UNIT 4. NERVOUS SYSTEM

Introduction

An animal can survive only if its internal environment remains stable. This steady-state condition, called homeostasis, is maintained by control and coordination of the activities of the various cells of the body. Such a control and coordination requires gathering information about changes in the external environment, transmitting this information to the internal cells located away from the surface, and exchange of information between the cells situated away from each other. Three types of control systems have been developed for this purpose.

i) Nervous system: composed of neurons which exercise control by sending electrical signals called nerve impulses.

ii) Endocrine system: consists of specialized glands which bring about control by sending chemical messengers termed hormones.

iii) Immune system. This system protect the body against foreign materials by forming antibodies.

Functions of Nervous systems.

The nervous system serves four important functions.

i) It controls and coordinates the working of all the parts of the body.

ii) It recieves sensory impulses from the sense organs, analyses and interperets these impulses to produce sensation such as vision, pain, smell, initiates proper motor impulses and relays, the latter to the effector organs (muscles & glands) for response to the stimuli acting on the sense organs.

iii) It preserves the impressions of previous

to guide the animal in future. These impressions are referred to as the experiences or memory.

(iv) It also receives information of the changes in the interior of the body and coordinates the activities of the viscera in the light of these changes. This helps in the maintenance of homeostasis in the body's internal environment.

Main Division of Nervous System

The nervous system of an animal is composed of nervous tissue that develops from the ectoderm of the embryo. The cells of this tissue, called neurons, have the properties of irritability and conductivity developed to the highest degree in the body. The nervous system is very extensive and all its parts are structurally connected and functionally integrated. However, for the convenience of description, the nervous system divided into three main divisions:

I) Central Nervous system (CNS). It lies along the middle line of the body. Most of the neurons (cell bodies, axons and dendrites) occur in the central nervous system. The CNS consist of two parts: the anterior large part is brain which is situated in the head, and the posterior long, narrow part is spinal cord which is located in the neck and trunk.

II) peripheral Nervous system (PNS). It ~~extends~~ consist of nerves, which extend between the central nervous system and the sense organs and body muscles. It carries information to and from the CNS. It mainly controls the voluntary activities of the body. It includes the cranial or cerebral, nerves which arise from the brain and

spinal nerves which originate from the spinal cord.

III. Autonomic Nervous System (ANS). It consist of nerves which connect the visceral receptors and effectors with the central nervous system through the cranial and spinal nerves. It controls the involuntary activities of the body.

Embryonic Development of Central Nervous System.

The development of central nervous system in vertebrates occurs at end of gastrula stage, when ectoderm in front of blastoporic lips thickens to form neural or medullary plate (Fig 1). The lateral edges of neural plate are elevated to form neural folds. So a longitudinal neural groove is developed above the neural plate. The neural folds approach each other and finally fuse middorsally to form a hollow neural tube. The cavity of neural tube is called neurocoel. Neural tube sinks down to take its position just above the notochord. Neural tube is dilated at anterior end. It gives rise to brain. Neural tube communicates with the outside environment by a small opening called neuropore. Some cells at lateral edges of neural plate do not become part of neural tube. These are called neural crests. Neural crest cells give rise to various cranial ganglia.

The cells migrate from neural crest to whole body to form sensory neuron, Schwann cells on nerves, pigment cells, osteoblasts, chondroblasts and mesen-chemical cells in gills.

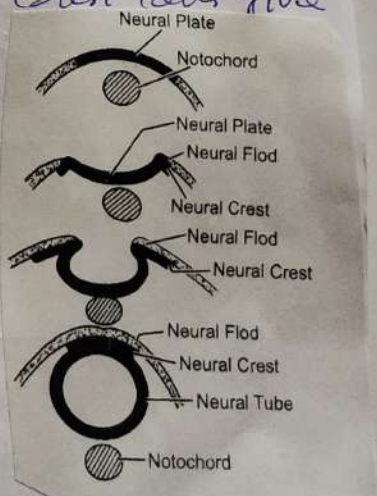

Fig 11. Development of neural tube.

PARTS OF BRAIN

Brain is anterior dilated part of neural tube. The brain is controlling centre of all receptors and effectors organs. It is enclosed in the cranial cavity of skull.

In all the vertebrates, brain is formed on same architectural plan. At embryonic level, the anterior end of neural tube gets enlarged forming the brain called encephalon. By differential growth, it is divided into three primary cerebral vesicles termed as forebrain or prosencephalon, midbrain or mesencephalon and hindbrain or rhombencephalon (Fig. 2)

These three cerebral vesicles gives rise to various parts of brain by thickenings, outgrowths and foldings. The structure of the brain may be summerised as follows.

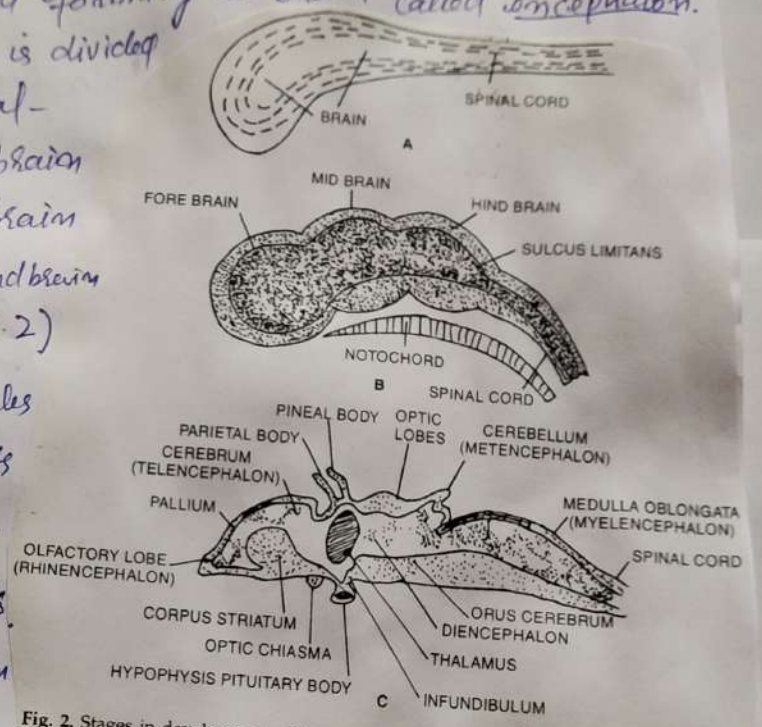

Fig. 2. Stages in development of brain. **A.** Anterior end of neural tube in lateral view. **B.** L.S. of embryonic brain to show three primary cerebral vesicles. **C.** Differentiation of brain from three vesicles.

Brain

Prosencephalon (Fore brain)	i) Telencephalon	It includes cerebral hemispheres olfactory lobes, corpus striatum, cerebral cortex and olfactory bulb.
	ii) Diencephalon	It includes epithalamus, thalamus, Hypothalamus and its appendages.
Mesencephalon (mid brain)	Tectum	includes optic lobes, tegumentum and crura cerebi.
Rhombencephalon (Hind brain)	Metacephalon	includes part of medulla oblongata, cerebellum and pons in mammals.
	Myelencephalon	part of medulla oblongata.

Ventricals (Fig 4)

The original cavity of the neural tube persists in most of the parts of the brain as cavities called the ventricles. These include the first and second ventricles or lateral ventricles or paracoel in the cerebral hemispheres; third ventricle or diacoel in the diencephalon; and fourth ventricle or myelocoel in the medulla oblongata (Fig 4). The lateral ventricles communicate with the third ventricle by an aperture called the interventricular foramen or foramen of monro. Third ventricle is connected with the fourth ventricle by a narrow channel, the cerebral aqueduct or iter, passing through the midbrain. In lower vertebrates, the optic lobes enclose the iter. In higher vertebrates, the optic lobes are almost solid. The cerebellum contains cerebellar ventricle or metacoel. The lateral ventricles may extend into the olfactory lobes as the narrow olfactory ventricles or rhinocoels. The myelocoel continues posteriorly as the central canal of the spinal cord.

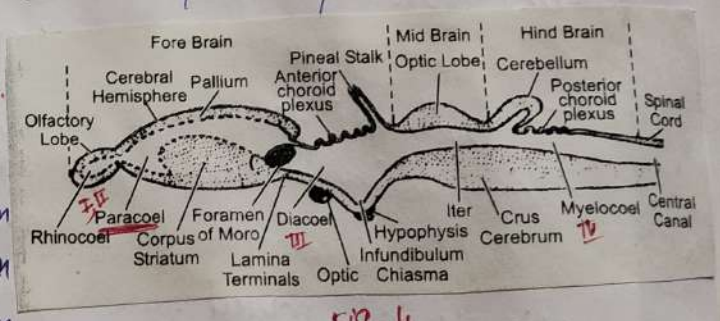

Fig. 4

1. Forebrain or prosencephalon.

The forebrain is further sub-divided by a constriction into an anterior telencephalon and posterior diencephalon.

The anterior wall of the telencephalon is known as lamina terminal which marks the original anterior boundary of the brain. The telencephalon grows beyond the lamina terminalis and forms paired cerebral hemispheres. The roof of the cerebral hemispheres becomes the pallium and its ventro-lateral thicker walls form the corpora striata. Each cerebral hemisphere has a cavity, the lateral ventricle. From the antero-ventricular part of the telencephalon paired

olfactory lobes (rhinencephalon) grow out towards the nose. Each olfactory lobe has a cavity, the rhinocoel, which communicates with the lateral ventricle of its side. The diencephalon or thalamencephalon has an upper epithalamus, a middle thalamus, and a lower hypothalamus. Dorsally the diencephalon gives out a median unpaired paraphysis, which is well developed in fishes but is much reduced in reptiles and birds and is absent in mammals. Behind the paraphysis the diencephalon gives out two more unpaired evaginations, an anterior parietal body and a posterior pineal body or epiphysis. The parietal body forms an eye in lampreys, some fishes and many reptiles where as in others it is lost in the adult. The pineal body forms a rimplified eye in lampreys but in all other vertebrates it becomes glandular and is believed to be an endocrine gland, but there is no real evidence for this, most probably the pineal body is a vestigial organ of no functional significance. Between the thalami of diencephalon is a third ventricle which communicates with each lateral ventricle by an aperture called a foramen of monro. The thalami give rise to optic vesicles which form parts of the eyes. The roof of the diencephalon is a thin ependymal layer which fuses with the vascular piamater to form a tela choroid plexus. The lower part of the diencephalon known as hypothalamus forms a ventral infundibulum. An ectodermal evagination of the roof of the stomodaeum forms a Rathke's pouch or hypophysis, which fuses with the infundibulum to form a pituitary body or hypophysis cerebri, which loses its nervous character and becomes an important

endocrine gland. Except in a few lower forms the Rathke's pouch loses its connection with the stomodaeum. The fibres of the optic nerves cross in front of the infundibulum to form an optic chiasma.

2. Midbrain or mesencephalon.

The midbrain has a thick roof. Its dorso-lateral walls form two optic lobes (four in mammals). The optic lobes are hollow, each having an optocoel except in mammals where they have no cavity and are solid. The ventral wall of mesencephalon forms thick crura cerebri, which are tracts of nerve fibres joining the diencephalon with the hindbrain. Passing through the mesencephalon form the third to the fourth ventricle is a narrow iter or aqueduct of Sylvius, which in non-mammals is also connected to the optocoels.

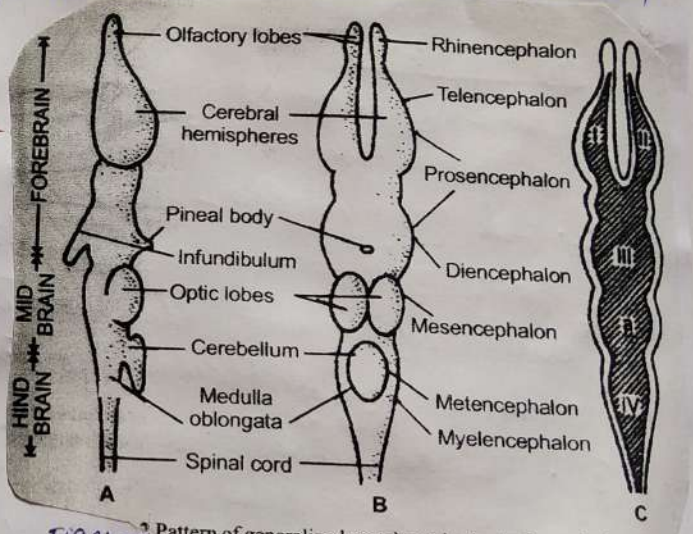

Fig showing Pattern of generalized vertebrate brain; A- Lateral view; B- Dorsal view; C- H.L.S showing ventricles

3. Hindbrain or Rhombencephalon.

The hindbrain forms a metencephalon from its anterior dorsal part. The metencephalon enlarges dorsally to give rise to a cerebellum. The surface of the cerebellum has a layer of grey matter, called cerebellar cortex. In birds and mammals there is thick white matter below the cerebellar cortex. In lower forms of vertebrates the cerebellum has an extension of the fourth ventricle known as cerebellar ventricle or metacoel. The remaining part of the rhombencephalon forms a myelencephalon, which becomes a thick medulla

Oblongata having a cavity, the fourth ventricle. The roof of the medulla has a posterior choroid plexus formed in the same way as the anterior choroid plexus. In lower vertebrates the floor of the metencephalon and myelencephalon does not differ, but in higher forms the floor of the metencephalon is thickened due to many tracts of nerve fibres, and in mammals it forms a conspicuous pons varolli. The posterior commissure lies in the roof of the diencephalon at its junction with the midbrain. In mammals there are several other commissures. The commissures make bilateral integration possible.

While doing comparative study of brain from fish to mammals a few important points are to be noted which are as follows:

1. There is tendency to increase the size of cerebral hemispheres in proportion to other parts of the brain.
2. The grey matter which at first is concentrated on the roof of the paracoels, tends to move towards the surface and thickens to form the cerebral cortex, its thickness is directly proportional to the intelligence.
3. The cerebral hemispheres become more and more connected with each other by means of commissures to co-ordinate the actions of the two hemispheres.
4. The surface area of the hemispheres tend to increase by folding.
5. Olfactory lobes and other olfactory centres are better developed in lower vertebrates than in higher vertebrates.
6. The large size of cerebral hemisphere in lower vertebrates is not because of cerebral cortex, but because of large corpora striata.
7. Cerebellum is more extensive and advanced in mammal which move is more than one plane and

(A) whose muscular responses are far more numerous than in animals leading quite life.