Neurology

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)**

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NERVOUS SYSTEM

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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.

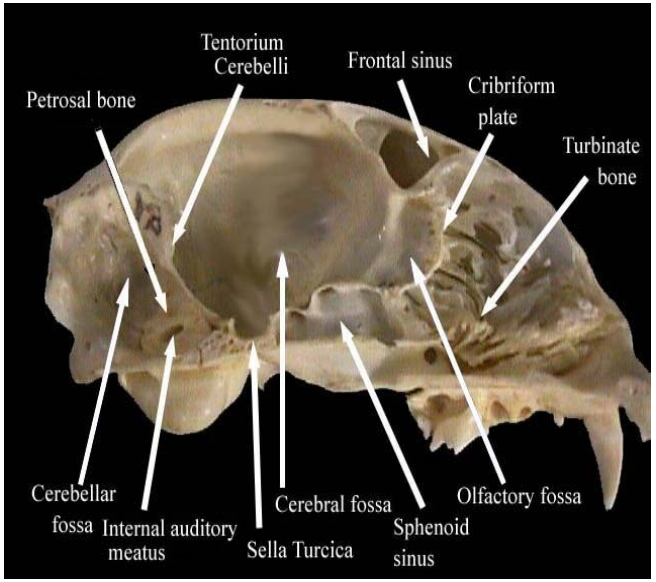
NERVOUS SYSTEM

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):** consisiting 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 Interparietalbones.

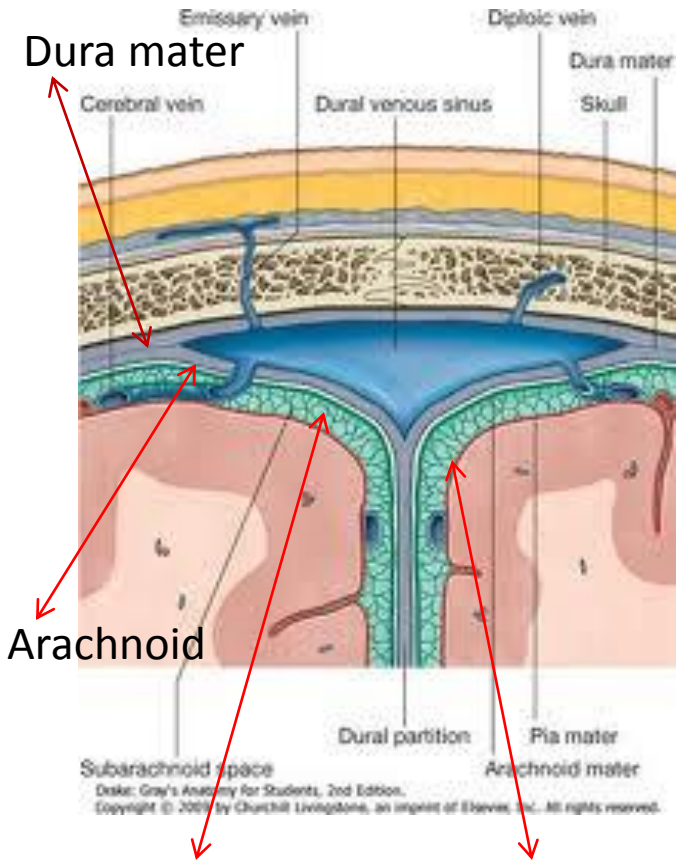
Ventrally: Basilar part of the Occipital,Sphenoid and Presphenoid bones.

Caudally: Occipital bone.

Cranially: Ethmoid and Crista gallae.

Laterally: Temporal bone.

COVERINGS OF THE BRAIN (Meninges)



Subarachnoid space

Pia mater

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 dainage of cerebrospinal fluid (CSF).

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

3. Piamater: This layer is closely invest the brain and richof blood supply.

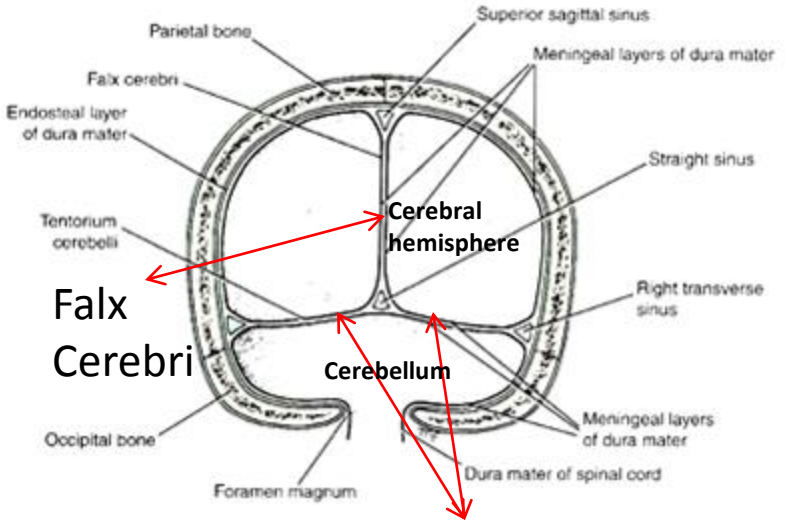
COVERINGS OF THE BRAIN (Meninges)

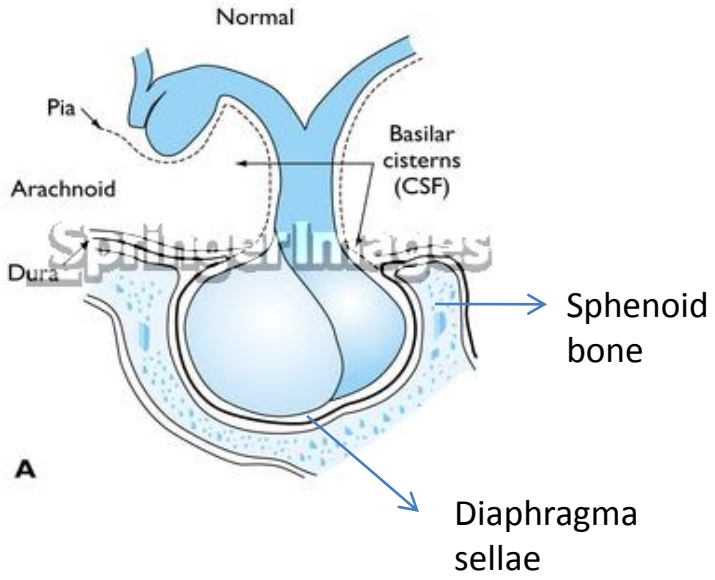
- Leptomeninges: The pia mater and arachnoid together is called leptomeninges because these two membranes are thin in comparison to the Dura mater (Pacchymenix-because dura is thick).

✓ 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

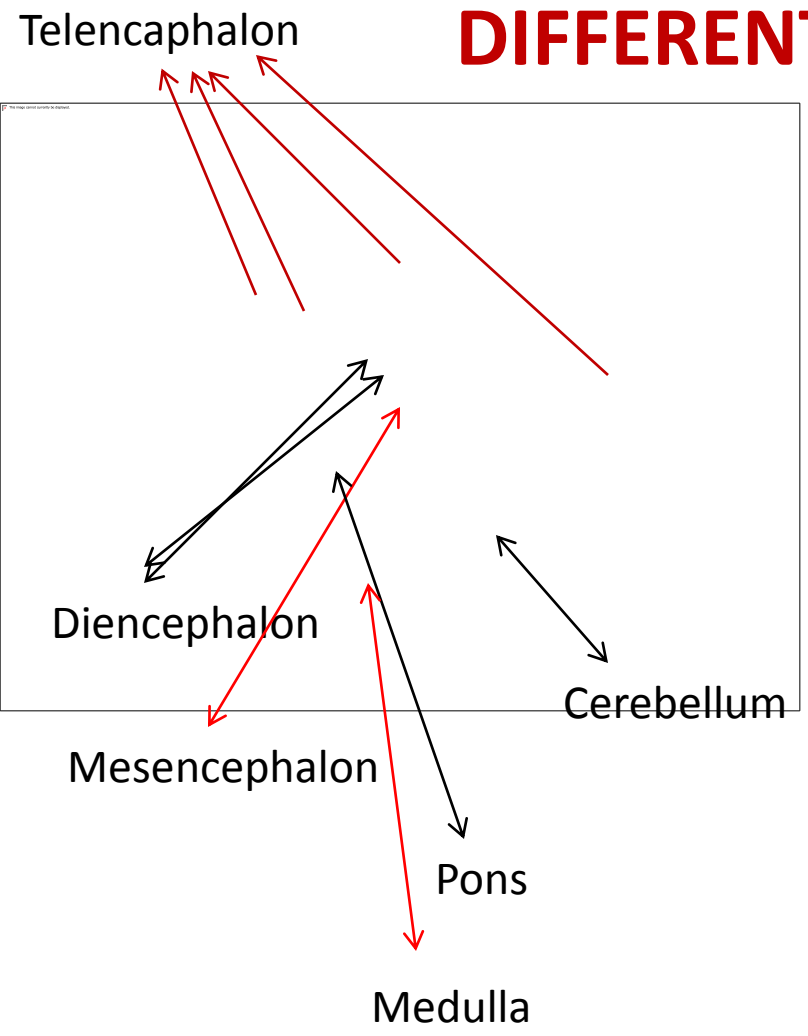
Cerebral hemisphere+Cerebral hemisphere= Cerebrum





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.

DIFFERENT PARTS OF BRAIN



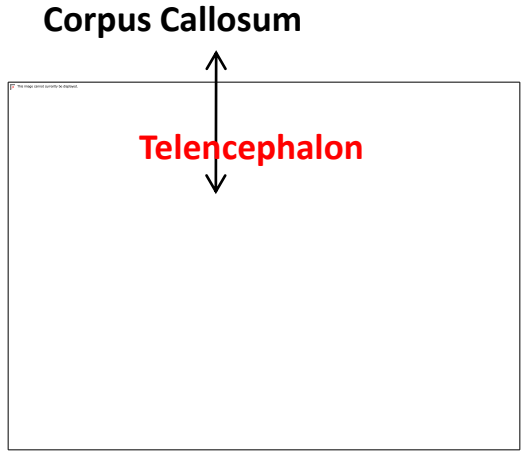
Based on the development from the rostral part of the neural tube, the brain can be subdivided into 3 major parts:

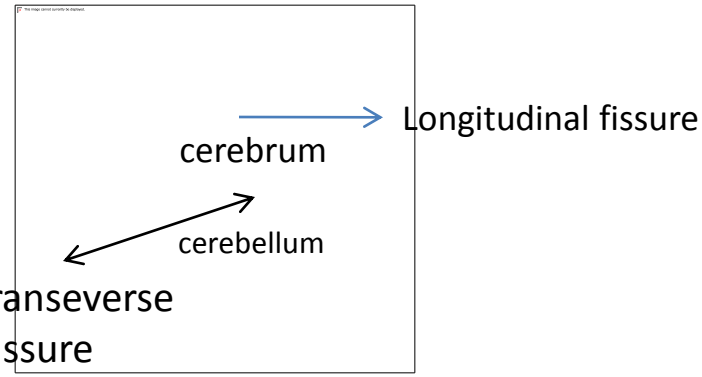
1. Prosencephalon : Telencephalon and Diencephalon (forebrain).
2. Mesencephalon (mid brain)
3. Rhombencephalon (hind brain):

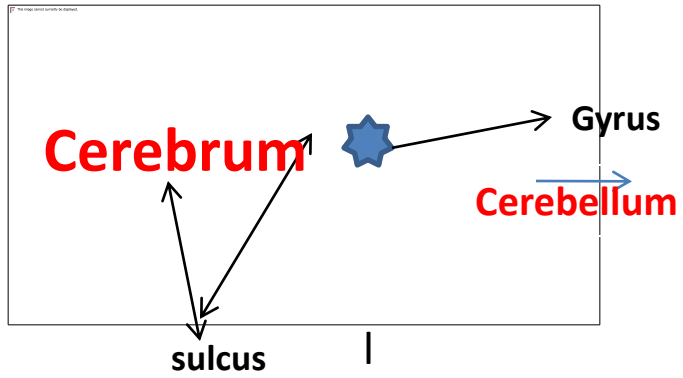
a) Metencephalon: Pons and cerebellum

b) Myelencephalon: Medulla oblongata

Parts of the Prosencephalon (forebrain)







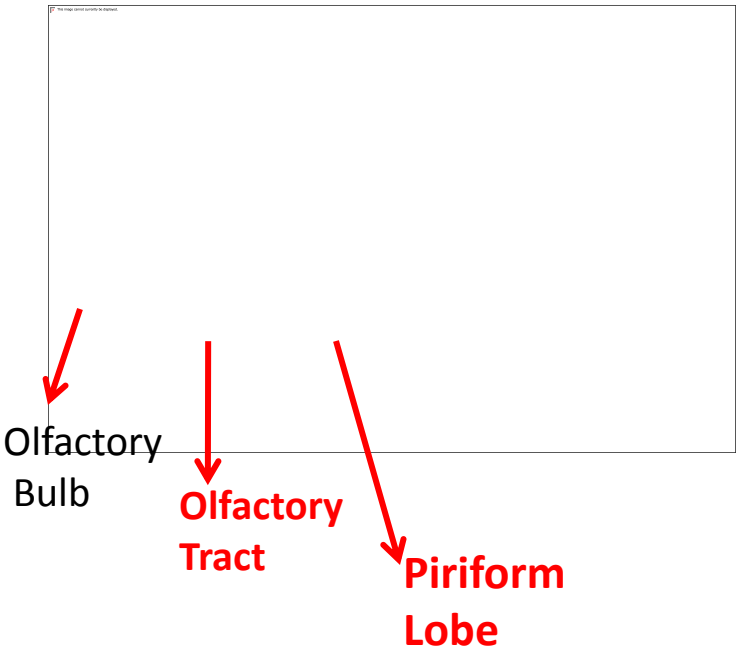
1. Telencephalon or the distant brain (far brain): It consist of:

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).

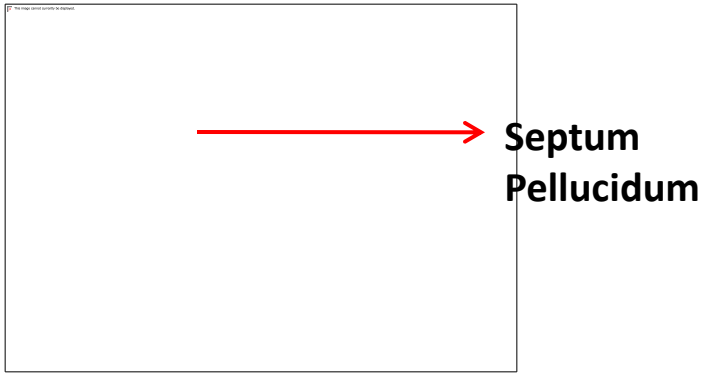
II) Lobes of the brain: Frontal, Parietal, Occipital, Temporal, Piriform (in ruminant), Olfactory (in dog), and Optic lobe (in bird).

Parts of the Prosencephalon (forebrain)



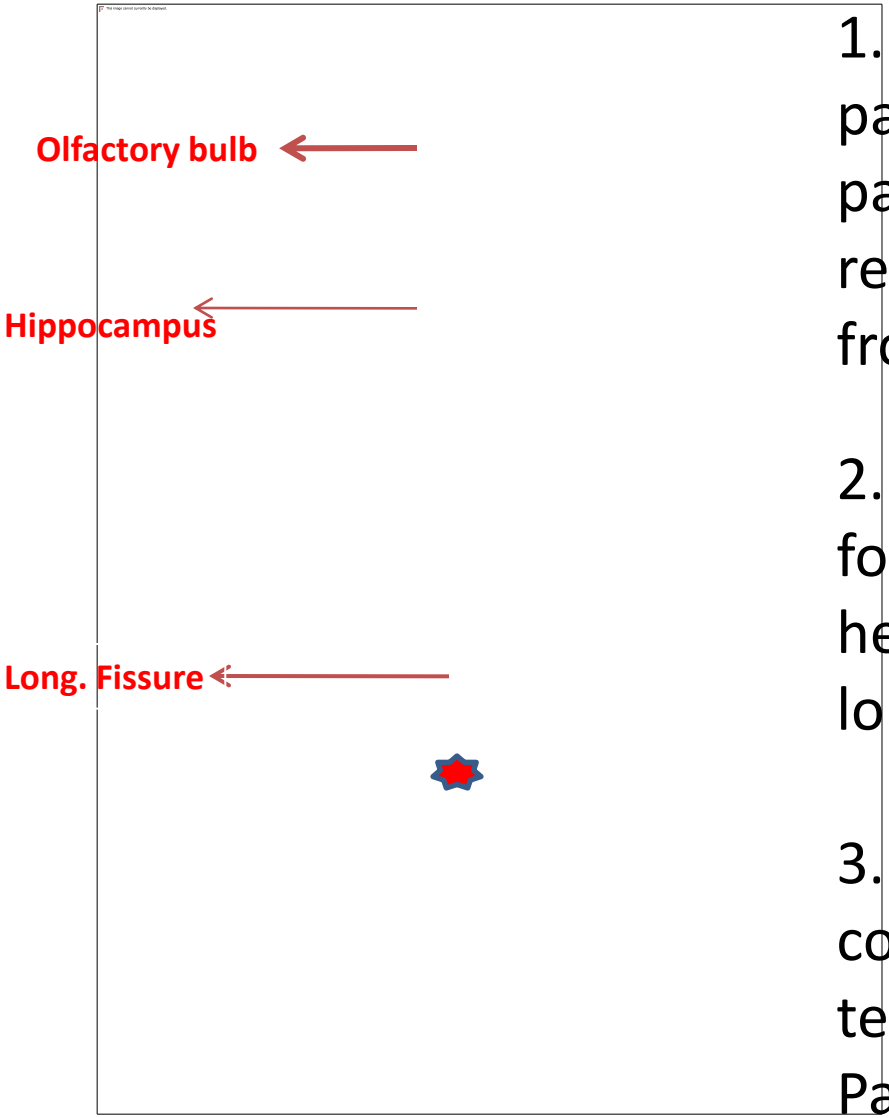
b. Rhinencephalon begins with the olfactory bulb, olfactory tract and ends into piriform lobe.

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.

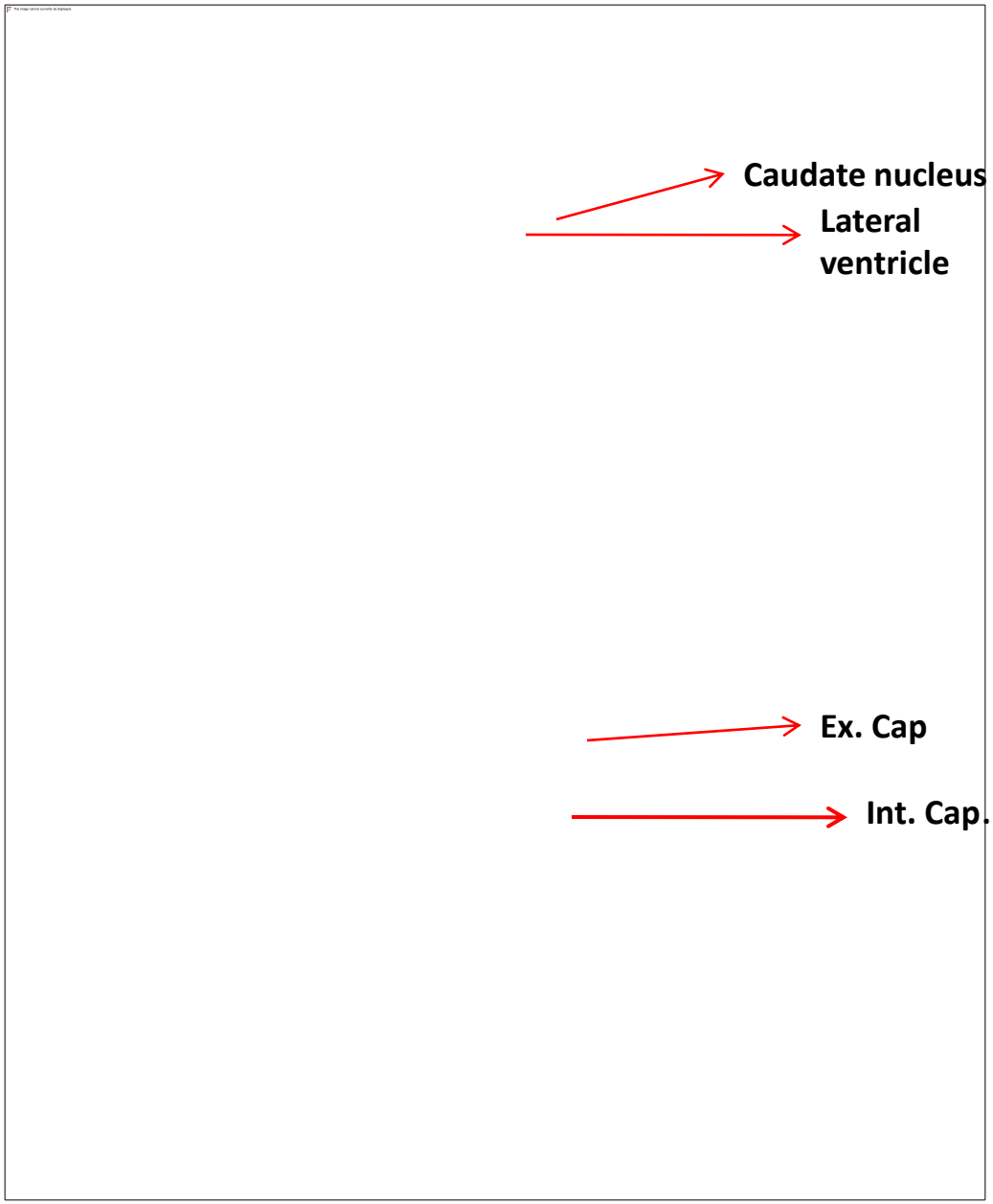
2. Archipallium: It is the next oldest, forms the medial part of each hemisphere and extends from the longitudinal fissure into the hemisphere.

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).

Internal structure of Cerebral hemisphere (basal ganglion)



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):

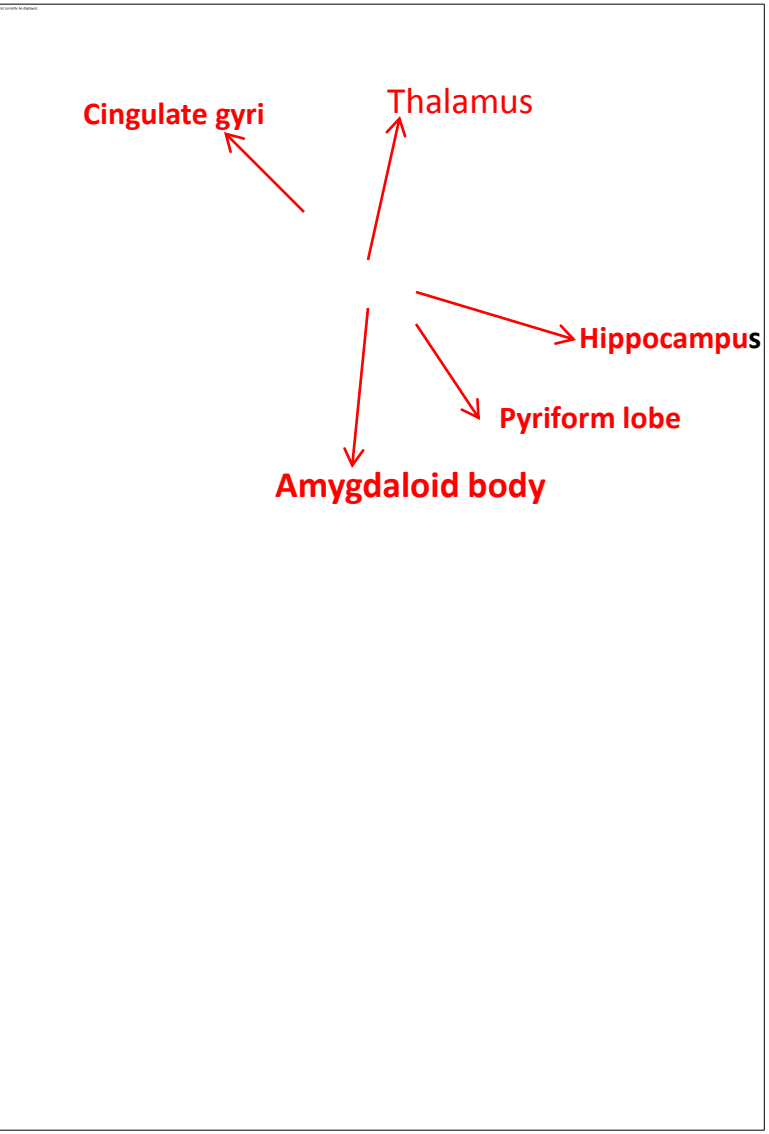
a) Caudate, (b) Putamen, © Claustrum and (d) Amygdaloid body.

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



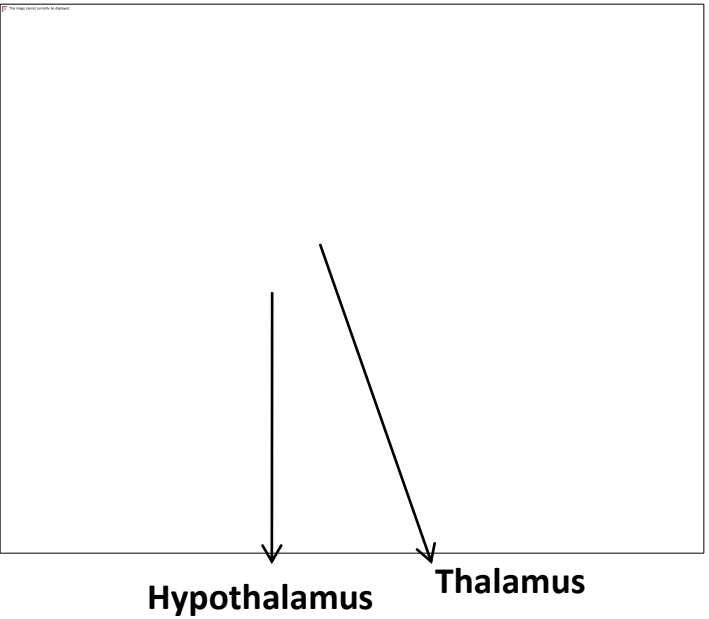
The term lymbic system means some parts of brain structure involved with emotional behavior. It consists of:

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

Function:

- **Viscerel motor activity.**
- **Trigger behavior,such as fear, aggression, and apparent pleasure.**
- **Great input on thirst, hunger, and sexual behavior.**

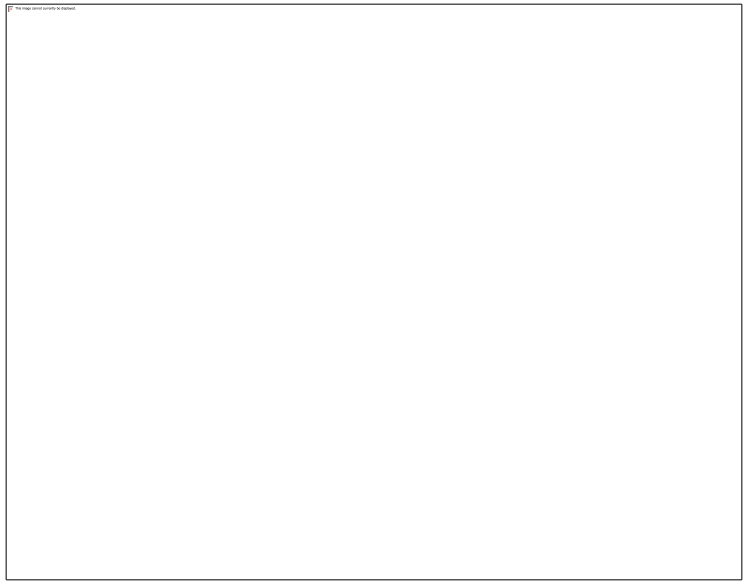
Diencephalon (Parts of Prosencephalon)



Diencephalon: It is also known as twin brain. It is visible in sagittal section view and ventral view and comprises:

- Epithalamus
- Thalumus
- Subthalumus, and
- Hypothalumus.

Epithalamus and Thalamus

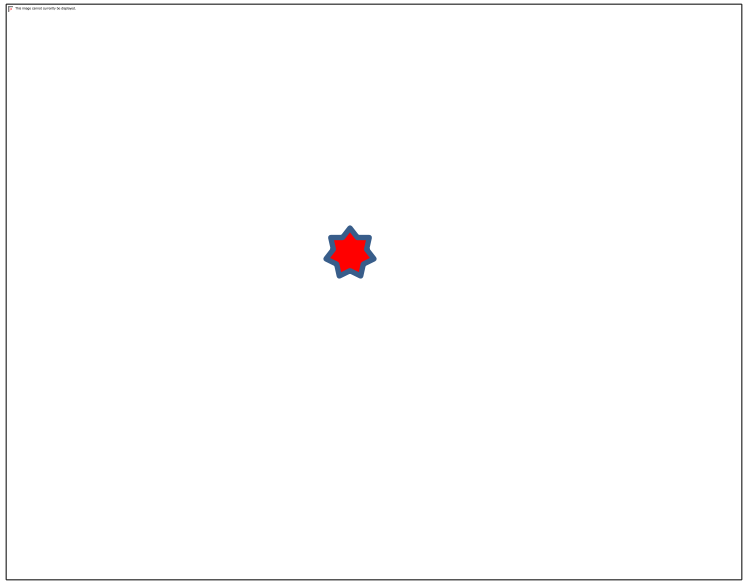


- a. Epithalamus comprises:

  Pineal gland and Habenula (nucleus and fibers for olfactory pathway).

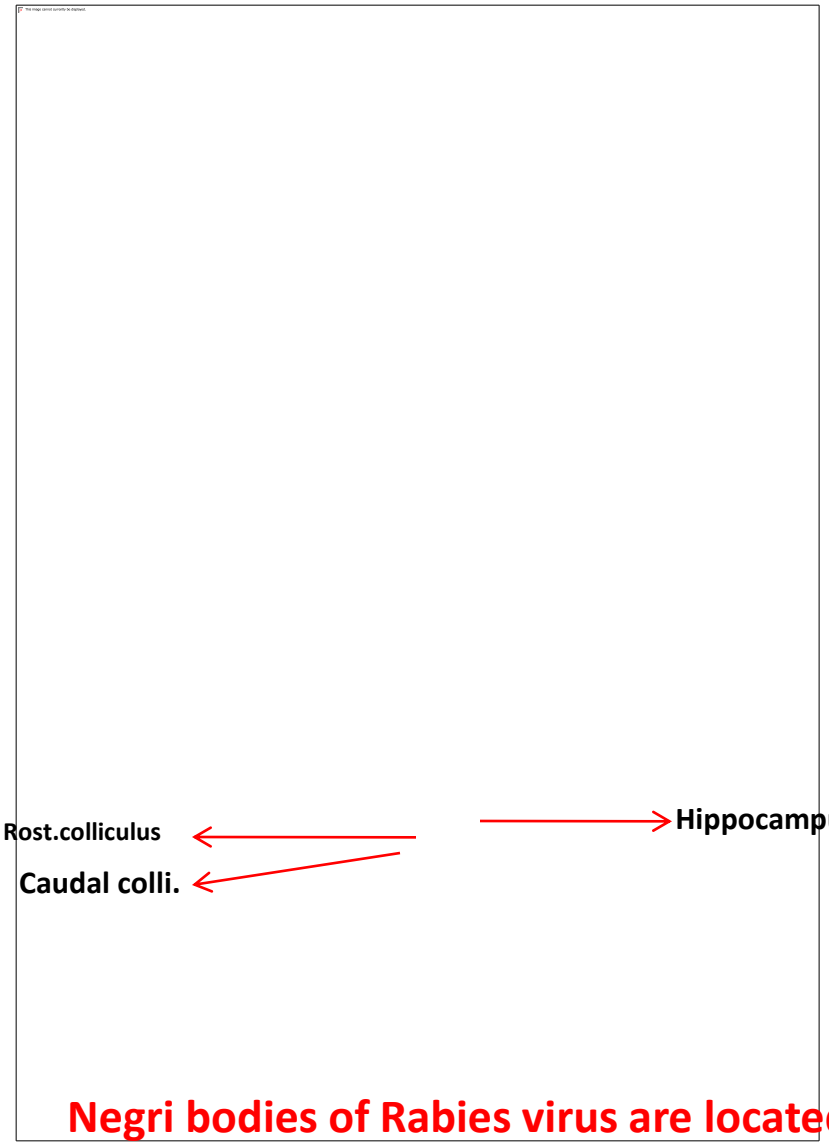
- b. Thalamus is a large rounded mass composed of large number of nuclei through which input of cerebral cortex in channelled including sensory information from gustatory (taste), optic (vision), vestibulo-cochlear (hearing and balance).

Subthalamus and Hypothalamus



- c. Subthalumus is ventral to the thalumus contains subthalamic nuclei and it is the relay station of extrapyramidal motor pathway.
- d. Hypothalumus 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 temparature.

Different parts of Mesencephalon (mid brain)

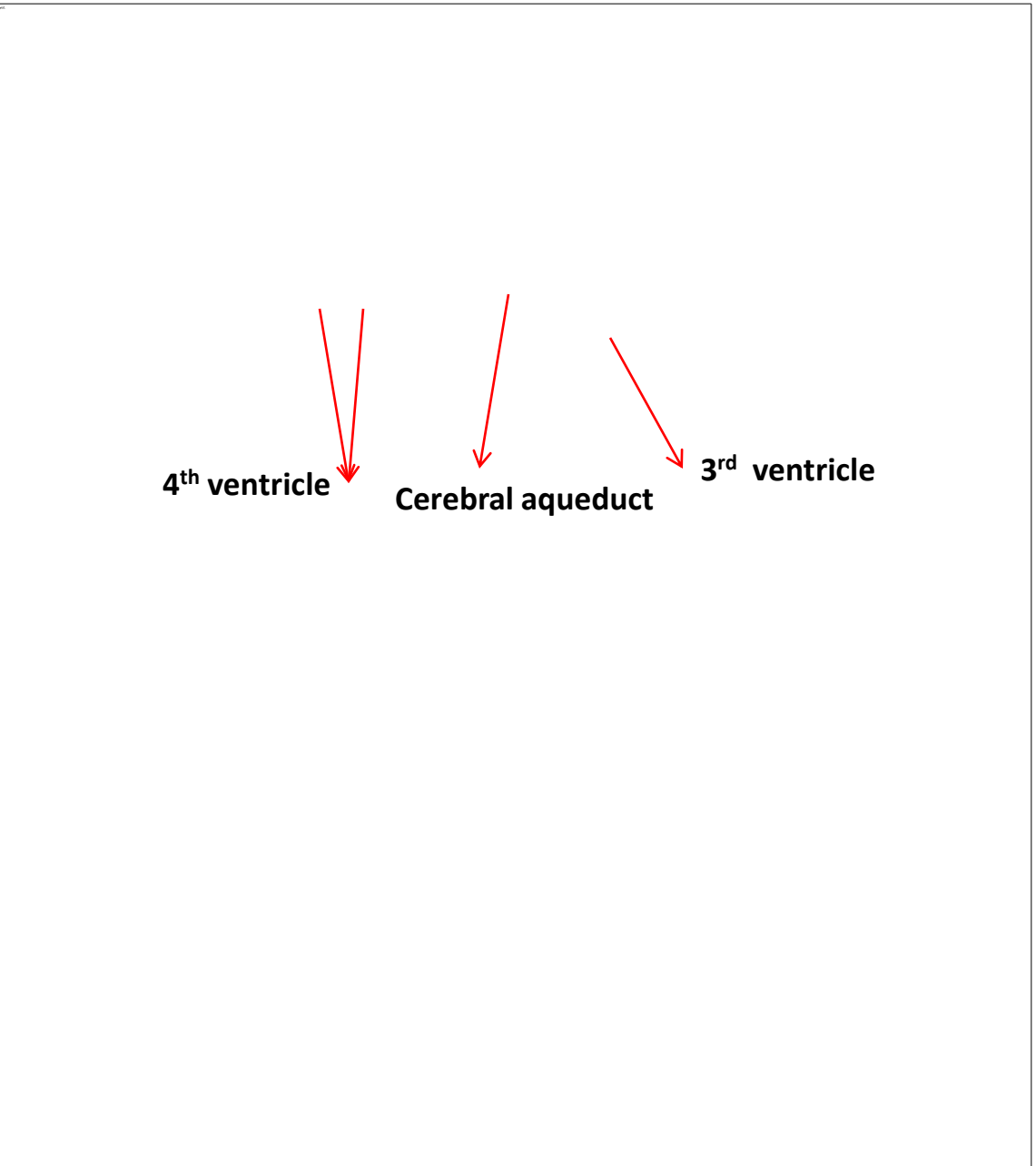


Negri bodies of Rabies virus are located In the hippocampus of brain

Mesencephalon consists of following structures:

1. Tectum: Roof of mesencephalon and comprises corpora quadrigemina (rostral colliculus and caudal colliculus).
2. Tegmentum: Floor of mesen - cephalon. 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)

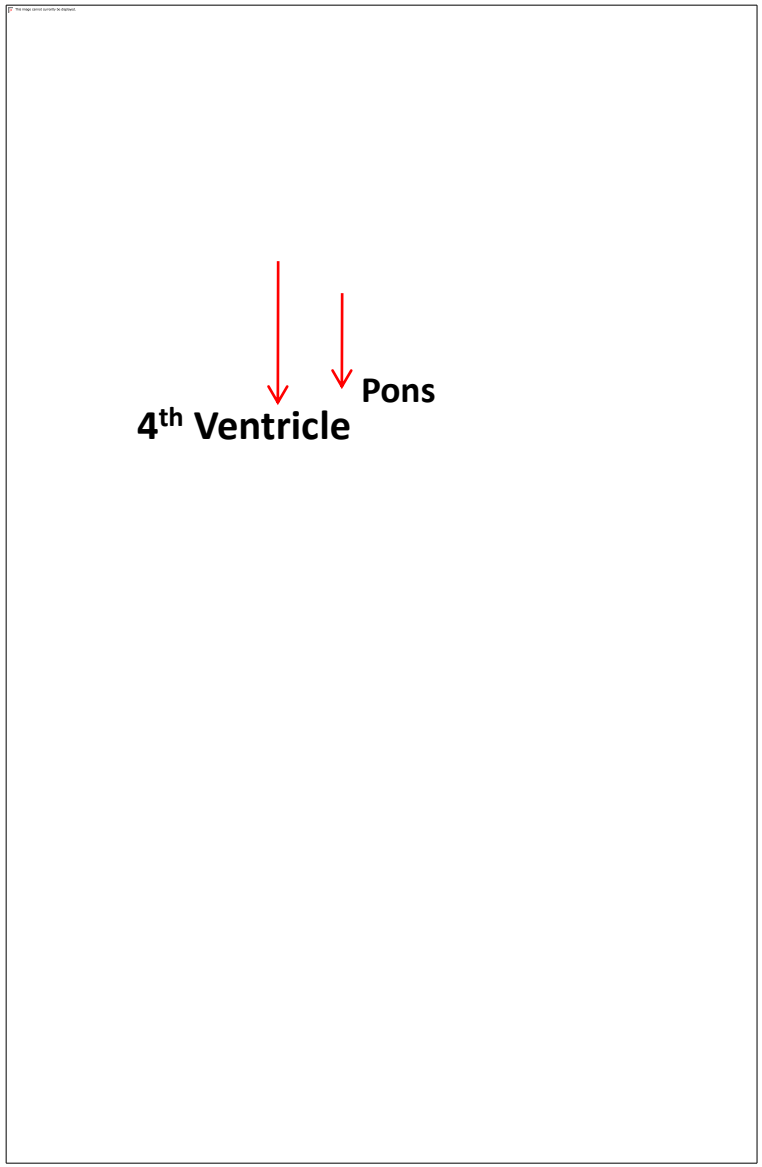


Rhombencephalon consists of:

1. Metencephalon:
   Pons and
   Cerebellum

2. Myelencephalon:
   Medulla oblongata

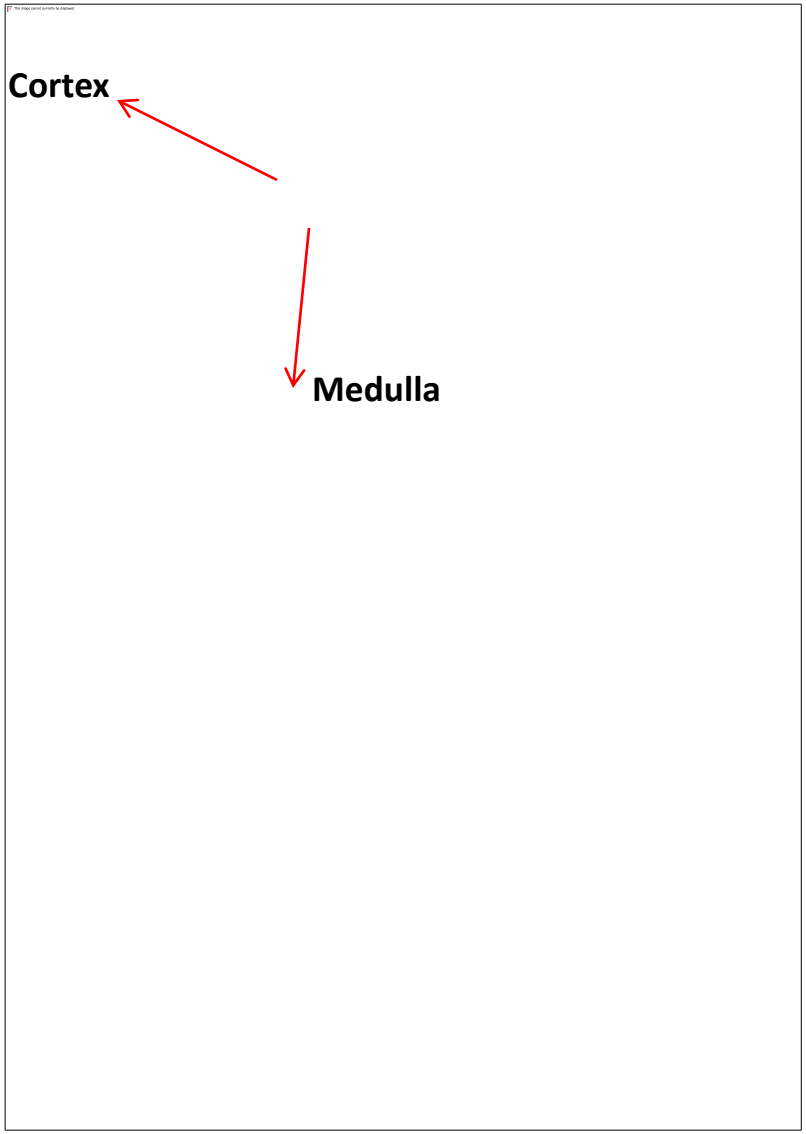
Metencephalon



Metencephalon can be divided into:

1. Pons: a bulging structure at the ventral part of the brain and caudaul to the cerebral peduncle. It consist of the motor nucleus of trigeminal nerve.
2. Tegmentum: It is the floor of the metencephalon.
3. Rostrum medullary vellum: It is the roof of the 4rth ventricle.
4. Cerebellum: The cerebellum is the second largest part of the metencephalon and is located above the 4th ventricle.

Structure of Cerebellum

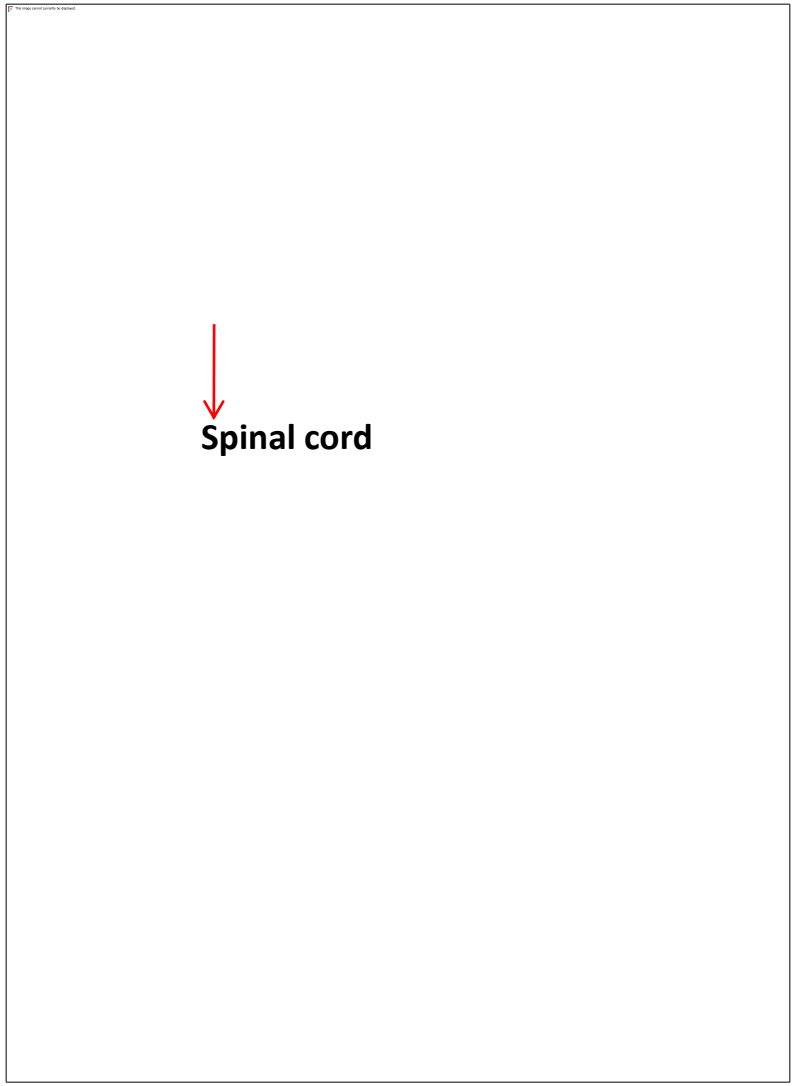


- The cerebellum consists of lobes, lobules and smallest folia.
- Outer part is called cortex.
- Inner part is called medulla.
- Vermis located centrally.
- Hemisphere on either side of the vermis.

Function: Body balance, coordination of skeletal muscle, and control motor function. Control pyramidal and Extrapyramidal system of brain.

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.

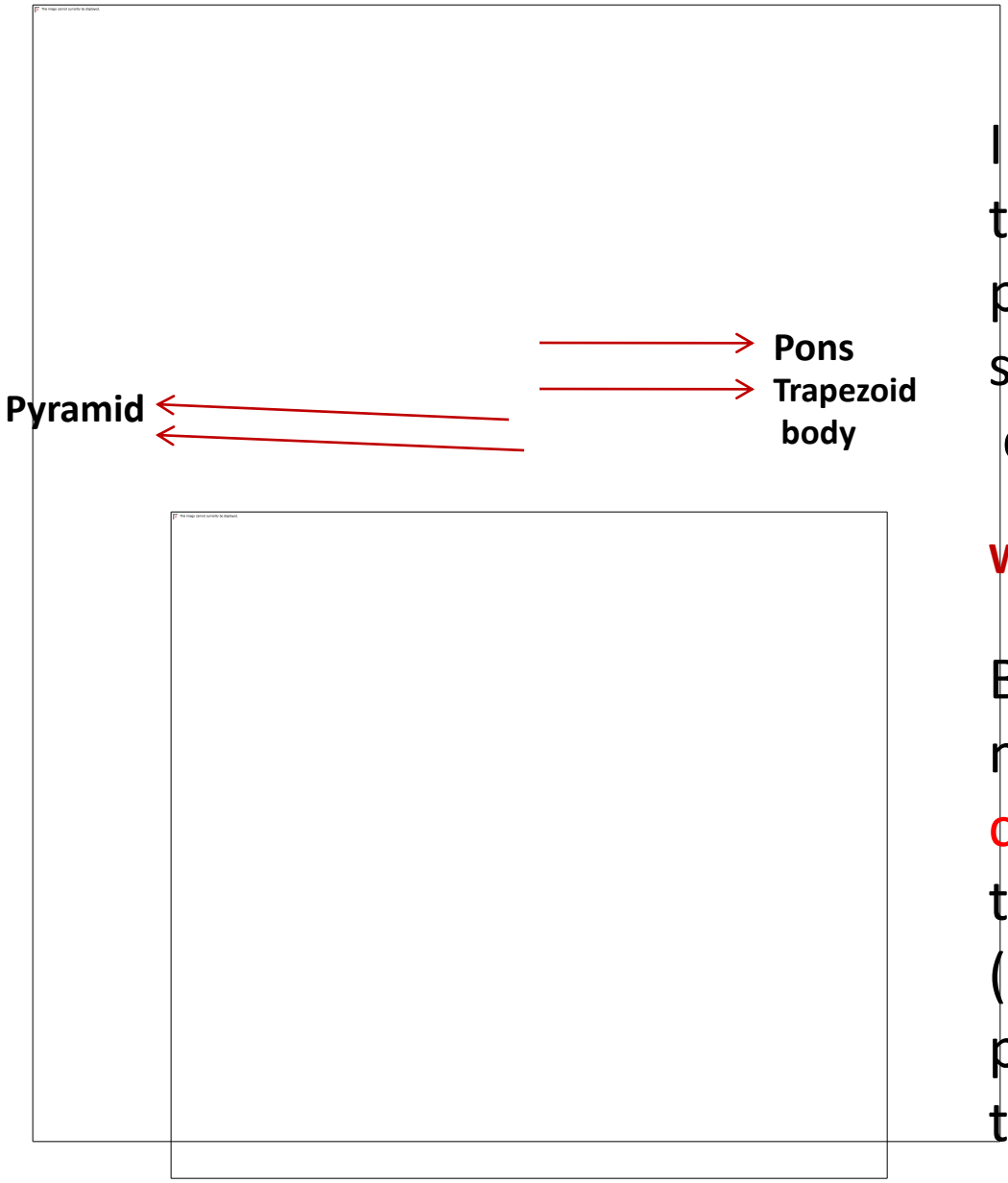
Function: Control respiration, circulation, food intake, reflex for the protection of eye.

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)

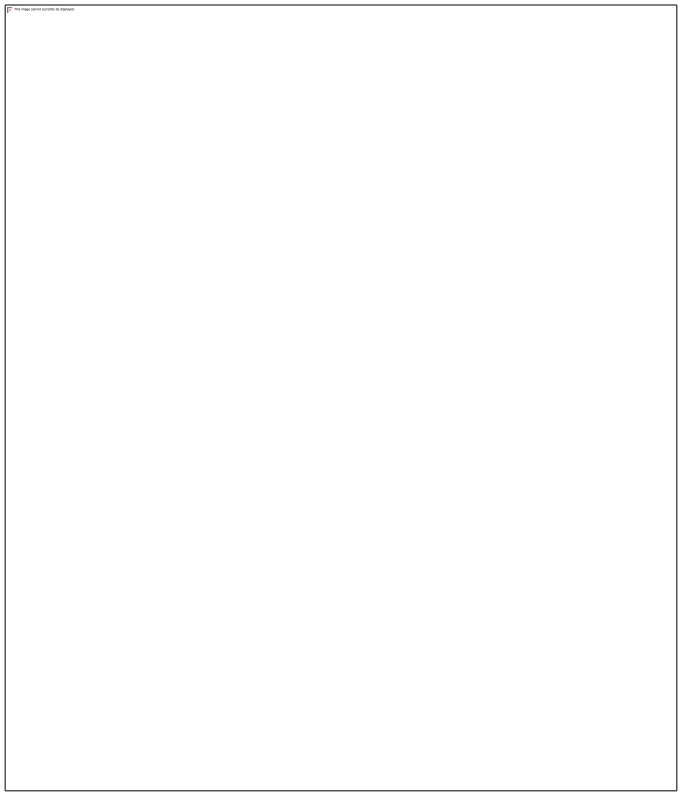


In higher vertebrates damage of the cortex of one side make permanent paralysis of the skeletal muscles of the contralateral side.

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.

Clinical Neurology-Extrapyramidal System

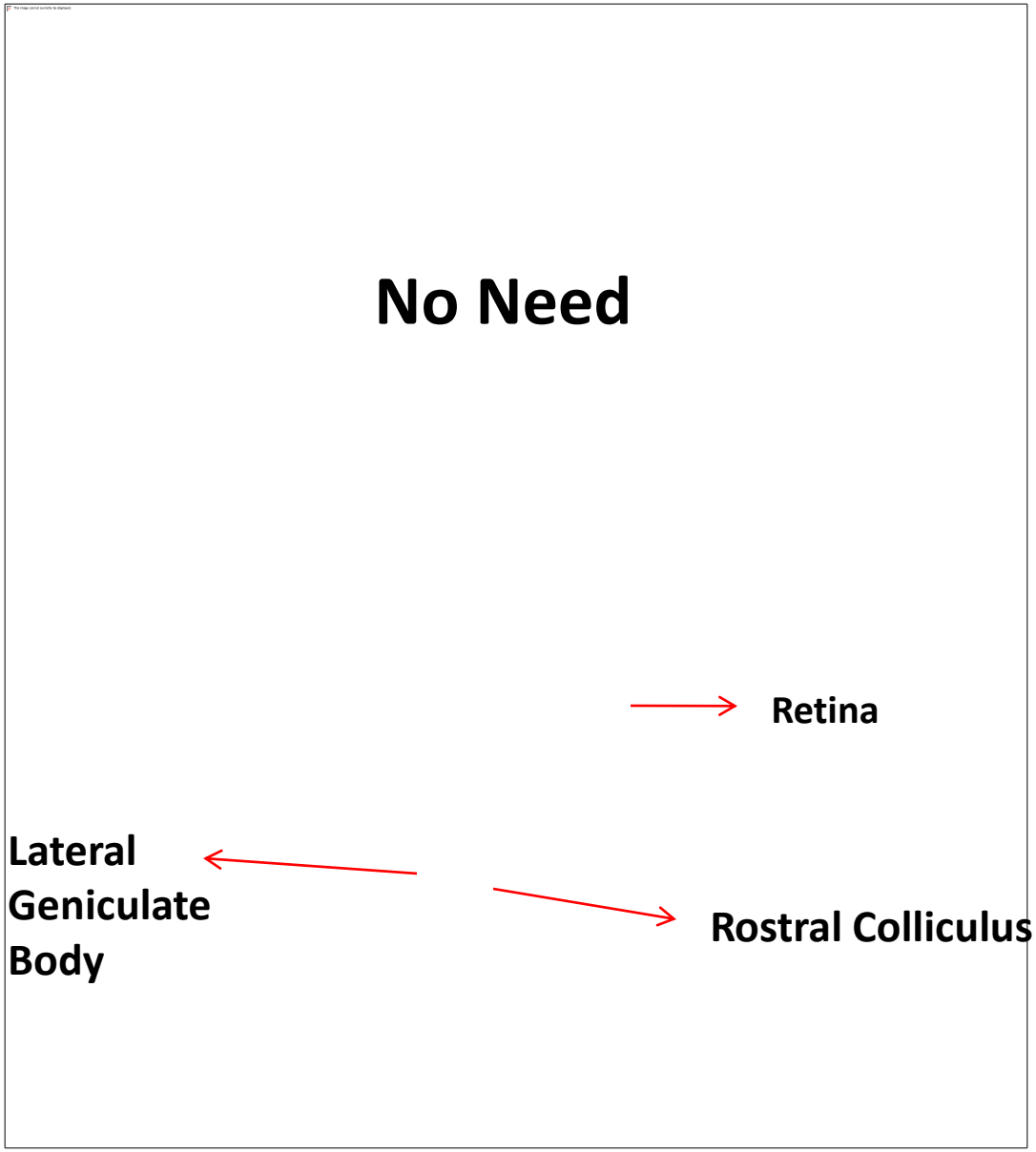


In extrapyramidal system the motor nerve originate from basal ganglia, substantia nigra, subthalamic nuclei, red nuclei, and reticular formation and don't reach their targets by travelling through the pyramid of the medulla.

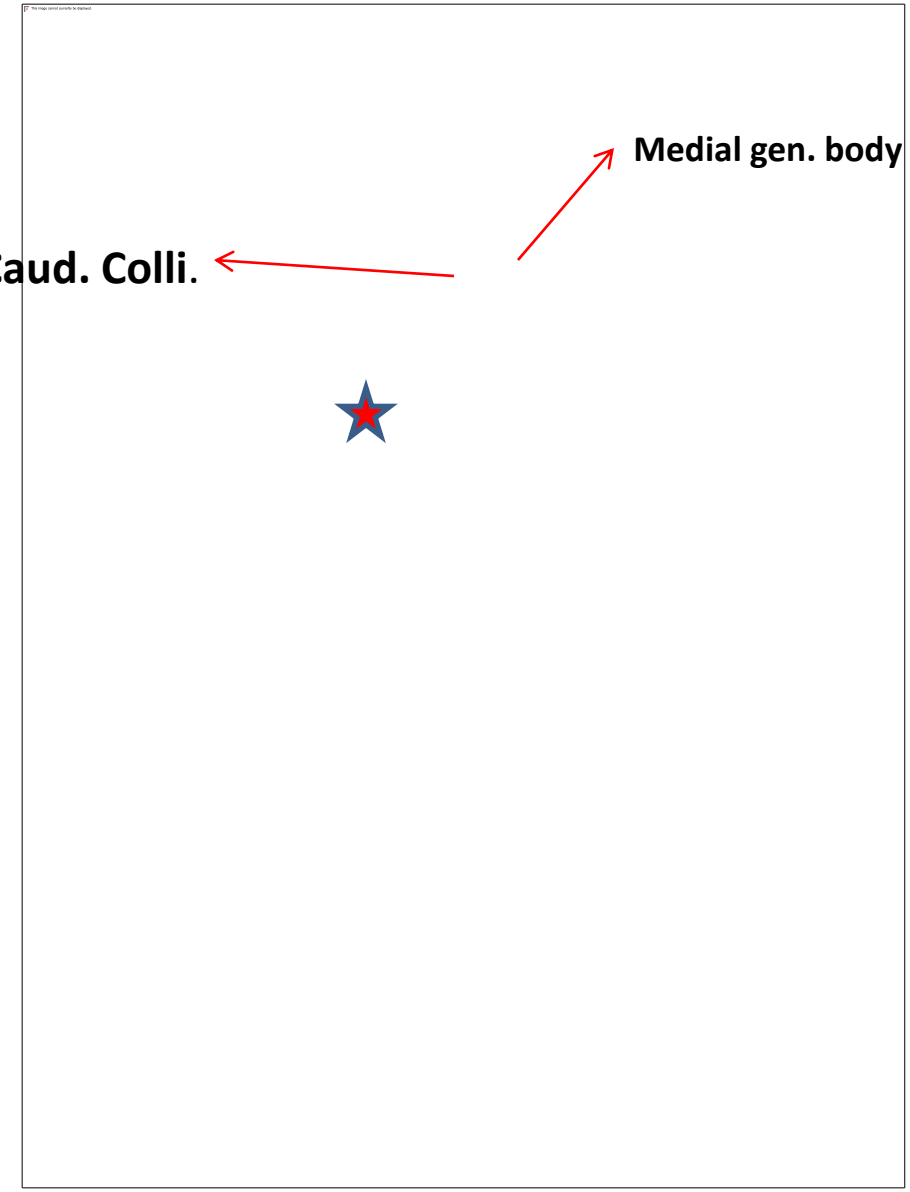
Function and control:

- **Maintenance of posture**
- **Coordination of muscular activity.**

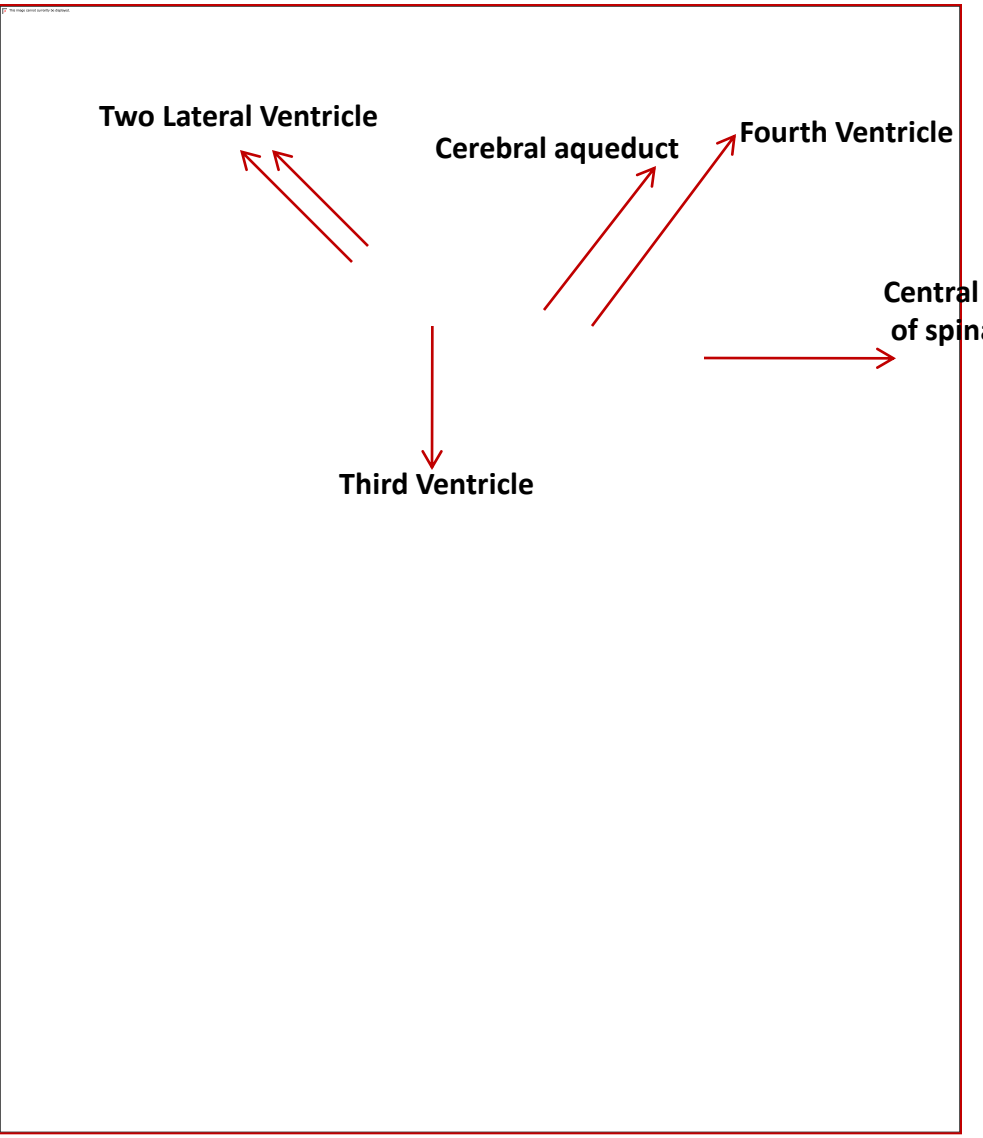
Vision Pathway



Hearing Pathway



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

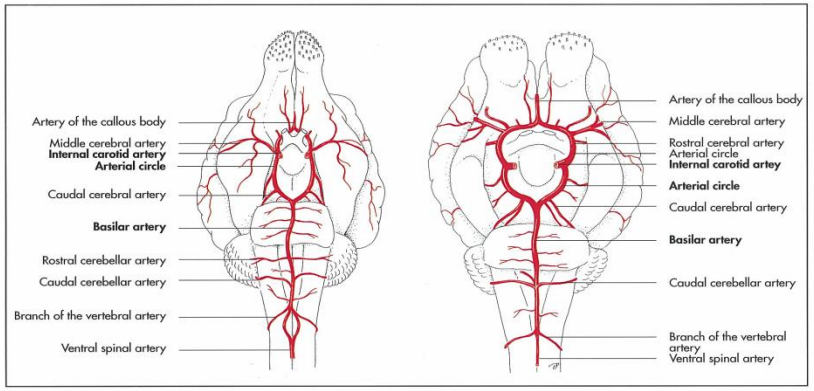


Fig. 14-44. Basal arteries of the brain of the dog, left (Budras, 1996) and the horse, right (Rösslein, 1987), ventral aspect.

sists of the rostral and caudal **epidural rete mirabile,** which reunite in the **cerebral carotid artery.** The internal carotid artery of the pig also forms a rostral rete mirabile.

The **internal carotid artery** in the horse and dog and the cerebral carotid artery in the other domestic mammals penetrates the dura mater at the **diaphragma sellae** and forms a **ring** around the infundibular stalk ventral to the hypothalamus. This **cerebral arterial circle** (circulus arteriosus cerebri), formerly known as the **Circle of Willis,** is only complete in the dog, while it remains open rostrally in the other domestic mammals (Fig. 14-44 and 45). The arterial circle is joined caudally by the **basilar** and the **vertebral arteries.** In the ox, the vertebral artery contributes a considerable proportion to the circle of Willis. The arterial cerebral circle and the basilar artery give rise to all other cerebral arteries (Fig. 14-44 to 50).

The main branches are the:

- Rostral cerebral artery (a. cerebris rostralis),
- Middle cerebral artery (a. cerebri media),
- Caudal cerebral artery (a. cerebri caudalis),
- Rostral cerebellar artery (a. cerebelli rostralis) and
- Caudal cerebellar artery (a. cerebelli caudalis).

The **main cerebral arteries** are located on the surface of the brain from which they extend small arteries and arterioles into the neural tissue, which then branch into smaller vessels. While the **grey matter** contains a very dense network of capillaries, the **white matter** receives a less generous blood supply (Fig. 14-47 and 48).

The permeability of the blood capillaries within the neural tissue is reduced by the so-called **blood-brain barrier,** which is formed by the endothelium of the capillaries and the surrounding glial cells.

Intracerebral anastomoses are rare and, when present, so narrow, that they connect functional end-arteries. Occlusion of one of these end arteries e.g. by blood clots, air or fat emboli results in the death of the neural tissue it supplies. In human beings, the middle cerebral artery and its branches seem to be predisposed.

The **veins of the brain** can be grouped in **dorsal, basal** and **inner veins,** that are **valve-less** and run independently from the arteries before they open into the also valve-less **dural venous sinuses** (sinus durae matris) (Fig. 14-47 and 48). The sinuses enclosed within the dura mater are divided in dorsal and ventral systems.

The **dorsal system** includes the **dorsal sagittal sinus,** which collects the blood from the dorsal parts of the brain and the bones of the cranial vault. It passes within the falx cerebri and is joined towards its caudal end by the straight sinus before dividing into the transverse sinuses, which extend to both sides in the membranous tentorium cerebelli.

The **transverse sinuses** receive the blood from the cerebellar veins. The transverse sinuses unite with the **temporal sinus,** which opens in the retroarticular foramen and connects with the **ventral system** (except in the horse). The straight sinus is continuous with the great cerebral vein, which drains the inner parts of the brain.

The **ventral or basilar system** drains the ventral part of the brain and parts of the face. It consists of the cavernous sinus, which **surrounds the hypophysis** and is closely related to the distal sigmoid end of the internal carotid artery or the **epidural rete mirabile** respectively. The ventral system re-

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 Cerebellum

Hemisphere of Cerebrum

Longitudinal fissure

Transeverse fissure

Vermis of Cerebellum

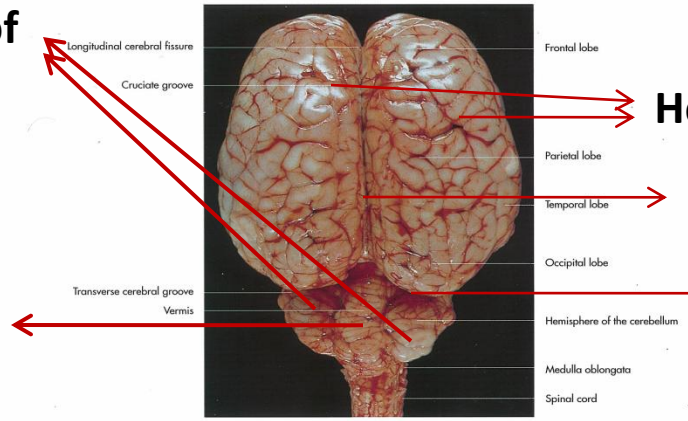


Fig. 14-17. Brain of a horse, dorsal aspect.

The **deep longitudinal cerebral fissure,** which is flanked by the marginal and suprasylvian sulci, separates the **left** and **right hemisphere** (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 pseudosylvian fissure in which the middle cerebral artery ascends. Rostral and caudal to the pseudosylvian fissure runs the rostral and the caudal ectosylvian sulci. The rhinal sulcus divides the neopallium from the rhinencephalon.

The **medial surface** features the splenial sulcus, which divides the **neopallium** from the **archipallium.** Caudodorsal to the splenial sulcus passes the ectosplenial sulcus. Close to the commissure of the cerebral hemispheres, is another sulcus (sulcus corporis callosi) and rostral to it the genual 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 stem ganglia) (Fig. 14-19, 21, 24 and 26).

The corpus striatum includes the following structures:

- Caudate nucleus (nucleus caudatus),
- Putamen,
- Claustrum and
- Amygdaloid body (corpus amygdaloideum).

The **caudate nucleus** protrudes at the rostral part on the floor of the **lateral ventricle** (Fig. 14-18 to 22). Lateroventral 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 sustance (Fig. 14-19 and 26). Between the putamen and the claustrum, pass the fibres of the **external capsule** (capsula externa). A thin band of white substance (capsula extrema) 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)

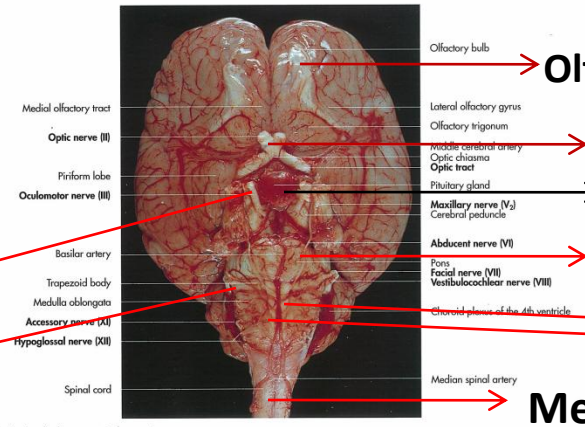


Fig. 14-16. Brain of a horse, ventral aspect.

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 cribriform 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 fossa** (Fig. 14-14, 16 and 21). The rhinencephalon continues caudally with the **olfactory peduncle** (pedunculus olfactorius), that extends from the olfactory bulb to bifurcate into the medial and lateral olfactory tract. The olfactory tracts border a **triangular area** (trigonum olfactorium), that constitutes, together with the **rostral perforate substance** (substantia perforata rostralis), the olfactory area. The rostral perforated area is located caudal to the olfactory trigone and is perforated by numerous blood vessels.

The **larger lateral olfactory tract,** continues caudally as the **piriform lobe** (lobus 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 gyri, the piriform lobe and the hippocampus. The **subcortical part** includes components of the diencephalon (habenula, hypothalamus, thalamus), midbrain (interpeduncular and tegmental nuclei) and the amygdaloid body.

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

Neopallium and cerebral hemispheres

The neopallium constitutes the major part of the telencephalon, forming the dorsolateral part of each hemisphere, interposed between the ventral paleopallium 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.

Practical (Sagittal view of brain of horse)

Corpora Quad.

Epithalamus

Cerebellum

Sep. Pellucidum

Medulla Oblong.

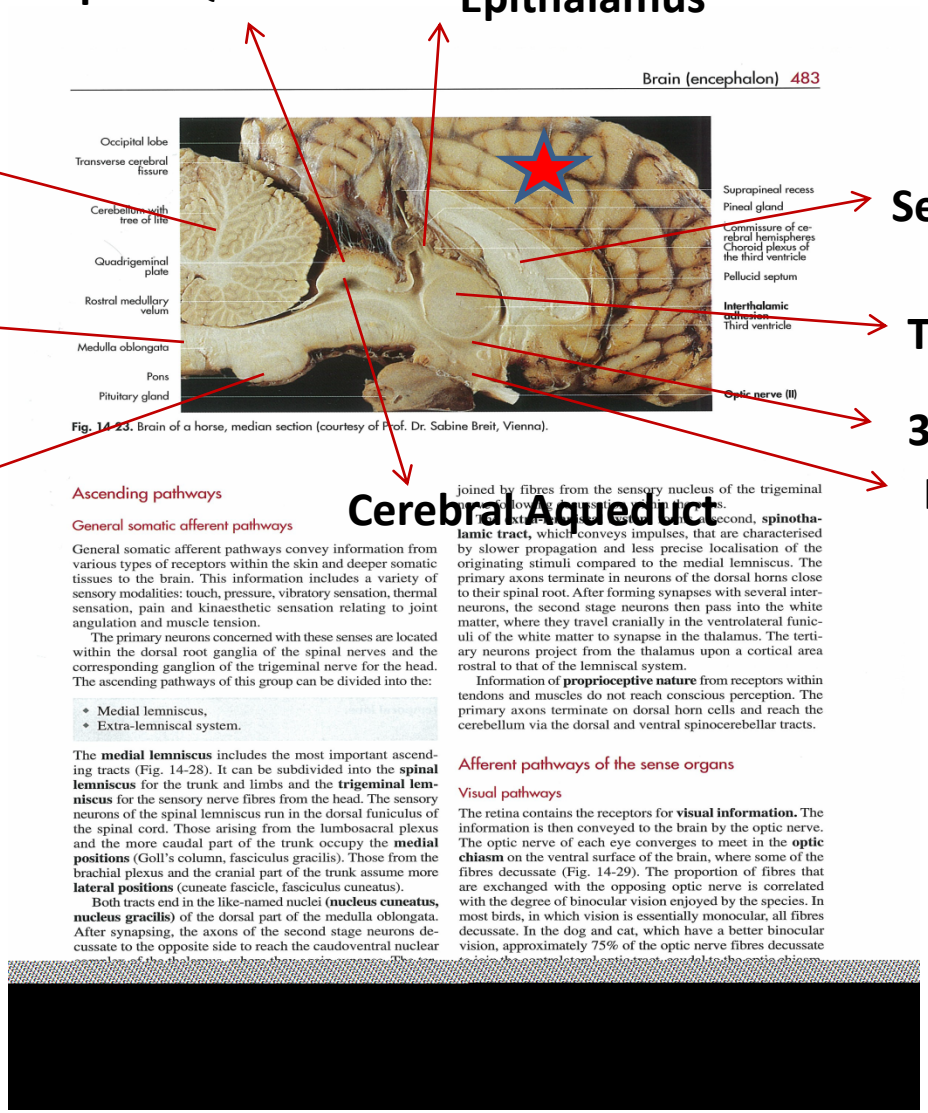
Thalamus

3rd Ventricle

Pons

Cerebral Aqueduct

Hypothalamus



Occipital lobe
Transverse cerebral fissure
Cerebellum with tree of life
Quadrigeminal plate
Rostral medullary velum
Medulla oblongata
Pons
Pituitary gland

Suprapineal recess
Pineal gland
Commissure of cerebral hemispheres
Choroid plexus of the third ventricle
Pellucid septum
Interthalamic adhesion
Third ventricle
Optic nerve (II)

Fig. 14-23. Brain of a horse, median section (courtesy of Prof. Dr. Sabine Breit, Vienna).

Ascending pathways

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

- Medial lemniscus,
- Extra-lemniscal system.

The **medial lemniscus** includes the most important ascending tracts (Fig. 14-28). It can be subdivided into the **spinal lemniscus** for the trunk and limbs and the **trigeminal lemniscus** for the sensory nerve fibres from the head. The sensory neurons of the spinal lemniscus run in the dorsal funiculus of the spinal cord. Those arising from the lumbosacral plexus and the more caudal part of the trunk occupy the **medial positions** (Goll's column, fasciculus gracilis). Those from the brachial plexus and the cranial part of the trunk assume more **lateral positions** (cuneate fascicle, fasciculus cuneatus).

Both tracts end in the like-named nuclei **(nucleus cuneatus, nucleus gracilis)** of the dorsal part of the medulla oblongata. After synapsing, the axons of the second stage neurons decussate to the opposite side to reach the caudoventral nuclear

joined by fibres from the sensory nucleus of the trigeminal

second, **spinothalamic tract,** which conveys impulses, that are characterised by slower propagation and less precise localisation of the originating stimuli compared to the medial lemniscus. The primary axons terminate in neurons of the dorsal horns close to their spinal root. After forming synapses with several interneurons, the second stage neurons then pass into the white matter, where they travel cranially in the ventrolateral funiculi of the white matter to synapse in the thalamus. The tertiary neurons project from the thalamus upon a cortical area rostral to that of the lemniscal system.

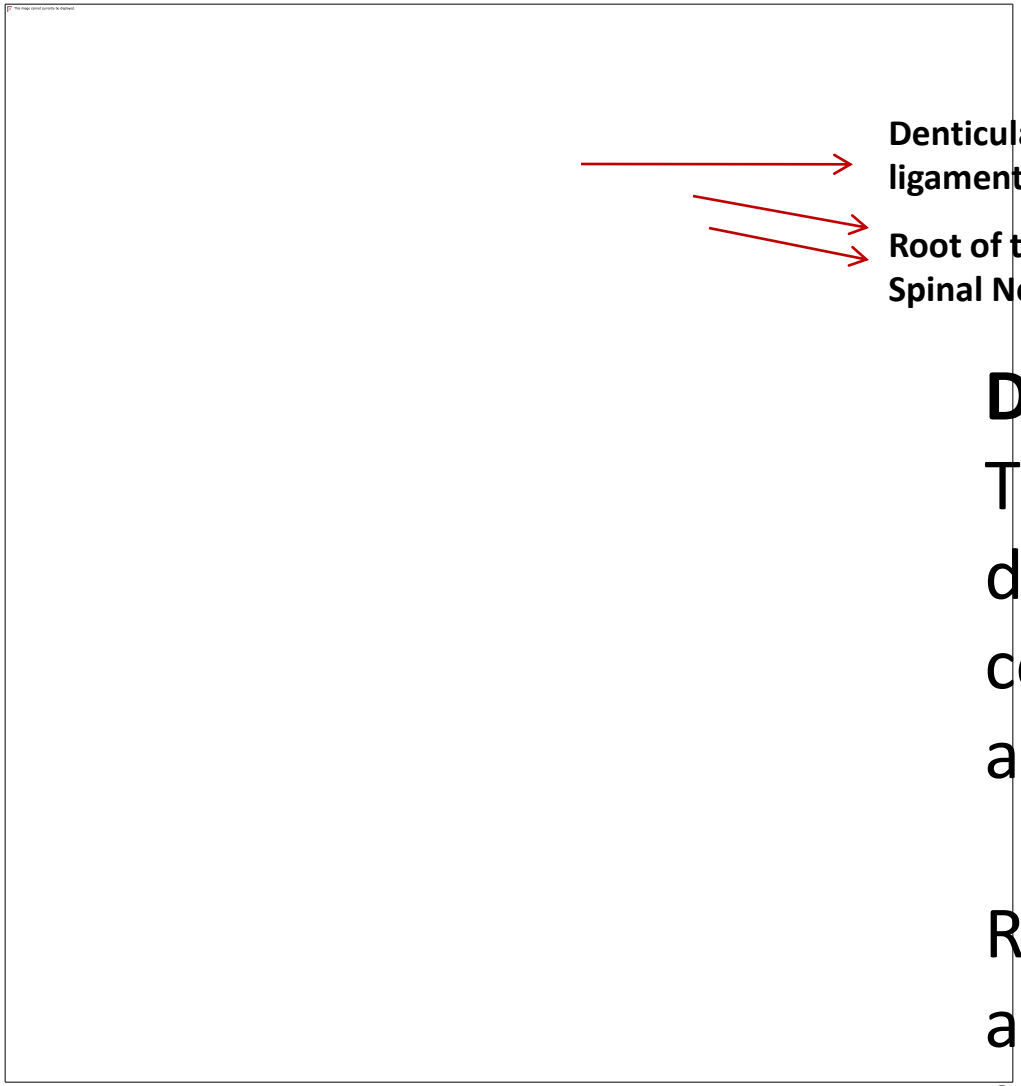
Information of **proprioceptive nature** from receptors within tendons and muscles do not reach conscious perception. The primary axons terminate on dorsal horn cells and reach the cerebellum via the dorsal and ventral spinocerebellar tracts.

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 fibres decussate (Fig. 14-29). The proportion of fibres that are exchanged with the opposing optic nerve is correlated with the degree of binocular vision enjoyed by the species. In most birds, in which vision is essentially monocular, all fibres decussate. In the dog and cat, which have a better binocular vision, approximately 75% of the optic nerve fibres decussate

Spinal Cord and its Covering



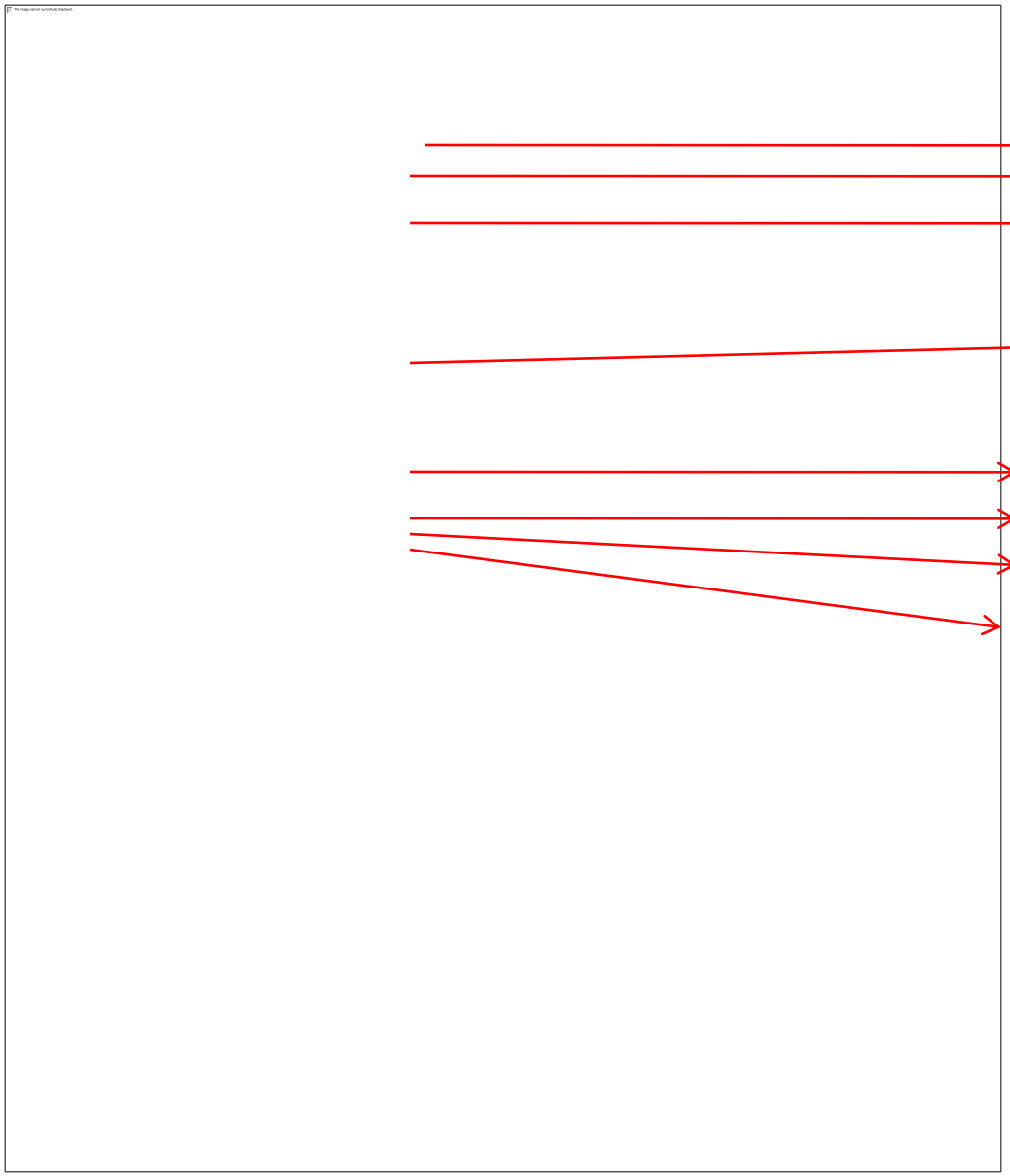
Meninges: Similar to the Covering of Brain

Denticulate Ligament

Thickening of Dura mater due to accumulation of collagen fibers in some areas of the dura.

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

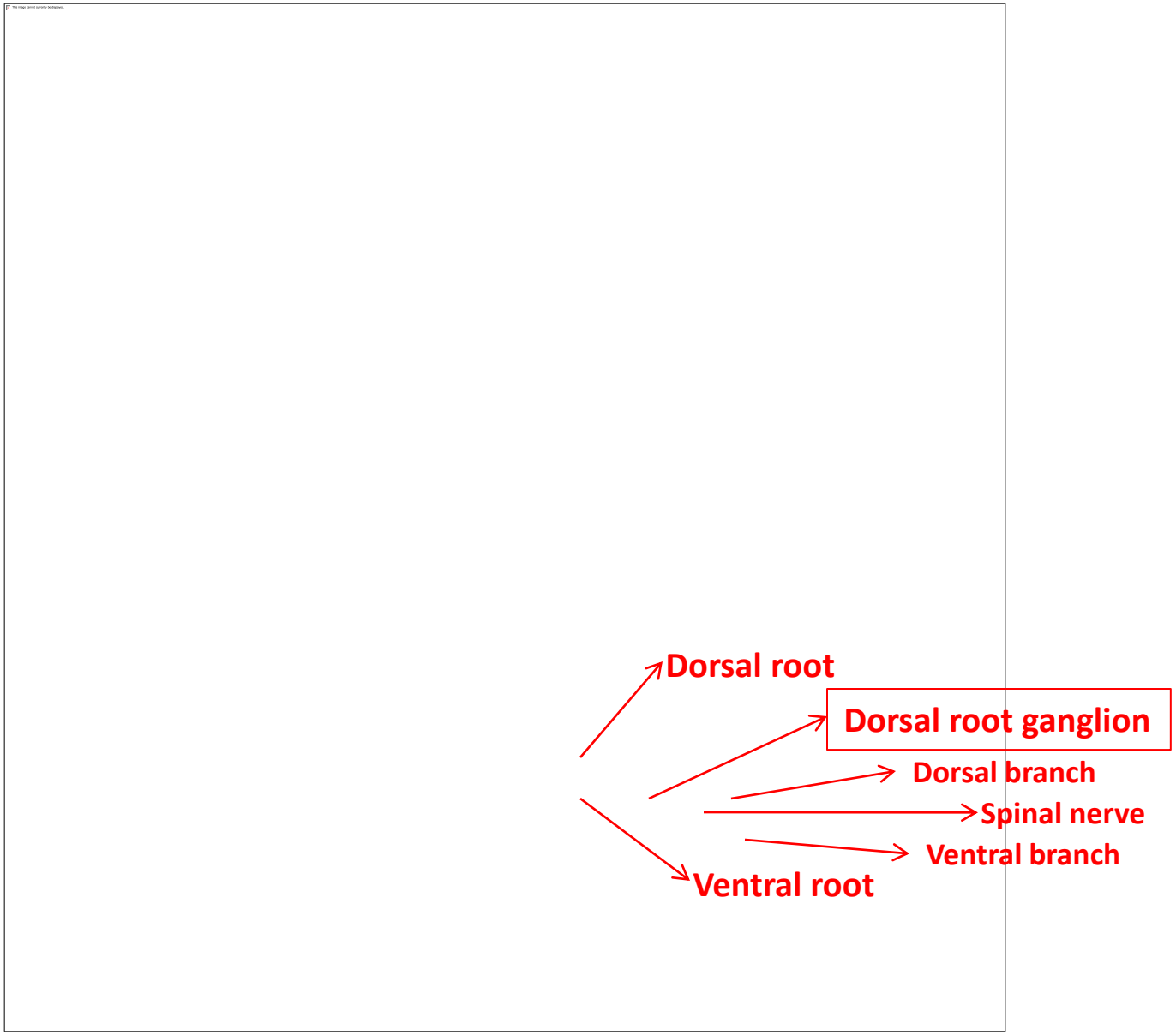
Different Segments of the Spinal Cord



Conus medullaries and 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



Grey and White mater of the spinal cord