Neurology

By,

Dr. Mohd. Zahirul Islam Khan
DVM, MS, Ph.D, Postdoc.

Occupation: Professor of
Anatomy and Histology,
FVM, Bangladesh Agricultural
University, Bangladesh.

At Present
Professor Madya, FPV, UMK

1. Central Nervous System:
   a) Brain of different animals.
   b) Spinal cord.

2. Peripheral Nervous System (PNS):
   a) Cranial Nerves
   b) Spinal Nerves and ganglia

3. Autonomic Nervous System (PNS)
Introduction: The nervous system, along with the endocrine and immune system and the sensory organs, is responsible for receiving various stimuli (Sensory Impulses) and coordinating the reactions of the organism. The nervous system receives stimuli that affect the body surface and/or insides. The stimuli cause impulses that are transmitted, processed and answered in the form of passive or active reactions.

In short, the nervous system enables the body to interact, adapt and react to the environment.
NERVOUS SYSTEM

Embryological origin: Nervous system originate embryologically from the Neural plate of Ectoderm.

Division of the nervous system

1. Central Nervous System (CNS): consisting of brain and spinal cord.

2. Peripheral Nervous System (PNS): consisting of cranial nerves, spinal nerves and their associated ganglia (aggregation of nerve cell bodies).
1. CENTRAL NERVOUS SYSTEM—THE BRAIN (Encephalon)

The brain is the control organ of the body, and is responsible for the regulation, coordination and integration of the rest of the nervous system.

**Location of Brain:** The brain is located in the cranial cavity.

**Formation of cranial cavity:**
- **Dorsally:** Frontal, Parietal, and Interparietal bones.
- **Ventrally:** Basilar part of the Occipital, Sphenoid and Presphenoid bones.
- **Caudally:** Occipital bone.
- **Cranially:** Ethmoid and Crista gallae.
- **Laterally:** Temporal bone.
COVERINGS OF THE BRAIN (Meninges)

The brain is covered by 3 layers:

1. **Dura mater**: made up of dense connective tissue.

2. **Arachnoid mater**: made up of loose connective tissue with arachnoid villi for the drainage of cerebrospinal fluid (CSF).

   - below the arachnoid, the space is called subarachnoid space through which CSF is circulated.

3. **Pia mater**: This layer is closely invested in the brain and rich of blood supply.
COVERINGS OF THE BRAIN (Meninges)

- **Leptomeninges**: The pia mater and arachnoid together is called leptomeninges because these two membranes are thin in comparison to the Dura mater (Pachymeninx—because dura is thick).

- In some places of the brain pia mater entered into the brain and form plexus known as choroid plexus which secretes CSF.
Modification of meninges

1. **Falx cerebri**: Fold of dura mater in the longitudinal fissure of cerebrum.

2. **Tentorium cerebelli**: (means tent of the cerebellum). It is extension of dura mater which separates cerebellum from cerebrum.

3. **Diaphragma sellae**: It is the circular fold of the dura mater covers that part of the pituitary gland which lies on the sphenoid bone and completing the roof of the sella turcica.
Based on the development from the rostral part of the neural tube, the brain can be subdivided into 3 major parts:

1. **Prosencephalon**: Telencephalon and Diencephalon (forebrain).
2. **Mesencephalon** (mid brain)
3. **Rhombencephalon** (hind brain):
   a) Metencephalon: Pons and cerebellum
   b) Myelencephalon: Medulla oblongata
Parts of the Prosencephalon (forebrain)

1. Telencephalon or the distant brain (far brain): It consists of:
   a. Paired cerebral hemisphere which separated by longitudinal fissure, and connected by corpus callosum (rostrum, genu, body and splenium). It is a commissural fiber.

   i) Gyrus and Sulcus: Grey matter (nerve cells) and White matter (fiber).

II) Lobes of the brain: Frontal, Parietal, Occipital, Temporal, Piriform (in ruminant), Olfactory (in dog), and Optic lobe (in bird).
b. Rhinencephalon begins with the olfactory bulb, olfactory tract and ends into piriform lobe.

c. Two lateral ventricles: cavity of brain separated by a membrane known as septum pellucidum.

- Function of Telencephalon: Olfaction, visual activity,
- Hearing, intelligence, fear, emotion, hunger, thirst etc.
Pallium or Cortex of Cerebral Hemisphere

1. **Paleopallium**: The oldest part is the paleopallium and constitute the ventral part of each hemisphere. It is primarily related to the olfaction. The area extend from olfactory bulb to hippocampus.

2. **Archipallium**: It is the next oldest, forms the medial part of each hemisphere and extends from the longitudinal fissure into the hemisphere.

3. **Neopallium**: The neopallium constitutes the major part of the telencephalon, forming the dorsolateral Part of each hemisphere.
Cortex and Medulla of Brain

- Cortex of brain located peripherally and consists of nerve cell bodies (grey matter) and medulla located centrally, white in nature consists of nerve fibers (white matter).
Internally Cerebral Hemisphere consist of following structure:

- **Corpus Striatum**: It is an accumulation of grey matter within the white matter. E.g. basal ganglia (nucleus of the brain):
  - a) Caudate, 
  - b) Putamen, 
  - © Claustrum 
  - (d) Amygdaloid body.
Internal structure of Cerebral hemisphere (Fibers of brain)

There are 3 types of gross fibers which connect different parts of brain or separates different structures of brain:

- **External capsule**: It is thin and separates claustrum.

- **Projection fibers**: Internal capsule is thick and separates putamen. This fibers projects within the same hemisphere.

- **Commissural fibers**: Corpus callosum which connects two cerebral hemisphere.
Lymbic System of Cerebral Hemisphere

The term lymbic system means some parts of brain structure involved with emotional behavior. It consists of:

- Cingulate gyri, Piriform lobe and hippocampus of cortex of brain.
- Thalamus and hypothalamus of diencephalon, and amygdaloid body of basal ganglion.

Function:
- Visceral motor activity.
- Trigger behavior, such as fear, aggression, and apparent pleasure.
- Great input on thirst, hunger, and sexual behavior.
Diencephalon: It is also known as twin brain. It is visible in sagittal section view and ventral view and comprises:

- Epithalamus
- Thalamus
- Subthalamus, and
- Hypothalamus.
Epithalamus and Thalamus

• a. Epithalamus comprises:
  Pineal gland and Habenula (nucleus and fibers for olfactory pathway).

• b. Thalamus is a large rounded mass composed of large number of nuclei through which input of cerebral cortex in channelled including sensory information from gustatory (taste), optic (vision), vestibulo-cochlear (hearing and balance).
Subthalamus and Hypothalamus

- c. Subthalamus is ventral to the thalumus contains subthalamic nuclei and it is the relay station of extrapyramidal motor pathway.
- d. Hypothalamus consist of optic chiasma, mammilary body tuber cinereum through which infundibulum protruded for the suspension of pituitary gland.
- e. Third ventricle: Around the thalamus a narrow strip is the 3rd ventricle.
- Function of Diencephalon: It regulates sexual activity, role in behaviour including eating and drinking and regulating body temperature.
Different parts of Mesencephalon (mid brain)

Mesencephalon consists of following structures:

1. Tectum: Roof of mesencephalon and comprises corpora quadrigemina (rostral colliculus and caudal colliculus).
2. Tegmentum: Floor of mesencephalon. Much of it is formed by reticular formation. It contains nucleus of cranial nerve III and IV.
3. Cerebral aqueduct: a channel which connect 3rd ventricle rostrally and 4th ventricle caudally.
4. Cerebral peduncle: Visible on the ventral aspect of the brain just caudal to the optic tract.
Rhombencephalon (hind brain)

Rhombencephalon consists of:

1. Metencephalon: Pons and Cerebellum
2. Myelencephalon: Medulla oblongata
Metencephalon

Metencephalon can be divided into:

1. **Pons**: a bulging structure at the ventral part of the brain and caudal to the cerebral peduncle. It consists of the motor nucleus of the trigeminal nerve.

2. **Tegmentum**: It is the floor of the metencephalon.

3. **Rostrum medullary vellum**: It is the roof of the 4th ventricle.

4. **Cerebellum**: The cerebellum is the second largest part of the metencephalon and is located above the 4th ventricle.
The cerebellum consists of lobes, lobules and smallest folia.
Outer part is called cortex.
Inner part is called medulla.
Vermis located centrally.
Hemisphere on either side of the vermis.

Deficit of cerebellar function: Loss of balance and in coordination of muscles.
Myelencephalon-Medulla Oblongata

Medulla oblongata is continuous with pons cranially and spinal cord caudally.

- It comprises nuclei of the cranial nerves from VI (abducens) to XII (hypoglossal n.).
- It also comprises nuclei of the respiratory and circulatory center.

**Function:** Control respiration, circulation, food intake, reflex for the protection of eye.
Brain Stem

- **Brain Stem**: When cerebellum and cerebral hemisphere is removed the remaining part of the brain is called brain stem.

- Brain stem consists of medulla oblongata, pons, and mid brain.
Clinical Neurology (Pyramidal System)

In higher vertebrates damage of the cortex of one side make permanent paralysis of the skeletal muscles of the contralateral side.

Why?

Because some of the motor nerves originate from pyramidal cells of one cerebral cortex travel to the spinal cord (cortico-spinal tract) via the pyramid of the medulla to another side.
In extrapyramidal system the motor nerve originate from basal ganglia, substantia nigra, subthalamic nuclei, red nuclei, and reticular formation and don’t reach their targets by travelling through the pyramid of the medulla.

Function and control:
- Maintenance of posture
- Coordination of muscular activity.
Vision Pathway

No Need

Retina

Lateral Geniculate Body

Rostral Colliculus of Cor. Quadri.
Hearing Pathway

- Caud. Colli.
- Medial gen. body
Cerebrospinal Fluid Circulation

1. CSF formed by the choroid plexuses of all ventricles of brain and ependymal cells of the central canal of spinal cord.
2. From the lateral ventricle CSF passes through Foramen Monro located in the septum pellucidum in the 3rd ventricle. Here CSF become voluminous by adding more CSF of the 3rd ventricle. All these CSF move to the 4th ventricle.
3. CSF formed in the spinal canal of the spinal cord move towards 4th ventricle.
4. From the 4th ventricle via Foramina Luschka and Magendie CSF enters into the subarachnoid space. From here via arachnoid villi enters into venous sinus and general circulation.
Blood Circulation of Brain

Brain receives blood from two sources:
1. Ventral spinal artery, and
2. Internal carotid artery.

These two arteries forms a circle like pattern at the ventral aspect of the brain (around the optic chiasma and pituitary gland) known as circle of Willis.

Branches:
1. Rostral cerebral artery
2. Middle cerebral artery
3. Caudal cerebral artery
4. Rostral cerebellar artery
5. Caudal cerebellar artery.
Practical (Dorsal View of Brain of horse)

**Hemisphere of Cerebrum**

**Hemisphere of Cerebellum**

**Longitudinal fissure**

**Tranverse fissure**

**Vermis of Cerebellum**

---

The deep longitudinal cerebral fissure, which is flanked by the marginal and supragyrillary sulci, separates the left and right hemispheres (Fig. 14-17). The cruciate sulcus extends from the longitudinal cerebral fissure running transversely on the rostrodorsal aspect (Fig. 14-17). The transverse cerebral fissure separates the cerebrum from the cerebellum. The lateral surface of each hemisphere is marked by the suprasylvian fissure in its middle cerebral artery sulcus. Rostral and caudal to the suprasylvian fissure runs the rostral and the caudal ectosylvian sulci. The lateral sulcus divides the neopallium from the rhinencephalon.

The medial surface features the splenial sulcus, which divides the neopallium from the archipallium. Caudal to the splenial sulcus passes the ectosplenial sulcus. Close to the commissure of the cerebral hemispheres, another sulcus (sulcus corporis calloso) and rostral to the genu sulcus (Fig. 14-20; 22 and 23).

To facilitate description the neopallium can be divided into lobes named according to the overlying bones. These are the frontal, the parietal, the temporal and the occipital lobes (Fig. 14-13, 15 and 17). Motor areas are located mostly in the frontal lobe, which give origin to the pyramidal tracts. The parietal lobe features mainly sensory areas, the temporal lobe includes the auditory area and the occipital lobe the visual area.

**Internal organisation of the hemispheres**

The accumulations of grey matter, embedded within white matter are generally known as corpus striatum (formerly designated basal or Stern ganglia) (Fig. 14-19, 21, 24 and 26).

The corpus striatum includes the following structures:

- **Caudate nucleus (nucleus caudatus)**
- **Putamen**
- **Claustrum**
- **Amygdaloïd body (corpus amygdaloideum)**

The caudate nucleus protrudes at the rostral part on the floor of the lateral ventricle (Fig. 14-18 to 22). Lateral to the caudate nucleus is the **putamen**, separated by fibres of the **internal capsule (capsula interna)**. Adjacent to the lateral aspect of the putamen lies the **claustrum**, a narrow band of grey substance (Fig. 14-19 and 26). Between the putamen and the claustrum, pass the fibres of the **external capsule (capsula externa)**. A thin band of whiter substance (capsula externa) separates the claustrum from adjacent cerebral cortex.

The function of the claustrum is not well understood, but it has connections with the visual system and the limbic system. The other nuclei are principally concerned with voluntary posture and movement. The corpus striatum is responsible for producing appropriate direction and magnitude of move-
Practical (Ventral view of Brain of Horse)

Note the origin of Cranial nerves
- **Occulomotor Nerve root**
- **Trigeminal nerve root**

**Olfactory bulb**

**Optic Chiasma**

**Pituitary gland**

**Pons**

**Pyramid**

**Medulla Oblongata**

---

**Rhinencephalon**

The olfactory pathway begins with special afferent neurons in the olfactory mucosa. Bundles of nonmyelinated axons of these neurons constitute the olfactory nerves, and pass through the cribiform plate to terminate in the olfactory bulb (Fig. 14-25).

The olfactory bulb (bulbus olfactorius) forms the most rostral part of the rhinencephalon, located in the ethmoidal fina (Fig. 14-14, 16 and 21). The rhinencephalon continues caudally with the olfactory peduncle (pulvinar olfactoria), that extends from the olfactory bulb to bifurcate into the medial and lateral olfactory tract. The olfactory tract forms a triangular area (trigeminum olfactorius), that constitutes, together with the central perforated substance (substantia perforata terminalis), the olfactory area. The central perforated area is located caudal to the olfactory trigone and is perforated by numerous blood vessels.

The lateral olfactory tract, continues caudally as the piriform lobe (lobo piriformis), and forms a massive bulge, situated lateral to the hypothalamus (Fig. 14-21). Medially it is continuous with the hippocampus. Underlying the piriform lobe is the amygdaloid body (corpus amygdaloideum) (Fig. 14-21 and 24), which is composed of several nuclei.

**Limbic system**

The term limbic system is applied to a collection of brain structures involved with emotional behaviour. It consists of cortical and subcortical components (Fig. 14-24). The cortical part comprises interconnected telencephalic structures on the medial and basal aspect of the hemispheres, namely the cingulate gyrus, the piriform lobe and the hippocampus. The subcortical part includes components of the diencephalon (thalamus, hypothalamus, thalamus), midbrain (interpeduncular and tegmental nuclei) and the striatum/putamen.

The limbic system receives olfactory input from the piriform lobe that initiates mainly visceral motor activities, but also triggers emotional behaviour, such as fear, aggression and appetitive pleasure. The limbic system has great input on thirst, hunger and sexual behaviour and is closely related to the motoric formation.

**Basal ganglia and caudal hemispheres**

The neopallium constitutes the major part of the telencephalon, forming the dorsoventral part of each hemisphere, interspersed between the ventral pallidum and the medial archipallium. In the domestic mammals, its surface is marked by cerebral convolutions (gyri cerebri) and grooves (sulci cerebri), which can be used as anatomical landmarks.
Ascending pathways

General somatic afferent pathways convey information from various types of receptors within the skin and deeper somatic tissues to the brain. This information includes a variety of sensory modalities: touch, pressure, vibratory sensation, thermal sensation, pain and kinaesthetic sensation relating to joint angulation and muscle tension.

The primary afferents concerned with these senses are located within the dorsal root ganglia of the spinal nerves and the corresponding ganglion of the trigeminal nerves for the head. The ascending pathways of this group can be divided into:

- Medial lemniscus,
- Lateral lemniscus system

The medial lemniscus includes the most important ascending tracts (Fig. 14-28). It can be subdivided into the spinthalamic system for sensory nerves in the head. The sensory neurons of the spinal lemniscus run in the dorsal funiculus of the spinal cord. Those arising from the substantia grisea and the spinal ventral horn occupy the tract ansae (Gall's column, fasciculus gracilis). Those from the brachial plexus and the cervical portion of the cord assume more lateral positions (commissural fasciculus, fasciculus cuneatus).

Both tracts end in the lateral nuclei of the cerebellum (medial lemniscus) and the spinal lemniscus, which occupies the dorsal horn of the spinal nerve. The secondary sensory tract conveys information to the spinal cord and to the brain, where it travels cranially in the ventrolateral funiculi of the white matter to the thalamus. The thalamic sensory system originates in the thalamus upon a cortical area that is located in the lateral fissure.

Information of proprioceptive nature from receptors within muscles and tendons do not reach conscious perception. The primary afferents terminate in dorsal horn cells and reach the cerebellum via the dorsal and ventral spinocerebellar tracts.

Afferent pathways of the sense organs

Visual pathways

The retina contains the receptors for visual information. The information is then conveyed to the brain by the optic nerve. The optic nerve of each eye converges to meet in the optic chiasm on the ventral surface of the brain, where some of the fibers decussate. In the dog and cat, which have a binocular vision, approximately 75% of the optic nerve fibers decussate while the remainder project to the contralateral region of the thalamus and thus to the visual cortex of the opposite side.
Spinal Cord and its Covering

**Root of the Spinal Nerve:** dorsal and ventral root originate from dorsal and ventral horn of the spinal cord.

**Meninges:** Similar to the Covering of Brain

**Denticulate Ligament:** Thickening of Dura mater due to accumulation of collagen fibers in some areas of the dura.
Different Segments of the Spinal Cord

- Cerebrum
- Cerebellum
- Cervical part of the spinal cord
- Thoracic part of the spinal cord
- Lumbar part of the spinal cord
- Sacral part of the spinal cord
- Conus medullaries
- Cauda equina
• Conus Medullaries: The spinal cord tapers at the mid of the sacrum and looks like a cone shaped.

• Cauda Equina: From the conus medullaries several spinal nerves originate to innervate in the muscles, fascia and skin of tail.
Spinal Cord and Formation of Spinal Nerve

- Dorsal root
- Ventral root
- Dorsal root ganglion
- Dorsal branch
- Spinal nerve
- Ventral branch
Grey and White mater of the spinal cord

- Dorsal Horn
- Intermediate Horn
- Ventral Horn
- Central Canal