus**

The **hypothalamus** includes the anterior **pituitary gland**, the master gland which secretes different hormones key in **metabolism** and

2.Medulla :

It is situated in the posterior cranial fossa. It is integrated autonomic reflex centre for coughing, sneezing, gagging, swallowing, vomiting and also controls circulation of heart and lungs.

3.Pons :

It is situated in front and above the medulla with various nuclei and tracts. It appears anteriorly as a bulging mass of transverse fibers and is separated from cerebellum posteriorly by IV ventricle. It take part in regulation of respiration.

4.Cerebellum :

The **cerebrum** is the uppermost part of the brain that contains many different *lobes* that control various **voluntary** functions such as **speech, movement and thought**. Cerebellum attached to the central nervous system by three peduncle, superior, middle and inferior in just above and behind the medulla. It is related with posture and controls movements or volitional.

4.Midbrain :

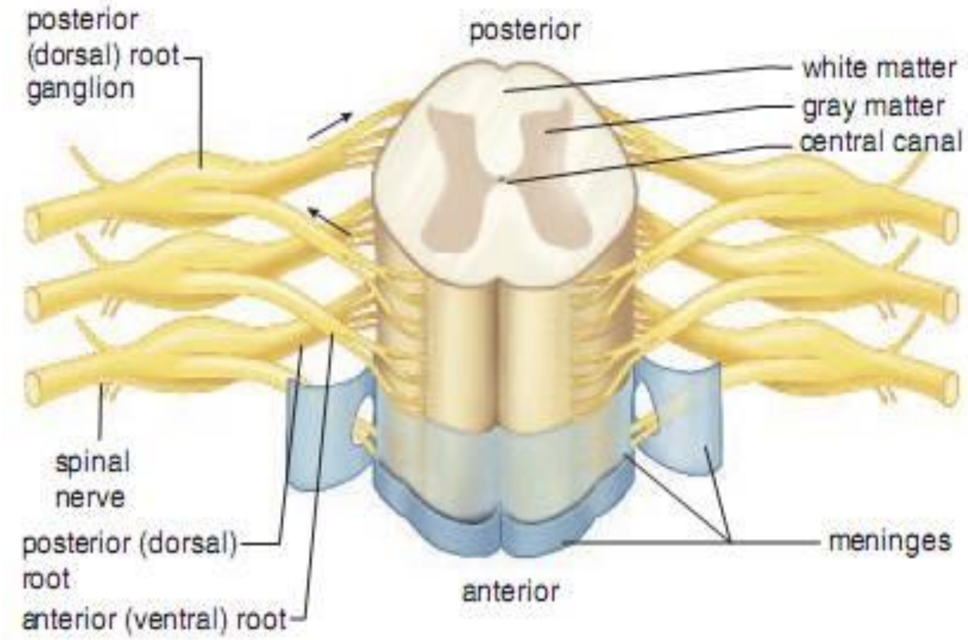
It is upward continuation of the brain stem, through it passes the **aqueduct of sylvius**. There are present collections of nerve cells viz superior, colliculus, inferior colliculus. The part ventral to the aqueduct is called cerebral peduncle. The peduncle is divided into two areas by a dark line of nerve cells containing melanin called **Substantia nigra** and ventral area is called **Crustaorpes** and dorsal are is called **Tegmentum,**

Meninges, Ventricles and Cerebrospinal fluids :

The brain and spinal cord covered by three membranes called meninges, these are duramater, arachnoidmater and piamater under the arachnoidmater there is subarachnoid space containing cerebrospinal fluid. The interior of nervous system is hollowed out by four cavities and two canals filled with cerebrospinal fluid. One cavity called the **Third ventricle**, which opens by foramen of monro. The 3rd ventricle continues to the 4th ventricle which continued downwards as the central canal of spinal cord. The roof of 4th ventricle has 3 perforations one central called Foramen of Magendie and two forament of Luschko.

Spinal cord :

The **spinal cord** consists of a central **canal** filled with cerebrospinal fluid, and **grey** (**H shape**) **and white matter**. Nerves connect to the cord, while the **meninges** act to protect the cord (along side the brain). Spinal cord being surrounded by loosely within the vertebral covering lies and is extended from foramen magnum as far down as interspace between 12th thoracic segment and lower border of Ist lumber vertebra.



The spinal cord is mostly cylindrical in shape and is flattened anterio-posteriorly. It has got two swelling, one in cervical-6, lumber-3 of the spinal cord. Spinal cord has 31 pairs of nerves in which-

08- pairs cervical

12- pairs thorasic

05- pairs lumber

05- pairs of sacral

01-pairs coceygeal nerves.

The nervous system of higher vertebrates (the group that includes humans) is a widely-distributed communication and processing network that serves controlling functions over other organ systems. It possesses a key function in the orientation of the individual; controls its behavior, motor function, and sensory processing; and contains mechanisms to store information. A classification of the nervous system can be performed under different aspects. The anatomical compartmentalization of its components defines the classical approach. Two major divisions of the nervous system are the central nervous system (CNS) and the peripheral nervous system (PNS).

Central Nervous System :

The vertebrate central nervous system (CNS) contains the brain and the spinal cord. The brain contains structurally- and functionally-defined regions. In mammals, these include the cortex (which can be broken down into four primary functional lobes: frontal, temporal, occipital, and parietal), basal ganglia, thalamus, hypothalamus, limbic system, cerebellum, and brainstem; although structures in some of these designations overlap. While functions may be primarily localized to one structure in the brain, most complex functions, such as language and sleep, involve neurons in multiple brain regions. The spinal cord is the information superhighway, connecting the brain with the rest of the body through the peripheral nerves. It transmits sensory and motor input and also controls motor reflexes.

The CNS is covered with three layers of protective coverings called meninges (from the Greek word for membrane). The outermost layer is the dura mater (Latin for "hard mother"). As the Latin name suggests, the primary function for this thick layer is to protect the brain and spinal cord. The dura mater also contains vein-like structures that carry blood from the brain back to the heart. The middle layer is the web-like arachnoid mater. The last layer is the piamater (Latin for "soft mother"), which directly contacts and covers the brain and spinal cord like plastic wrap. The space between the arachnoid and pia maters is filled with cerebrospinal fluid (CSF). CSF is produced by a tissue called the choroid plexus in fluid-filled compartments in the CNS called ventricles. The brain floats in CSF, which acts as a cushion and shock absorber, making the brain neutrally buoyant. CSF also functions to circulate chemical substances throughout the brain and into the spinal cord.

Peripheral Nervous System

The peripheral nervous system consists of nerves that are connected to the brain (cranial nerves) and nerves that are connected to the spinal cord (spinal nerves). The main function of the PNS is to connect the central nervous system (CNS) to the limbs and organs, essentially serving as a communication relay between the brain and the extremities. Unlike the CNS, the PNS is not protected by the bone of spine and skull. Nor does it have a barrier between itself and the blood, leaving it exposed to toxins and mechanical injuries.

Autonomic Nervous System :

The autonomic nervous system, also part of the peripheral nervous system, controls internal body functions that are not under conscious control. For example, when a prey animal is chased by a predator, the autonomic nervous system automatically increases the rate of breathing and the heartbeat. It dilates the blood vessels that carry blood to the muscles, releases glucose from the liver, and makes other adjustments to provide for the sudden increase in activity. When the animal has escaped and is safe once again, the nervous system slows down all these processes and resumes all the normal body activities, such as the digestion of food.

The Nervous system :

The nervous system is a network of neurons whose main feature is to generate, modulate and transmit information between all the different parts of the human body. This property enables many important functions of the nervous system, such as regulation of vital body functions (heartbeat, breathing, digestion), sensation and body movements.

Ultimately, the nervous system structures preside over everything that makes us human; our consciousness, cognition, behaviour and memories.

The nervous system is composed of nervous tissues 1- Nerve cells or neurons 2- The neuroglea.

Neuron or Nerve cell :

Neurons, or nerve cell, are the main structural and functional units of the nervous system. Every neuron consists of a body (soma) and a number of processes (neurites). The nerve cell body contains the cellular organelles and is where neural impulses (action potentials) are generated. The processes stem from the body, they connect neurons with each other and with other body cells, enabling the flow of neural impulses. There are two types of neural processes that differ in structure and function;

The structural and functional unit of nervous system is the neurons. A neuron consists of three distinct portions.

1. **Cell body or cyton or Perikaryon.**
2. **Axon.**
3. **Dendrites or Dendron**.

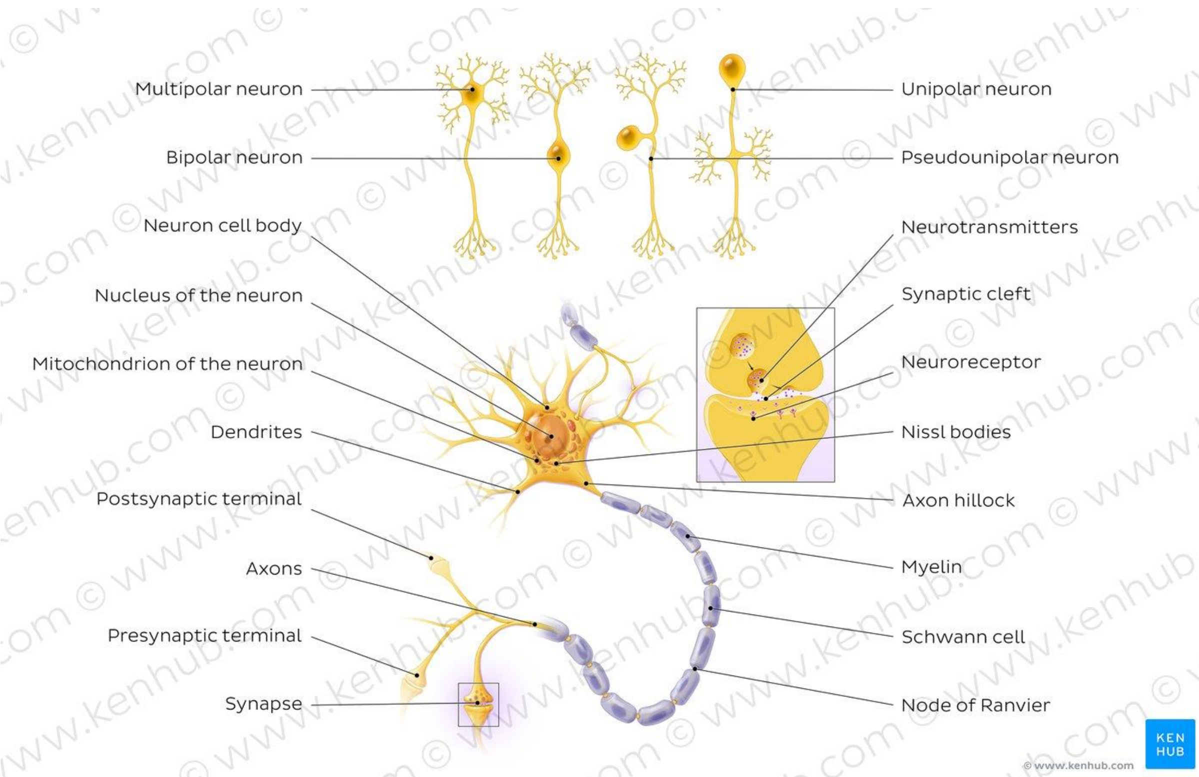
1. Cell Body or Cyton or Perikaryon : The functional part of neuron is consists of a button like structure called cellular body or cyton having nucleus, nucleolus and granular cytoplasm as well as mitochondria, golgi bodies and granular portions Nissil's granules concerns with synthesis of new cytoplasm. The cell body or nerve cell never multiply and never replaced when damaged in life of animals from each cell body a long fibres like (thread like) process is arises known as axon.

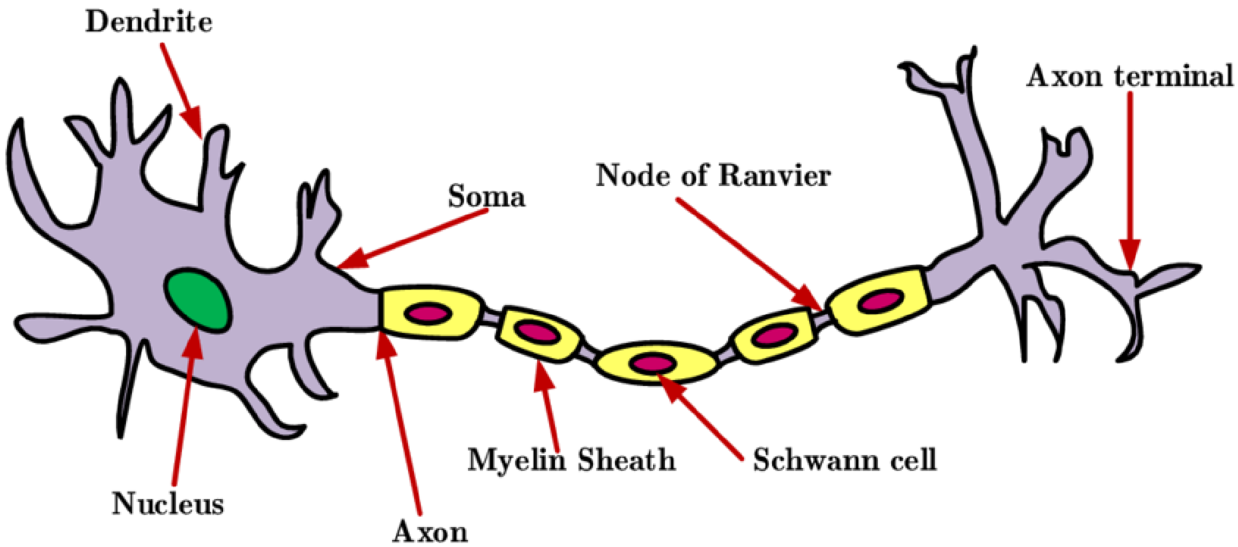
2. Axon :

Axons are long and conduct impulses away from the neuronal body. Axon is arises from cyton body. It is a single highly specialized long process that conducts impulses away from cell body to another neuron, its cytoplasm called axoplasm, contains mitochondria and neurofibrils but no Nissl's body. The plasma membrane of axon is called axolemma. There may be side branches called axon collaterals. The axon and its collaterals terminates by branching into many fine filaments called telodendria. There are several Schwann cell are located along the axon these cells produce the myelin sheath which around the large peripheral axons which are covered by myelinated sheath which insulate and maintain the axon. Each axon bears certain inner depressions at regular distance known as node of Ranvier.

3.Dendrites or Dendron :

Dendrites are short and act to receive impulses from other neurons, conducting the electrical signal towards the nerve cell body. Cell body is projected in the form of certain filamentous structures known as dendrites or Dendron. Dendrites is the process that carries impulses towards the cell body. It collects impulses from other neurons and carries them towards cell body. It is branched and attached to the skin of body.





Structure of Neuron

On the basis of number of process emerging from the cell body, neurons can be following types-

1. **Apolar neuron** : No axon
2. **Unipolar neuro**n : One axon
3. **Bipolar neuron** : Two axon
4. **Pseudopolar neuron** : False dendrites
5. **Multipolar neuron** : Many dendrites on one axon

On the basis of histology neurons are of following types.

1.Medullated or myelinated neurons : The neurons provided with myelin sheath and appears to be white hence known as white neurons.

2.Non-medulated or Unmylinated neurons : The neuron do not contain myelin sheath and appears to be gray called as non-medulated or unmylinated neurons made by gray matter hence named gray neurons.

2. Neuroglia : Neuroglia is a special type of tissue present both in the gray and white matter. According to the shape, size and number of processes, three main types of neuroglia are recognized.

1.Astrocytes : The astrocytes are ectodermal in origin and are of two types **(a) Protoplasmic astrocyte (b) Fibrous astrocytes.**

2.Digodendroglia or digodendrocytes : The oligodendrocytes are also ectodermal in origin.

3.Microglia : Microglia is mesodermal in origin.

Functions : Neuroglia of nervous system performs following functions.

1.Support.

2.Perform insulation process.

3.Under pathological conditions microglia becomes amoeboid and phagocytic and wander in meanings and blood vessels in CNS.

4.The digodendroglia take part in formation of myelin sheath of nerve fibers.

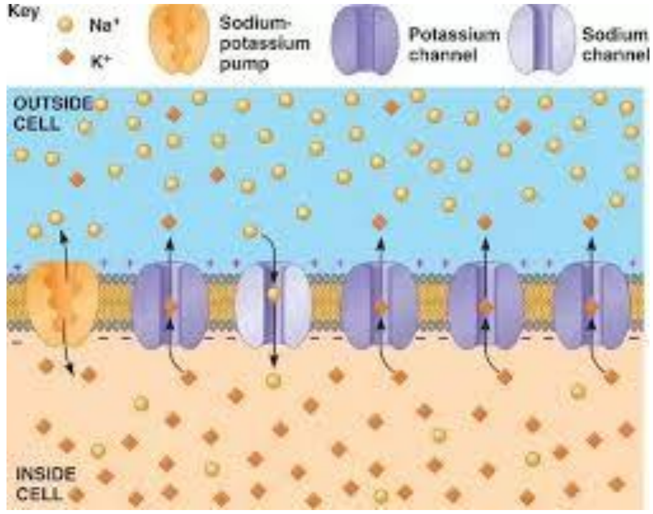
Nerve Impulse :

The nerve impulse was explained by Prosser. According to Prosser impulse is the sum total of mechanical, chemical or electrical distribution created by a stimulus in a neuron.

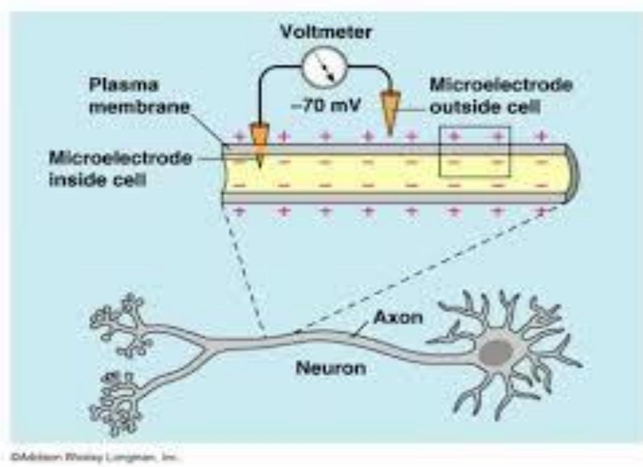
Every neuron of nervous system develops nerve impulse and shows two periods or state i.e. Resting potential and Action potential through which nerve impulse or electric current passes to different parts of the body through which animals perform their work.

Resting potential :

The resting potential is that type of state in which nerve are not excited because they are determined by concentration of Na^+ and K^+ ions on neurilemma. So that resting potential is the difference between the two electrodes and when such a difference exists, the cell is to be polarized. The resting potential is determined by K^+ ions concentration within the cell and outside the cell, which creates internal negativity. The value of resting potential is usually about -70 mv to – 90 mv. The membrane at this stage is said to be polarized.



Resting state of neuron (+tively charged)



Action potential :

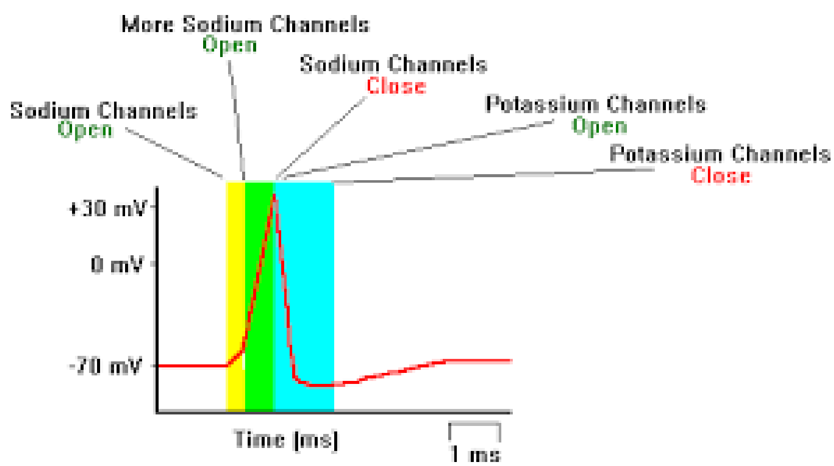
In physiology, an action potential occurs when the membrane potential of specific axon location rapidly rises and fall. This depolarization then causes adjacent locations to similarly depolarize.

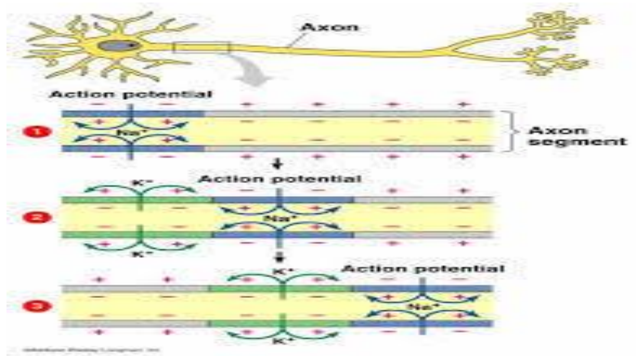
Actually action potential are caused when different ions cross the neuron membrane. A stimulus first causes Sodium (Na^+) channels to open. Because there are many more Na^+ ions on the outside and the inside of the neuron is negative relative to outside, Sodium (Na^+) ions rush into the neurons. Or

An action potential (Nerve impulse) travels down an axon there is a change in polarity across the membrane of the axon. In response to a signal from another neuron, Sodium (Na^+) and Potassium (K^+) gated ion channels open and close as the membrane reaches its threshold potential.

In resting state the nerve fibers remain in polarized state and the membrane potential lies with in -90mv. The inside the nerve is negative and outside of the nerve is positive. The concentration of Na^+ is about 10 times greater outside than inside, whereas concentration of K^+ is about 30 times greater inside than outside. During resting stage the membrane is permeable for K^+ ion and impermeable for Na^+ ion. In this state Ca^{++} ions works as cementing the pores of protein surface of membrane which not allow Na^+ permeability.

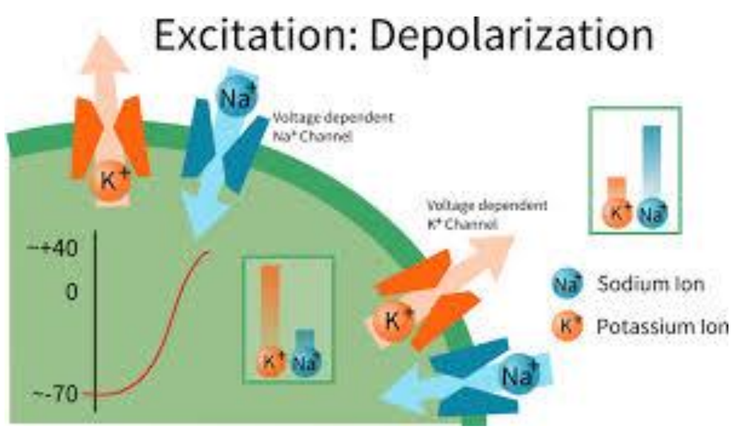
During excitation when membrane potential increases from -90 mv to -70mv then Ca++ ion is dislodged from its binding site and the permeability of Na+ is increased which conduct the Na+ ions. Due to this reversal of potential is caused with the development of positive charge (+++) inside and negative charge (---) outside.

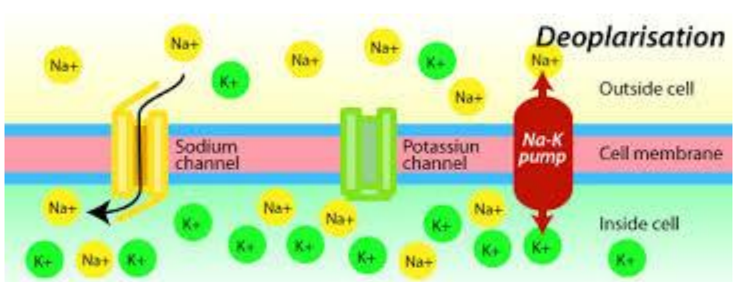




Action potential attains the voltage approximately +40 mv. So the membrane is completely depolarized. But during repolarization when action potential reduces from + 40 mv to +20 mv membrane is completely depolarized, the movement of K^+ begins from inside to outside the membrane. The inside becomes Negative (-) and outside becomes positive (+) again.

For the active Na^+ and K^+ pump mechanism high energy phosphate (ATP) is required. In this way resting normal ionic states is established during the period of positive after potential.





Action potential occurs in several types of animal cells called excitable cells which includes neurons, muscle cells and endocrine cells as well as in some plant cells. In neurons action potential play a central role in cell to cell communication by providing for (or assisting in , with regard to salutatory conduction) the propagation of signals along the neurons axon towards buttons (cyton) at the axon ends which can then connected with other neurons at synapses or to motor cells or glands.

In other type of cells, their main function is active intracellular processes. In muscle cells e.g. an action potential is the first step in the chain of events leading to contraction. In beta cells of pancreas, they provoke release of insulin. The action potential in neurons are also known as nerve impulse or spikes and temporal sequence of action potential generated by a neuron is called its **"Spiketrain".** So that a neuron that emits an action potential is often called to be **"Fire".**

Chemical Neurotransmiters :

(1) **Acetylcholine :** It is excitatory neurotransmitter released by major portion of CNS. It lowers the membrane potential of post synaptic neurons by increasing permeability of Na+. As long as acetylcholine is present at synapse. It stimulates post synaptic neurons. An enzyme cholinesterase or acetylcholinesterase is released into synaptic cleft to inactivate acetylcholine within 1/500 second. It is suppose to be neurotransmitter.

$$\textbf{Acetylcholine} \xrightarrow[\textbf{Co-A}]{\textbf{Cholinesterase}} \textbf{Acetyl Co-A + Choline}$$

(2) **Nor epinephrine, nor adrenaline or sympothin :** It is also a major excitatory transmitter agent in the post ganglionic sympathetic neurons and parts of CNS.

(3) **Dopamine :** It is the immediate precursor of nor epinephrine.

(4) **Serotonin :** Present in higher concentration in hypothalamus, basal ganglia and spinal cord.
(5) **Glutamic acid :** It has powerful excitatory effect.
(6) **Gamma aminibytyric acid (GABA) :** It acts as an inhibitory transmitter in the CNS.

Nervous System Disorders

Neurodegenerative Disorders

Alzheimer's disease and Parkinson's disease are both neurodegenerative disorders characterized by loss of nervous system functioning.

Neurodegenerative Disorders

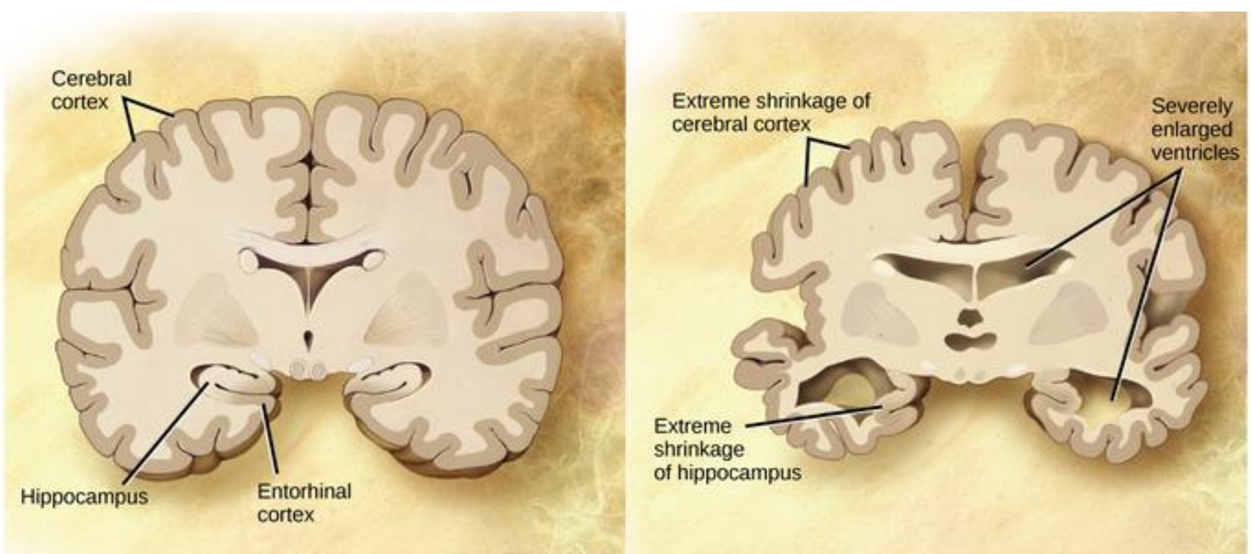
Neurodegenerative disorders are illnesses characterized by a loss of nervous system functioning that are usually caused by neuronal death. These diseases generally worsen over time as more and more neurons die. The symptoms of a particular neurodegenerative disease are related to where in the nervous system the death of neurons occurs. Spinocerebellar ataxia, for example, leads to neuronal death in the cerebellum. The death of these neurons causes problems in balance and walking. Neurodegenerative disorders include Huntington's disease, amyotrophic lateral sclerosis (ALS), Alzheimer's disease, other dementia disorders, and Parkinson's disease. In this section, Alzheimer's and Parkinson's disease will be discussed in more depth.

Alzheimer's Disease

Alzheimer's disease is the most common cause of dementia in the elderly. In 2012, an estimated 5.4 million Americans suffered from Alzheimer's disease. Payments for their care are estimated at $200 billion. Roughly one in every eight people age 65 or older has the disease. Due to the aging of the baby-boomer generation, there are projected to be as many as 13 million Alzheimer's patients in the United States in the year 2050.

Symptoms of Alzheimer's disease include disruptive memory loss, confusion about time or place, difficulty planning or executing tasks, poor judgement, and personality changes. Problems smelling certain scents can also be indicative of Alzheimer's disease and may serve as an early warning sign. Many of these symptoms are also common in people who are aging normally, so it is the severity and longevity of the symptoms that determine whether a person is suffering from Alzheimer's.

Alzheimer's disease was named for Alois Alzheimer, a German psychiatrist who published a report in 1911 about a woman who showed severe dementia symptoms. Along with his colleagues, he examined the woman's brain following her death and reported the presence of abnormal clumps, which are now called amyloid plaques, along with tangled brain fibers called neurofibrillary tangles. Amyloid plaques, neurofibrillary tangles, and an overall shrinking of brain volume are commonly seen in the brains of Alzheimer's patients. Loss of neurons in the hippocampus is especially severe in advanced Alzheimer's patients. Many research groups are examining the causes of these hallmarks of the disease.



Alzheimer's disease: Compared to a normal brain (left), the brain from a patient with Alzheimer's disease (right) shows a dramatic neurodegeneration, particularly within the ventricles and hippocampus.

One form of the disease is usually caused by mutations in one of three known genes. This rare form of early-onset Alzheimer's disease affects fewer than five percent of patients with the disease and causes dementia beginning between the ages of 30 and 60. The more prevalent, late-onset form of the disease probably also has a genetic component. One particular gene, apolipoprotein E (APOE) has a variant (E4) that increases a carrier 's probability of developing the disease. Many other genes have been identified that may be involved in the pathology.

Unfortunately, there is no cure for Alzheimer's disease. Current treatments focus on managing the symptoms of the disease. Because decrease in the activity of cholinergic neurons (neurons that use the neurotransmitter acetylcholine) is common in Alzheimer's disease, several drugs used to treat the disease work by increasing acetylcholine neurotransmission, often by inhibiting the enzyme that breaks down acetylcholine in the synaptic cleft. Other clinical interventions focus on behavioral therapies such as psychotherapy, sensory therapy, and cognitive exercises. Since Alzheimer's disease appears to hijack the normal aging process, research into prevention is prevalent.

Parkinson's Disease

Parkinson's disease is also a neurodegenerative disease. It was first characterized by James Parkinson in 1817. Each year, 50,000-60,000 people in the United States are diagnosed with the disease. Parkinson's disease causes the loss of dopamine neurons in the substantia nigra, a midbrain structure that regulates movement. Loss of these neurons causes many symptoms including tremor (shaking of fingers or a limb), slowed movement, speech changes, balance and posture problems, and rigid muscles. The combination of these symptoms often causes a characteristic slow, hunched, shuffling walk. Patients with Parkinson's disease can also exhibit psychological symptoms, such as dementia or emotional problems.

Although some patients have a form of the disease known to be caused by a single mutation, for most patients, the exact causes of Parkinson’s disease remain unknown. The disease probably results from a combination of genetic and environmental factors, similar to Alzheimer’s disease. Post-mortem analysis of brains from Parkinson’s patients shows the presence of Lewy bodies, abnormal protein clumps, in dopaminergic neurons. The prevalence of these Lewy bodies often correlates with the severity of the disease.

There is no cure for Parkinson’s disease; treatment is focused on easing symptoms. One of the most-commonly prescribed drugs for Parkinson’s is L-DOPA, which is a chemical that is converted into dopamine by neurons in the brain. This conversion increases the overall level of dopamine neurotransmission and can help compensate for the loss of dopaminergic neurons in the substantia nigra. Other drugs work by inhibiting the enzyme that breaks down dopamine.

Parkinson’s disease: Parkinson’s patients often have a characteristic hunched walk. The disease is likely the result of a combination of genetic and environmental factors.

Neurodevelopmental Disorders: Autism and ADHD

Autism and ADHD are neurodevelopmental disorders that arise when nervous system development is disrupted.

Neurodevelopmental Disorders

Neurodevelopmental disorders occur when the development of the nervous system is disturbed. There are several different classes of neurodevelopmental disorders. Some, like Down Syndrome, cause intellectual deficits, while others specifically affect communication, learning, or the motor system. Some disorders, such as autism spectrum disorder and attention deficit/hyperactivity disorder, have complex symptoms.

Autism

Autism spectrum disorder (ASD, sometimes just "autism") is a neurodevelopmental disorder in which severity differs from person to person. Estimates for the prevalence of the disorder have changed rapidly in the past few decades. Current estimates suggest that one in 88 children will develop the disorder. ASD is four times more prevalent in males than females.

A characteristic symptom of ASD is impaired social skills. Children with autism may have difficulty making and maintaining eye contact and reading social cues. They also may have problems feeling empathy for others. Other symptoms of ASD include repetitive motor behaviors (such as rocking back and forth), preoccupation with specific subjects, strict adherence to certain rituals, and unusual language use. Up to 30 percent of patients with ASD develop epilepsy. Patients with some forms of the disorder (e.g., Fragile X syndrome) also have intellectual disability. Because it is a spectrum disorder, other ASD patients are very functional and have good-to-excellent language skills. Many of these patients do not feel that they suffer from a disorder and instead just believe that they process information differently.

Except for some well-characterized, clearly-genetic forms of autism (e.g., Fragile X and Rett Syndrome), the causes of ASD are largely unknown. Variants of several genes correlate with the presence of ASD, but for any given patient, many different mutations in different genes may be required for the disease to develop. At a general level, ASD is thought to be a disease of "incorrect" wiring. Accordingly, brains of some ASD patients lack the same level of synaptic pruning that occurs in non-affected people. There has been some unsubstantiated controversy linking vaccinations and autism. In the 1990s, a research paper linked autism to a common vaccine given to children. This paper was retracted when it was discovered that the author falsified data; follow-up studies showed no connection between vaccines and autism.

Treatment for autism usually combines behavioral therapies and interventions, along with medications to treat other disorders common to people with autism (depression, anxiety, obsessive compulsive disorder). Although early interventions can help mitigate the effects of the disease, there is currently no cure for ASD.

Attention Deficit Hyperactivity Disorder (ADHD)

Approximately three to five percent of children and adults are affected by attention deficit/hyperactivity disorder (ADHD). Like ASD, ADHD is more prevalent in males than females. Symptoms of the disorder include inattention (lack of focus), executive functioning difficulties, impulsivity, and hyperactivity beyond what is characteristic of the normal developmental stage. Some patients do not have the hyperactive component of symptoms and are diagnosed with a subtype of ADHD: attention deficit disorder (ADD). Many people with ADHD also show comorbidity: they develop secondary disorders in addition to ADHD. Examples include depression or obsessive compulsive disorder (OCD).

Comorbidity with ADHD: Many people with ADHD have one or more other psychological or neurological disorders.

The cause of ADHD is unknown, although research points to a delay and dysfunction in the development of the prefrontal cortex and disturbances in neurotransmission. According to some twin studies, the disorder has a strong genetic component. There are several candidate genes that may contribute to the disorder, but no definitive links have been discovered. Environmental factors, including exposure to certain pesticides, may also contribute to the development of ADHD in some patients. Treatment for ADHD often involves behavioral therapies and the prescription of stimulant medications, which, paradoxically, cause a calming effect in these patients.

Neurodevelopmental Disorders: Mental Illnesses

Schizophrenia and depression are just two examples of mental illnesses caused by a disorder of the nervous system.

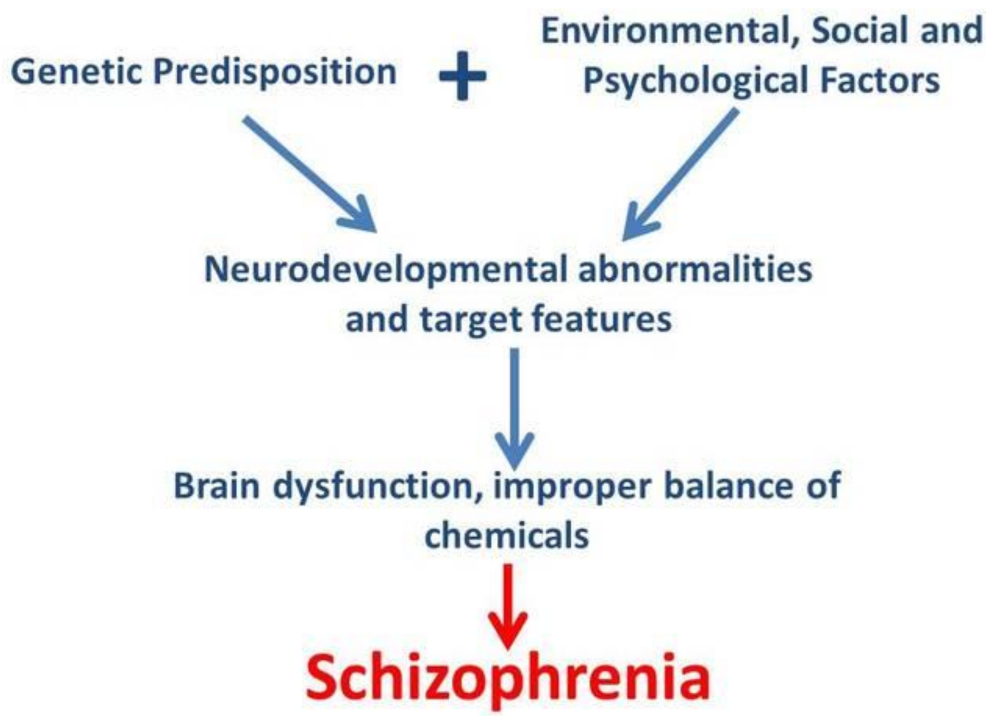
Neurodevelopmental Disorders and Mental Illness

Mental illnesses are nervous system disorders that result in problems with thinking, mood, or relating with other people. These disorders are severe enough to affect a person's quality of life and often make it difficult for people to perform the routine tasks of daily living. Debilitating mental disorders plague approximately 12.5 million Americans (about 1 in 17 people) at an annual cost of more than $300 billion. There are several types of mental disorders including schizophrenia, major depression, bipolar disorder, anxiety disorders, post-traumatic stress disorder, and many others. The American Psychiatric Association publishes the Diagnostic and Statistical Manual of Mental Disorders (or DSM), which describes the symptoms required for a patient to be diagnosed with a particular mental disorder. Each newly-released version of the DSM contains different symptoms and classifications as researchers learn more about these disorders, their causes, and how they relate to each other. A more detailed discussion of two mental illnesses, schizophrenia and major depression, is given below.

Schizophrenia

Schizophrenia is a serious and often-debilitating mental illness affecting one percent of the population in the United States. Symptoms of the disease include the inability to differentiate between reality and imagination, inappropriate and unregulated emotional responses, difficulty thinking, and problems with social situations. Symptoms of schizophrenia may be characterized as either “negative” (deficit symptoms) or “positive”. Positive symptoms are those that most individuals do not normally experience, but are present in people with schizophrenia. They can include delusions, disordered thoughts and speech, and tactile, auditory, visual, olfactory and gustatory hallucinations, typically regarded as manifestations of psychosis. Negative symptoms are deficits of normal emotional responses or of other thought processes, and commonly include flat or blunted affect and emotion, poverty of speech, inability to experience pleasure, lack of desire to form relationships, and lack of motivation.

Many schizophrenic patients are diagnosed in their late adolescence or early 20s. The development of schizophrenia is thought to involve malfunctioning dopaminergic neurons and may also involve problems with glutamate signaling. Treatment for the disease usually requires anti-psychotic medications that work by blocking dopamine receptors and decreasing dopamine neurotransmission in the brain. This decrease in dopamine can cause Parkinson's disease-like symptoms in some patients. While some classes of anti-psychotics can be quite effective at treating the disease, they are not a cure; most patients must remain medicated for the rest of their lives.



Schizophrenia: The development of schizophrenia is thought to be caused by malfunctioning dopaminergic neurons, which causes brain dysfunction and an imbalance of chemicals in the brain.

Depression

Major depression (also referred to as just "depression" or "major depressive disorder") affects approximately 6.7 percent of the adults in the United States each year and is one of the most common mental disorders. To be diagnosed with major depressive disorder, a person must have experienced a severely-depressed mood lasting longer than two weeks along with other symptoms that may include a loss of enjoyment in activities that were previously enjoyed, changes in appetite and sleep schedules, difficulty concentrating, feelings of worthlessness, and suicidal thoughts. The exact causes of major depression are unknown and probably include both genetic and environmental risk factors. Some research supports the “classic monoamine hypothesis,” which suggests that depression is caused by a decrease in norepinephrine and serotonin neurotransmission. One argument against this hypothesis is the fact that some antidepressant medications cause an increase in norepinephrine and serotonin release within a few hours of beginning treatment, but clinical results of these medications are not seen until weeks later. This has led to alternative hypotheses. For example, dopamine may also be decreased in depressed patients, or it may actually be an increase in norepinephrine and serotonin that causes the disease, and antidepressants force a feedback loop that decreases this release.

Treatments for depression include psychotherapy, electroconvulsive therapy, deep-brain stimulation, and prescription medications. Most commonly, individuals undergo some combination of psychotherapy and medication. There are several classes of antidepressant medications that work through different mechanisms. For example, monoamine oxidase inhibitors (MAO inhibitors) block the enzyme that degrades many neurotransmitters (including dopamine, serotonin, norepinephrine), resulting in increased neurotransmitter in the synaptic cleft. Selective serotonin reuptake inhibitors (SSRIs) block the reuptake of serotonin into the presynaptic neuron. This blockage results in an increase in serotonin in the synaptic cleft. Other types of drugs, such as norepinephrine-dopamine reuptake inhibitors and norepinephrine-serotonin reuptake inhibitors, are also used to treat depression.

Other Neurological Disorders

Epilepsy and stroke are examples of neurological disorders that arise from malfunctions in the nervous system.

Other Neurological Disorders

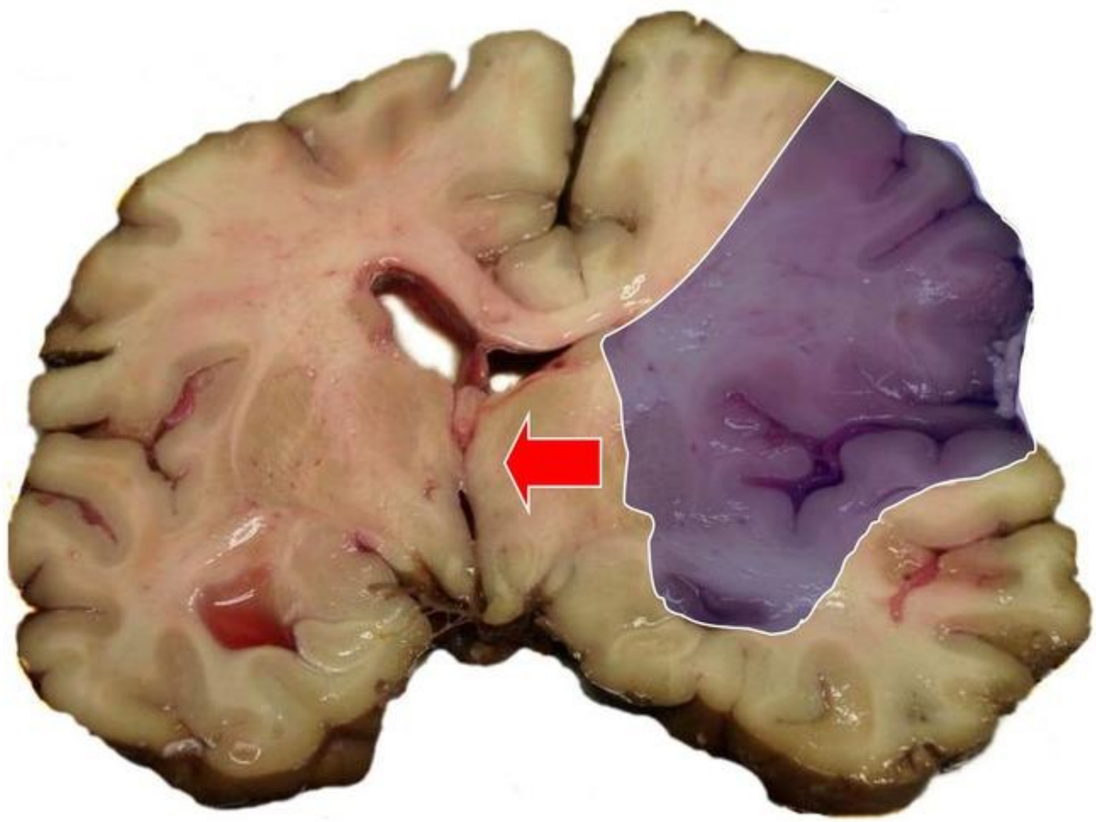
There are several other neurological disorders that cannot be easily placed into clean-cut categories. These include chronic pain conditions, cancers of the nervous system, epilepsy disorders, and stroke. Epilepsy and stroke are discussed below.

Epilepsy

Estimates suggest that up to three percent of people in the United States will be diagnosed with epilepsy in their lifetime. While there are several different types of epilepsy, all are characterized by recurrent seizures. Epilepsy itself can be a symptom of a brain injury, disease, or other illness. For example, people who have intellectual disability or autism spectrum disorder can experience seizures, presumably because the developmental wiring malfunctions that caused their disorders also put them at risk for epilepsy. For many patients, however, the cause of their epilepsy is never identified and is probably a combination of genetic and environmental factors. Often, seizures can be controlled with anti-convulsant medications. However, for very severe cases, patients may undergo brain surgery to remove the brain area where seizures originate.

Stroke

A stroke results when blood fails to reach a portion of the brain for a long enough time to cause damage. Without the oxygen supplied by blood flow, neurons in this brain region die. This neuronal death can cause many different symptoms, depending on the brain area affected, including headache, muscle weakness or paralysis, speech disturbances, sensory problems, memory loss, and confusion. Stroke is often caused by blood clots, but can also be caused by the bursting of a weak blood vessel. Strokes are extremely common; they are the third most-common cause of death in the United States. On average one person experiences a stroke every 40 seconds in the United States. Approximately 75 percent of strokes occur in people older than 65. Risk factors for stroke include high blood pressure, diabetes, high cholesterol, and a family history of stroke. Smoking doubles the risk of stroke. Treatment following a stroke can include blood pressure medication (to prevent future strokes) and (sometimes intense) physical therapy.



Stroke effects on the brain: A cerebral infarction, shaded in blue, occurs after a stroke when blood fails to reach a portion of the brain long enough to cause damage. The red arrow depicts the midline shift that occurs in the brain, which is also caused by a stroke.

Declaration

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