Introduction :

- Sensing the environmental changes and reacting accordingly are the two vital characteristics of organisms that exist in a dynamic or always changing environment. This is called **irritability.**
- Irritability is poorly developed in organisms with a static mode of life, but well developed in those which are active. In protozoans and sponges, the individual cells are directly exposed to the environment.
- Thus the interactions are at subcellular or cellular level respectively. With the evolution of multi-cellular condition, there is a 'cell differentiation' among the body cells.
- For the maintenance of structural and functional integrity two **'integrative** systems' are developed to transmit coded information from one part of the body to the other.
- They are 1. Nervous system and 2. Endocrine System

NERVOUS SYSTEM :

- This is structurally and functionally a complicated system found only in animals.
- The study of nervous system and receptors is called **Neurology.** In rabbit, nervous system plays three vital roles. 1. Response to stimuli, 2. Coordination, 3.Learning
- For convenience the nervous system is divided into three parts.
  1. Central nervous system (CNS)
  2. Peripheral nervous system (PNS)
  3. Autonomous nervous system (ANS)

CENTRAL NERVOUS SYSTEM

- This **includes a** brain and a **spinal cord and coordinates** the impulses **received from** receptors and transmits to effectors.
- The CNS develops from ectoderm as **middorsal** thickening called **medullary or neural plate. This** middorsal thickening **gradually** transforms **into a neural tube.**
- The anterior end of the neural tube enlarges to become **the brain,** while the remaining part of the neural tube forms the **spinal cord.**
- **Meninges:** The protective membranes around the brain and the spinal cord are called **meninges.** While in cyclostomes and fishes **there** is a single menix called **meninx primitiva.**
- In amphibians, reptiles and birds, there are two meninges. An **outer duramater** and inner **piamater.** The space between these membranes is **subdural space** and is **filled** with **cerebrospinal fluid.**
- In mammals **there** are three meninges, an outer tough membrane called **duramater,** middle **arachnoid membrane** and an inner thin vascular membrane called **piamater.**
- Cerebro spinal fluid is present between arachnoid membrane and piamater.
- Cerebro spinal fluid is secreted from choroids plexus
- Cerebro spinal fluid enters subdural space from 4^{th} ventricle
- The meninges and the cerebrospinal fluid give support to the brain and protect it from shocks.

A. Brain :

- **This is called encephalon.** Brain lies in the **cranium of the** skull and is protected by it. The encephalon is divided into three main parts:
  I. Forebrain or prosencephalon
  II. Mid brain or mesencephalon
  III. Hind brain or rhombencephalon
- These three parts are simple in the early embryonic stages, but later develop additional structures such as **cerebrum, optic lobes, and cerebellum etc.,** as dorsal outgrowths for higher nervous coordination.

I. Fore brain or procencephalon :

- It is the largest part of the brain and includes three parts, (i) two olfactory **lobes**, (ii) two cerebral hemispheres and (iii) a diencephalon.
  i. Olfactory lobes:
- These form the anterior most part of the brain. They are two small club shaped structures projecting in front of the cerebral hemispheres.
- Each olfactory lobe is continued as a narrow olfactory tract beneath the frontal lobe of cerebrum and connected with the hippocampal lobe.
- The cavity is called the **rhinocoel.** They are concerned with the sense of smell.
  ii. Cerebral hemispheres:
- The cerebral hemispheres are large and **overlap** the diencephalon and midbrain. The two cerebral hemispheres are divided by a longitudinal median fissure.
- They are narrow in front, but broad behind, A shallow, oblique **sylvian fissure** divides each hemisphere into a large anteromedian **frontal lobe** and a smaller posterolateral **temporal lobe** and posterio median parietal lobe.

- Ventrally a longitudinal **rhinal fissure** separates the **hippocampal lobe** from olfactory tract. Connecting the two cerebral hemispheres there is a **broad** transverse **band** of nerve tissue, **called corpus callosum.**
- Hippocampal sulcus demarcates the hippocampal lobe from the other lobes on ventral side. It is an important character of placental mammals.
- The surface of cerebral hemispheres is highly folded. These folds are called **gyri** and the depressions between them are known as **sulci**.
- The folds increase the surface area of the cerebrum. The gyri and sulci are absent in rabbit. The roof of cerebrum is very thick and forms the **neopallium.**
- This is the major part of cerebrum. The size and complexity of neopallium is an indication of gradual evolution of intelligence. The cavities of the cerebral hemispheres are **first** and **second ventricles** or **paracoels** or **lateral ventricles**.
- Thick fibrous thickening called **corpus striatum,** bulges into the cavity of each cerebral hemispheres from the floor of frontal lobe.
- The two corpora striata are connected by flat transverse fibrous strip, **the anterior commissure.**
- Cerebral hemispheres are not well developed in lower vertebrates.

iii. Diencephalon:

- This is also called as **thalamencephalon.** Diencephalon is small and narrow posterior part of the fore brain.
- The dorsal wall of diencephalon is thin with the overlying piamater. The roof is highly vascular and irregularly folded. The dorsal wall of diencephalons called **epithalamus** bears **epiphysis** or **pineal body**. This non-nervous vascular roof is called **anterior choroid plexus**.
- The ventral wall of diencephalons is called **hypothalamus**.
- It forms a funnel-like outgrowth called infundibulum that combines with an epithelial outgrowth the **Rathke's pouch** to form a **pituitary gland** or **hypophysis.**
- Infundibulum and hypophysis together form a pituitary body. The dilated ventral wall of the diencephalon behind pituitary is known as **corpus albicans.**
- Two optic nerves lie in front of hypothalamus crossing and form **optic chiasma.**
- The lateral thickened walls of diencephalon are called **optic thalami**. The two optic thalami are connected by a **median commissure**.
- The cavity of the diencephalon is **third ventricle** or **diacoel.**

II. Mid brain or mesencephaton:

- Dorsal part is in the form of two pairs of spherical optic lobes called **corpora quadrigemina.**
- The two large anterior optic lobes are called **superior colliculi** and concerned with the sight, while the smaller posterior lobes are called **inferior colliculi** and concerned with hearing.
- The floor of midbrain is formed by thick tracts of fibres called **crura cerebri** that link the fore and hind brains. The optic lobes are without any cavity.
- The dorsal wall of the two optic lobes are internally connected by a transverse strip called **posterior commissure.**
- The cavity of the midbrain is a narrow longitudinal passage called **iter** or **aqueduct of Sylvius.**

III. Hind brain or Rhombencephalon :

- It is divided into two parts :
  1.Metencephalon, 2. Myelencephalon.

i. Metencephaton :

- Anteroventral part is called **Pons Varolii** and rest is called **cerebellum.**
- **Pons Varolii:** This is a transverse band of nerve fibres. It connects right and left halves of the cerebellum.
- **Cerebellum:** It is well developed and transversely elongated. It consists of a median lobe called **vermis** and two lateral **lobes** each with a ventro lateral **extension** called **flocculus.**
- The surface of the cerebellum is much folded and is formed by grey matter. The white matter ramifies into the grey matter forming branched strips called **arbor vitae**.
- The pons Varolii and cerebellum are without a cavity.

ii. Myelencephalon:

- It is triangular in appearance and is called **medulla oblongata.** It is the last part of the brain. The cavity of medulla oblongata is called **metacoel** or **fourth ventricle**.
- The roof of metacoel is non-nervous and vascular. With the piamatcr it forms **the posterior choroid plexus.**
- **Cavities of the brain:** The brain is hollow within. The cavities are called **ventricles.** The cavity **of the** olfactory lobe is **rhinocoel**.
- This is continuous with the cavity of the cerebral hemispheres called **paracoels** or **lateral ventricle** or **first** and **second ventricles.**

- The two paracoels connect with each other and **open** into 3rd ventricle or **diacoel** through a passage called **Foramen of Monro.**
- Optic lobes and cerebellum are solid. The cavity of the medulla is called **metacoel** or fourth ventricle. It is connected to the diacoel through **aqueduct of Sylvius or iter.**
- **Functions : Olfactory lobes** control the sense of smell. The **cerebral hemispheres** are the seat of thinking, reasoning, memory, intelligence etc., **Diencephalon** controls perception *of* chemicals, temperature, reproduction, metabolism and autonomous nervous system.
- First pair of **optic lobes** are concerned with sense of sight. Second pair is concerned with hearing.

Cerebellum controls and coordinate the voluntary muscular movements.

- **Medulla oblongata** and pons Varolii control the involuntary activities in the body such as digestion, respiration, excretion, circulation etc.

B. The Spinal Cord.

- The medulla oblongata of the brain continues as spinal cord through the **Foramen magnum** of skull. The spinal cord is enclosed in the passage formed by neural canals of successive vertebrae.
- The spinal cord tapers down as non-nervous **Filum terminale,** spinal cord is a sub cylindrical structure, somewhat convex dorsally and flattened ventrally.
- It exhibits **brachial swellings** near the forelimbs and **lumbar swellings** near the hind limbs. A dorsal fissure and a deep ventral sulcus divide the spinal cord into symmetrical right and left longitudinal halves.
- In transverse section, it shows a narrow central canal. The central canal is continuous with the 4th ventricle of the brain.
- The central canal is lined by ependyma and filled with cerebrospinal fluid. The spinal cord has outer white matter made up of medullated nerve fibres, and inner grey matter.
- The grey matter contains cell bodies, dendrites and nonmedulated axons. The grey matter is 'H' shaped or butterfly shaped containing dorsal horns and ventral horns.
- The grey horns divide the white matter into dorsal, lateral and ventral funiculi.
- The fibres of the **dorsal** funiculus are sensory, those of the **ventral** funieulus are motor, and those of the **lateral funiculi** are both sensory and motor. These fibres are connected to the brain.

AUTONOMOUS NERVOUS SYSTEM

- **Autonomous Nervous System** is partly independent and not under voluntary control. This serves as an intermediary through which the central nervous system controls the involuntary activities of the animal.
- It is of two types:
  I. Sympathetic Nervous System
  II. Parasympathetic Nervous System
- **1. Sympathetic Nervous System:** This is also referred to as **thoracolumbar** outflow, because its outflow is by preganglionic fibres of thoracic and lumbar spinal nerves.
- There is a chain of small sympathetic ganglia from neck to the end of abdomen at the lateral sides of dorsal aorta and beneath the **vertebral column.**
- These ganglia on each chain are **two cervical**, superior and inferior cervical, **12 thoracic, six or seven lumbar** and **three or four sacral ganglia**.
- The sympathetic ganglia are connected with **the rami communicans** through preganglionic fibers.
- Next a few anterior thoracic nerves through their preganglionic nerve fibres go the ganglia on the sympathetic chain. The postganglionic nerve fibres from these ganglia innervate heart and lungs.
- Preganglionic nerver fibres in lower thoracic and upper lumber regions join outside the chain to form a **coeliac ganglion**, from their join a **superior mesenteric ganglion**. Post ganglionic nerve fibres innervate stomach, liver, spleen, small intestine and anterior part of large intestine.
- Nerve fibres from sympathetic chain of lumbar region join **hypogastric** or **inferior mesenteric** ganglion, that gives off nerves got posterior part of large intestine, urinary bladder, kidneys and gonads.
- **2. Parasympathetic Nervous System:** This is also called as **craniosacral outflow**. Its outflow is by the preganglionic nerve fibres of III, VII, IX and X cranial nerves and 2nd, 3rd and 4th sacral spinal nerves. The preganglionic fibres join the ganglia, which are close to the organs.
- The III cranial nerve runs to the ciliary ganglion in the orbit and nerve fibres from this supply muscles of iris.
- The parasympathetic fibres from the VII cranial nerve supply to the lacrimal gland, mucous membrane of nasal chamber, sub-maxillary and sub-lingual salivary glands.
- Parasympathetic nerves from IX cranial nerve supply to oral mucosa, parotid gland and otic ganglion. Parasympathetic fibres from X cranial nerve innervate heart, lungs, stomach, liver, pancreas, small intestine and anterior part of large intestine.

- The nerve fibres, of the sacral region unite to form **pelvic ganglion** on each side. The nerve fibres from this ganglion supply to the posterior part of large intestine, urinary bladder, kidney and gonads
- Sympathetic and parasympathetic nerves innervate the same organs, but their effects are usually antagonistic. Hence, it is also called **accelerator and brake system** of the body.
- The nerve endings of sympathetic system produce a substance called sympathin which increases the heart beat, dilates the blood vessels in muscles, constricts peripheral blood vessels thereby increasing the blood pressure, dilates iris of the eye and, bronchi and, inhibits the activities of the gut etc.
- Parasympathetic nerves secrete **acetyl choline.** The secretion slows down heart beat, decreases the blood pressure, constricts the pupil of the eye and bronchi and increases the peristalsis of the gut etc.
- The autonomous nervous system also controls the secretion of exocrine and endocrine glands.
- **Reflex reactions:** Reflex reactions are the simplest responses and basic units of nervous coordination.
- Watering of mouth at the sight of food and blinking of eyes due to sudden appearance of an object are some common examples of **somatic reflex reactions**.
- Reflex reaction is an immediate involuntary response to a stimulus. Reflex responses occur very fast because the responses are without the sensory impulse being carried to brain centre for analysis.
- Thus reflex reactions protect the body against injurious effects of sudden stimuli. The entire impulse circuit of a reflex response is called a reflex are

  Receptor $\rightarrow$ CNS $\rightarrow$ effectors
- Reflexes developed by training and learning are called **conditioned** or **acquired reflexes.**
- e.g. Dancing, cycling etc. Some reflexes like breeding, migration are genetic and are inherited. These are called **unconditioned reflexes.**