

COMPARATIVE ANATOMY OF BRAIN IN VERTEBRATES

Ms. Sarojmoni Sonowal
Assistant Professor
Department of Zoology
Pub Kamrup College

BRAIN

The brain is an **organ** that serves as the **Centre of Nervous System** in all Vertebrate animals. **All vertebrate brains share a common underlying form which appears most clearly during early stages of development.**

In its earliest form the brain appears as **three swellings at the front end of the neural tube**; these swellings eventually become the forebrain, midbrain and hindbrain (prosencephalon, mesencephalon and rhombencephalon).

In the initial stages of brain development, **the three areas are roughly equal in size.** In many classes of vertebrates, such as **Pisces and Amphibians**, the three parts remain **similar in size in the adult,**

but in **Mammals** the forebrain becomes much larger than the other parts, and **the midbrain becomes very small.**

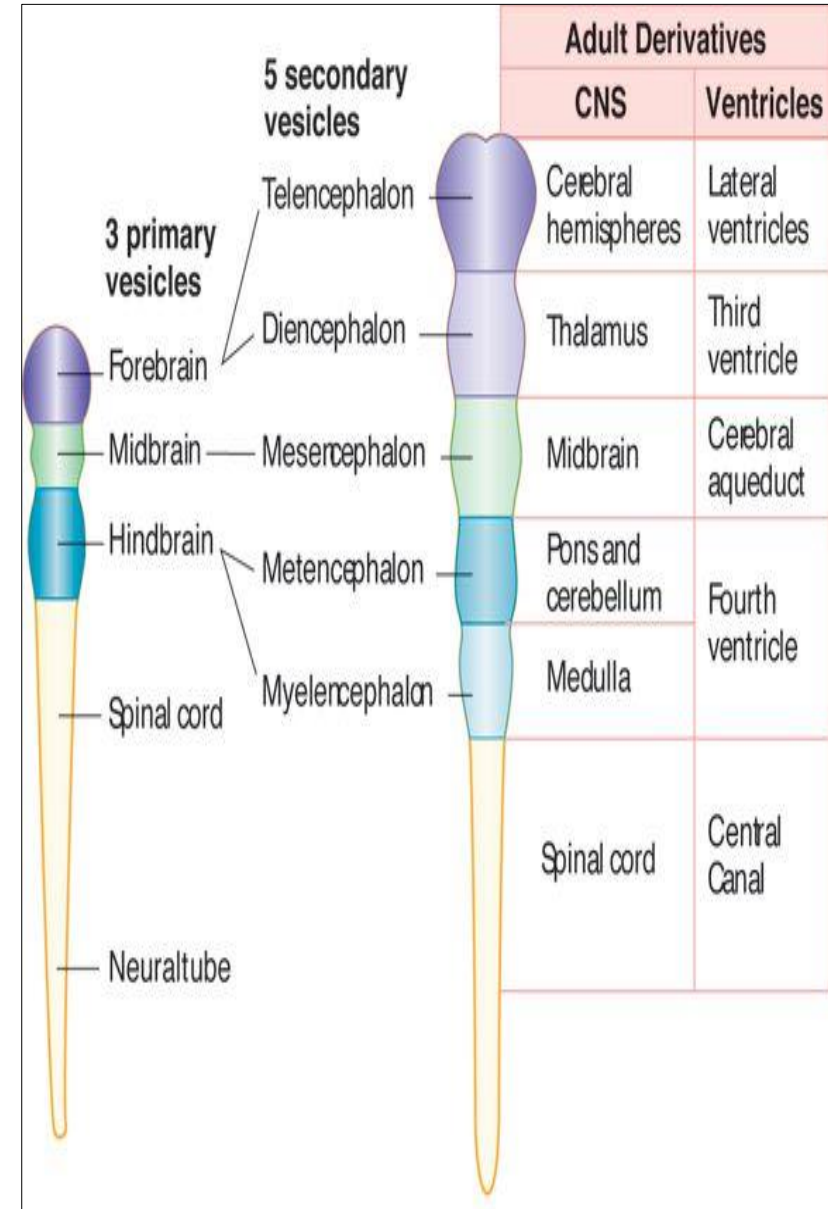
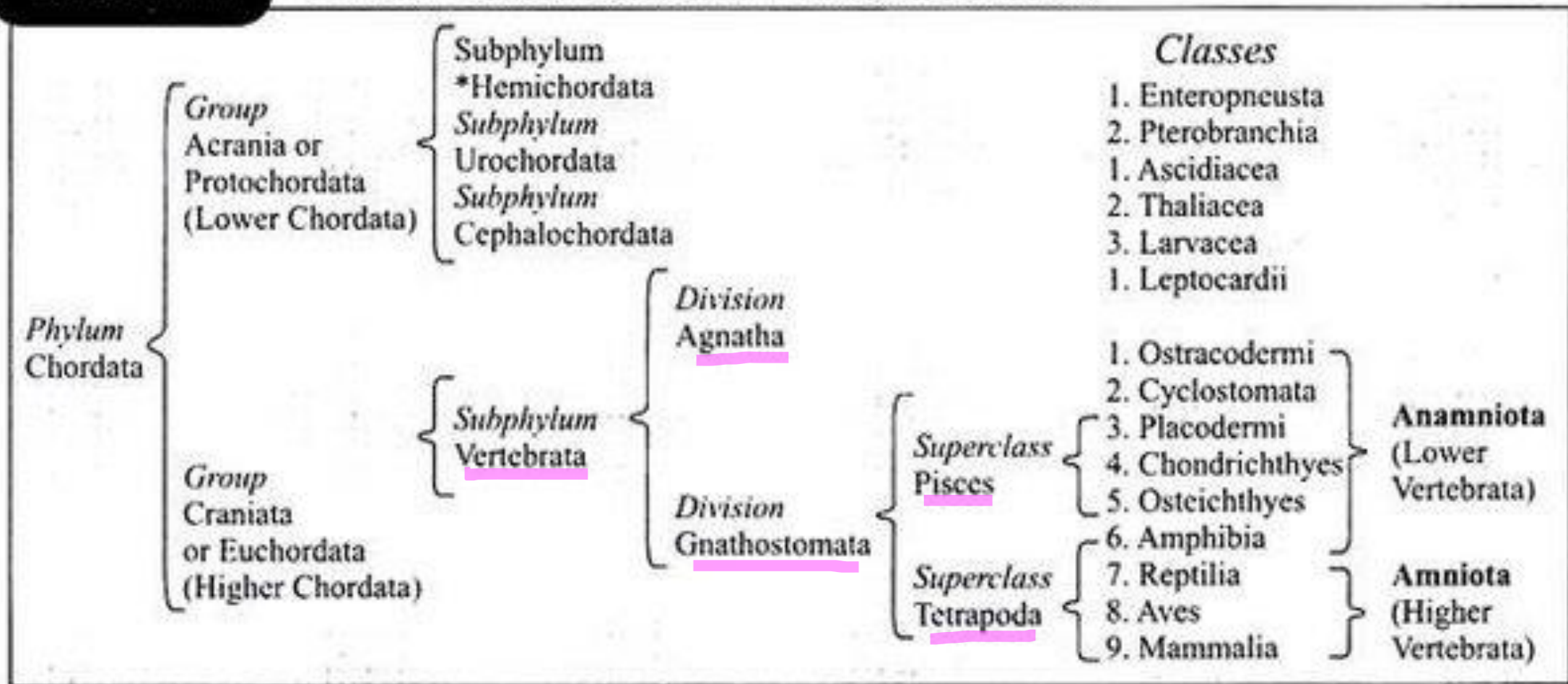
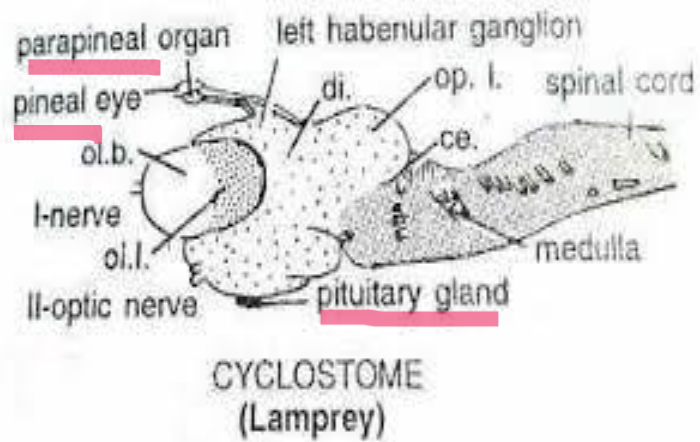


TABLE 1.2.

OUTLINE CLASSIFICATION OF PHYLUM CHORDATA.



*Subphylum Hemichordata is now considered to be an invertebrate group.



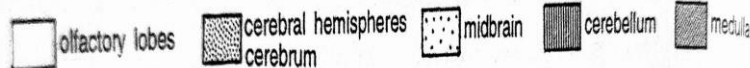
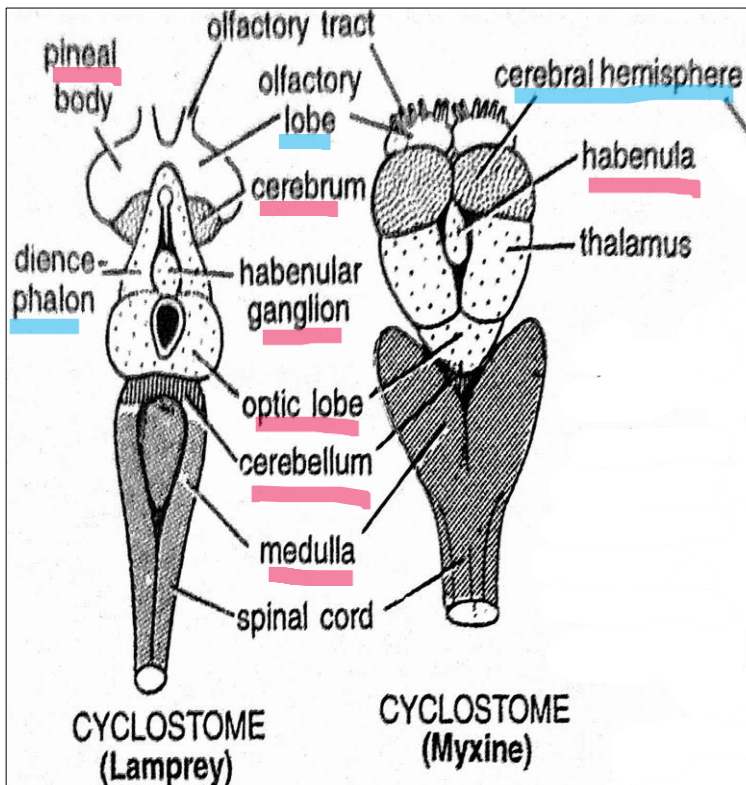
Brain of all vertebrates is built in accordance with the **same basic structural plan**. However, form of brain differs in different vertebrates in **accordance with the habits and behavior of the animals**.

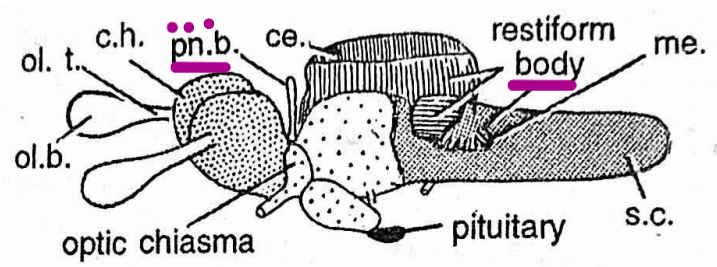
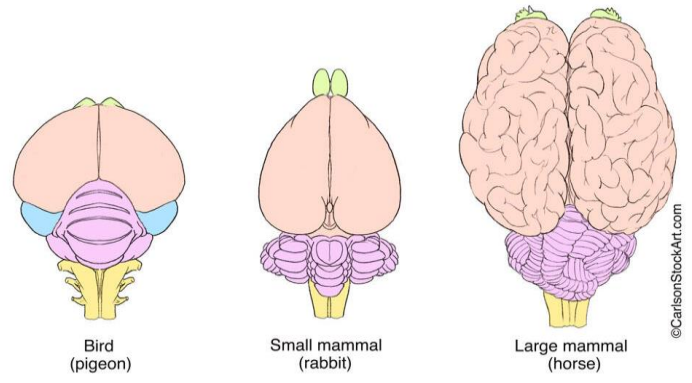
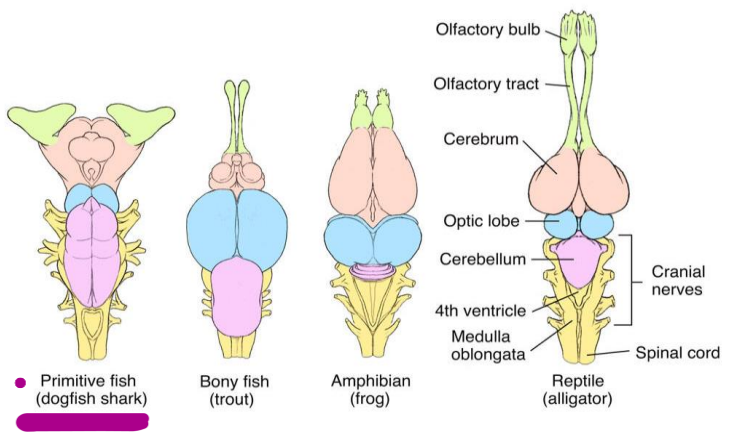
BRAIN OF CYCLOSTOMES (Jawless Fish Like Vertebrates-AGNATHA)

- ❖ **Brain of cyclostomes is very primitive and elongated**
- ❖ **The brain is divisible into three primary parts viz; Forebrain, Midbrain and Hindbrain but subdivision is not well marked.**
- ❖ **The forebrain includes large paired olfactory lobes** (lobes prominent). The Cerebral hemispheres are **quite small**, attached to the diencephalon.
- ❖ Cavities of the cerebral hemispheres or **lateral ventricles are rudimentary**. **Pineal apparatus and Para pineal body** are very **well developed in lamprey** and **absent in Myxine**.

Connected to the pineal apparatus is epithalamus made up of 2 habenula gangli
A well define Infundibulum from hypothalamus of diencephalon bears a hypophysis or **pituitary body**.

- ❖ **The midbrain** possesses a pair of large optic lobes rather dorsally placed.
- ❖ **The hind brain** is differentiated into a small transverse dorsal band-**the Cerebellum** and **much larger and well-defined Medulla Oblongata**. The ventricles within the brain are **four** as in other vertebrates.





ELASMOBRANCH FISH (Shark)

Fig. 7. Brains of representative vertebrates in lateral view. ce.—cerebellum, c.h.—cerebral hemisphere, di.—diencephalon. inf.—infundibulum. m.—medulla oblongata. ol.b.—olfactory bulb. ol.i.—olfactory lobe. ol.t.—olfactory tract, op.l.—optic lobe. pi.—pituitary, pn.b.—pineal body, s.c.—spinal cord.

PISCES (FISHES):

❖ Brain of Fishes is **more advanced** than Cyclostomes. However, subdivisions of brain are seen in primitive relations.

CHONDRICHTHYES/Elasmobranchs (Cartilaginous Fishes)

- ❖ Brain **enclosed within a cartilaginous cranium**
- ❖ Brain **simple, elongated, flattened** thrice as long as broad. Made up of **3 basic parts-** forebrain, midbrain and hindbrain.
- ❖ Brain protected by a **single membrane- meninx primitiva**
- ❖ **Forebrain-olfactory lobes** of brain are correspondingly large, bilobes, sense of smell highly developed, **attached anterolaterally to Cerebrum by short olfactory tracts.**
- ❖ Pineal apparatus is well developed.
- ❖ **Cerebrum large, somewhat rectangular.** It has **no median groove** dividing it into right and left cerebral hemispheres. **No corpus Callosum**
- ❖ **Surface smooth with no folds, fissures and lobes**
- ❖ **Midbrain** cavity (III ventricle) is quite large and extends into optic lobes.

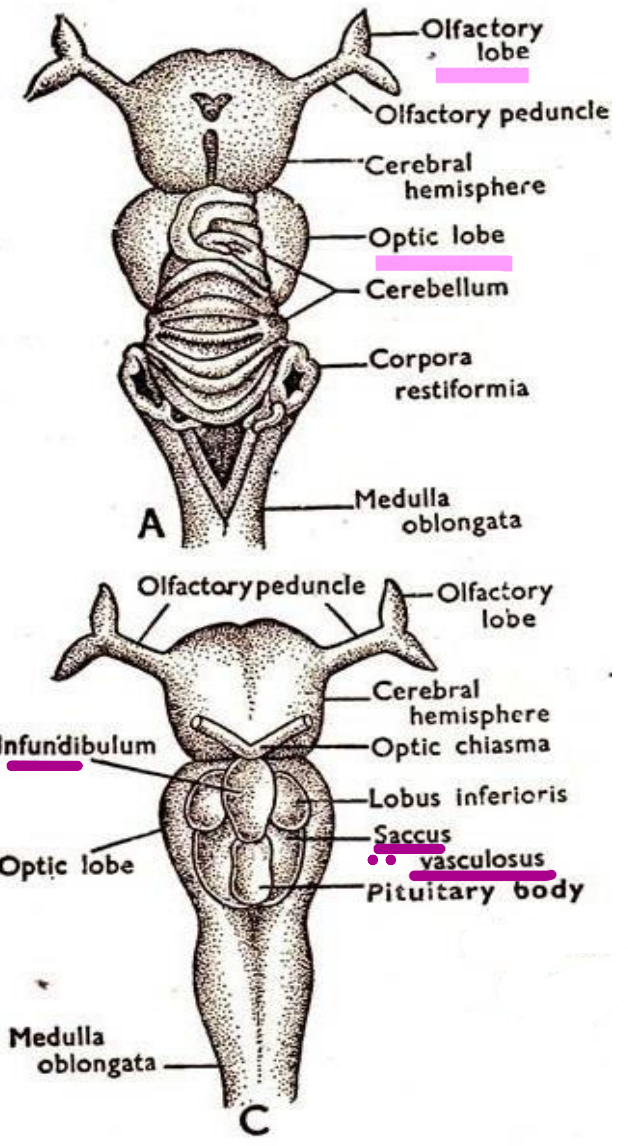
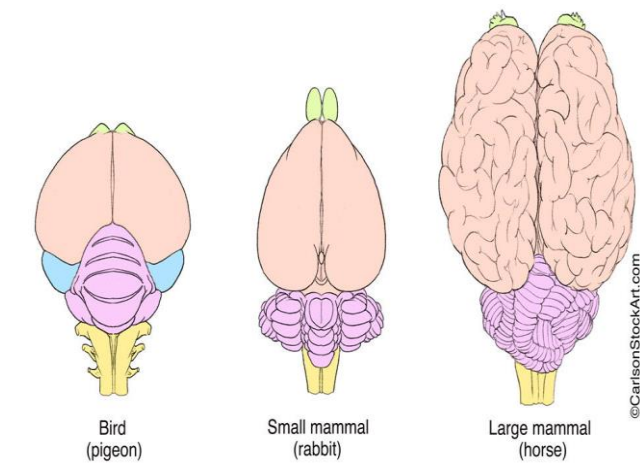
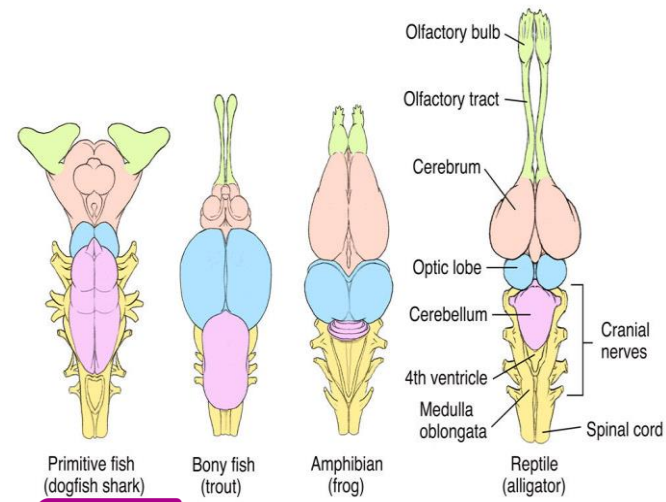


Fig. 37. *Scoliodon* sp. Brain
A. *Scoliodon* (dorsal view)
C. *Scoliodon* (ventral view)

CHONDRICHTHYES/Elasmobranchs (Cartilaginous Fishes)

CONTINUE



Dorsal view

- ❖ Dorsal side consists of two large hollow optic lobes which remains mostly concealed by Cerebellum-controls vision
- ❖ A thin-walled vascular sensory organ called saccus vasculosus is attached to pituitary and connected by fibre tracts with cerebellum (ventral side)
- ❖ Cerebellum of Hindbrain is especially large, elongated due to active swimming habit.
- ❖ Cerebellum is made up of 3 lobes divided by 2 transverse furrows. So, it bears irregular folds.
- ❖ Medulla oblongata is large, hollow triangular gradually tapering behind partly concealed in front by cerebellum.
- ❖ Medulla bears antero-laterally a pair of irregular thin walled hollow outgrowth -the restiform bodies (Absent in other classes) to assist cerebellum in maintenance of equilibrium.
- ❖ Cranial pairs- 10 pairs

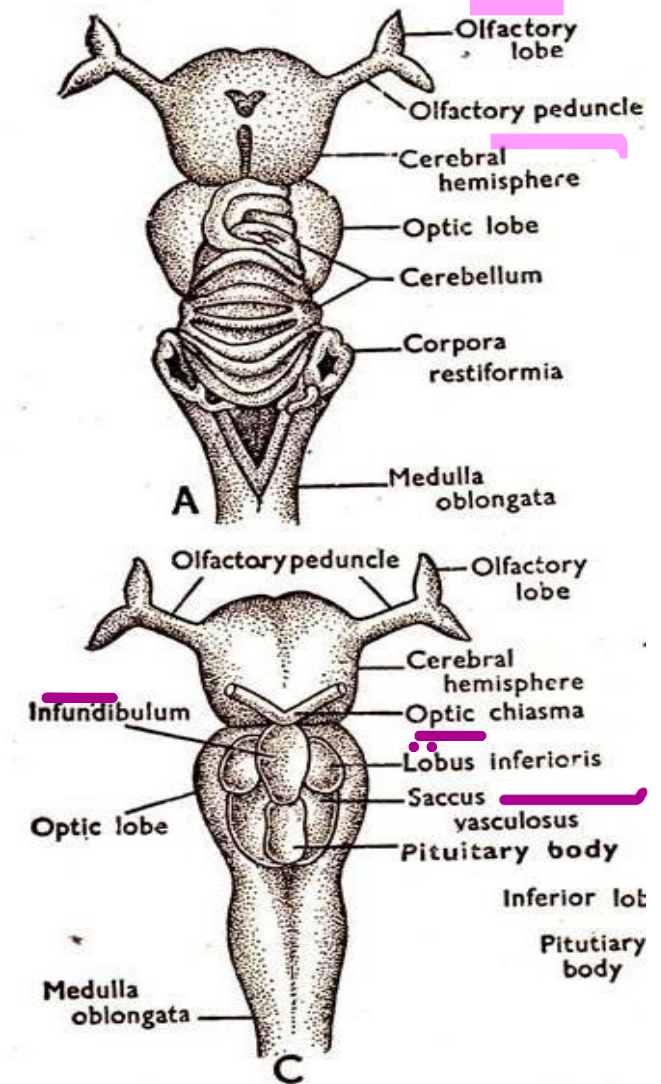
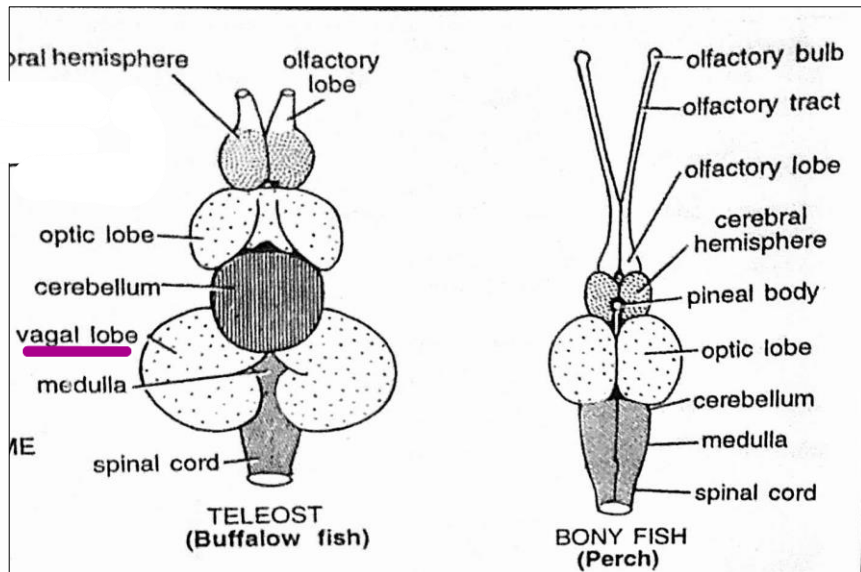
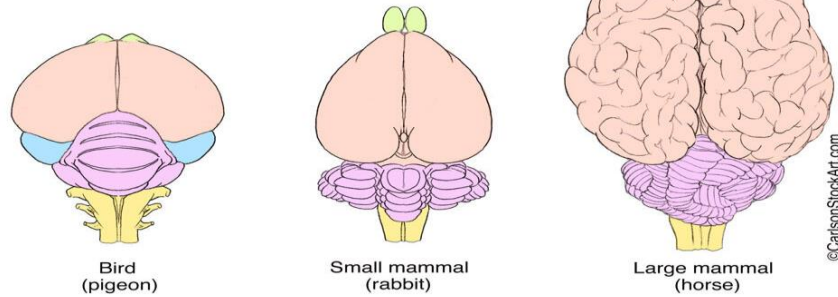
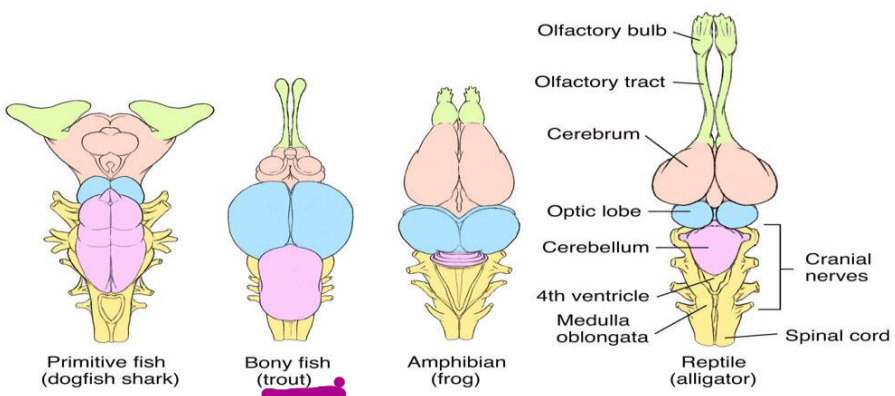
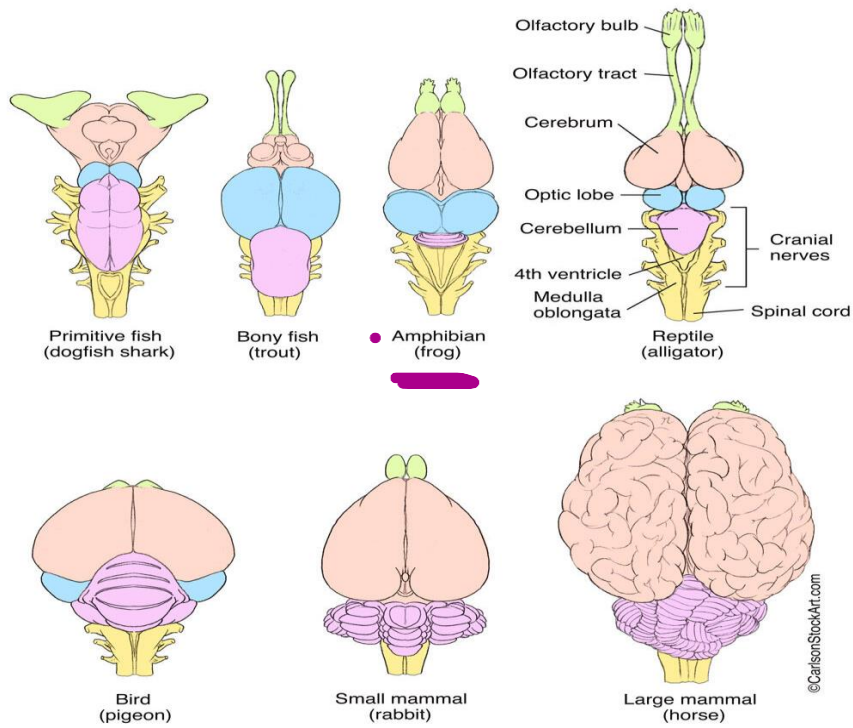


Fig. 37. *Scoliodon* sp. and *Lates* sp. Brain
 A. *Scoliodon* (dorsal view) B. *Lates* (dorsal view)
 C. *Scoliodon* (ventral view) D. *Lates* (ventral view)



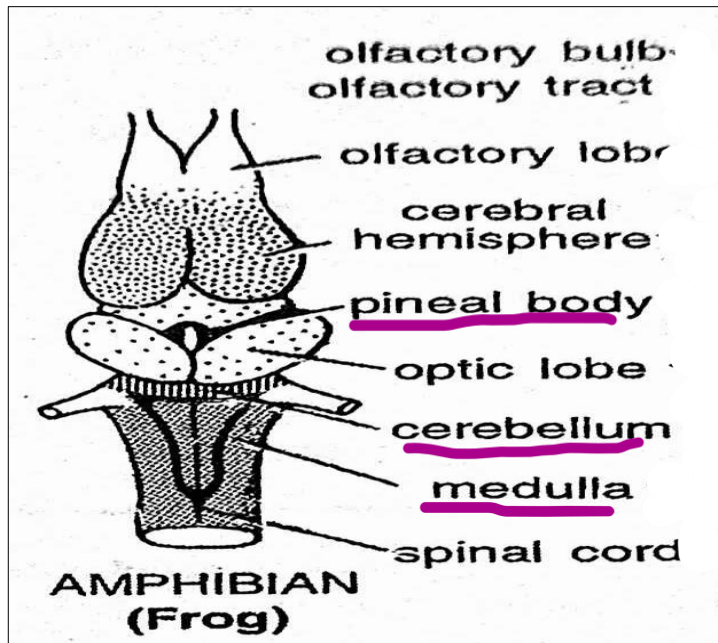
FISHES: Osteichthyes (Bony Fishes)

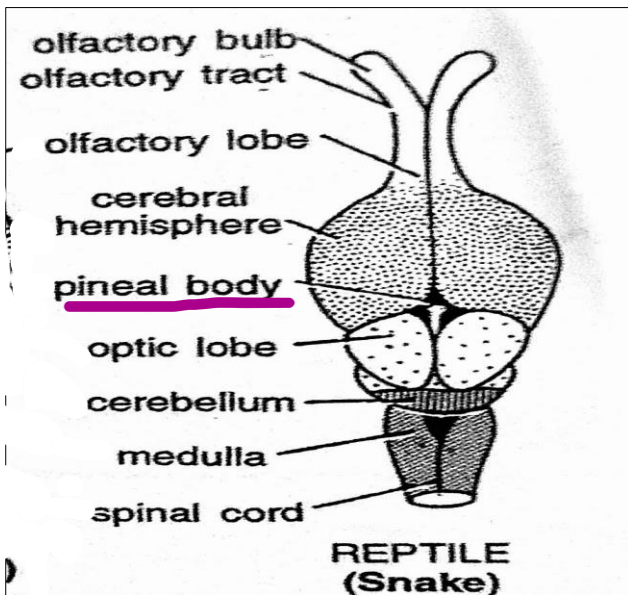
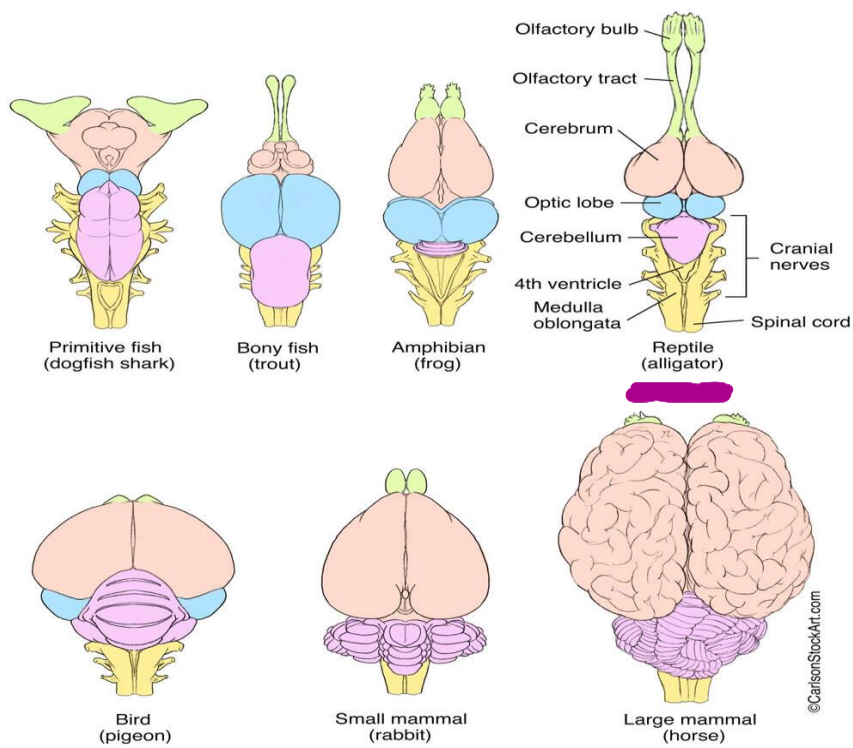
- ❖ In bony Fishes brain is more specialized than in Elasmobranchs.
- ❖ Brain **enclosed within a bony cranium**
- ❖ Brain **simple, elongated, flattened** thrice as long as broad. Also Made up of **3 basic parts**- forebrain, midbrain and hindbrain.
- ❖ **Forebrain:** Olfactory lobes, Cerebral hemispheres and Diencephalon are **smaller** while optic lobes and cerebellum larger than in a shark.
- ❖ Pineal body is absent in modern teleosts (synthesizes and secretes melatonin, a hormone that plays a crucial role in regulating circadian rhythms and influencing various physiological processes)
- ❖ **No Corpus callosum**
- ❖ Cerebellum is smooth with no folding and covers medulla
- ❖ The anterior part of the Cerebellum forms **valvula cerebella** which extend under the optic lobes; it is characteristic of bony Fishes and **controls active movements.**
- ❖ The medulla oblongata is **well developed.**
- ❖ In bottom feeders (Buffalow fish), the antero-lateral side of medulla show unusual bulgings called **vagal lobes**. The primary function of vagal lobes is to enhance the fish's ability to detect vibrations and pressure changes in the water.



AMPHIBIANS:

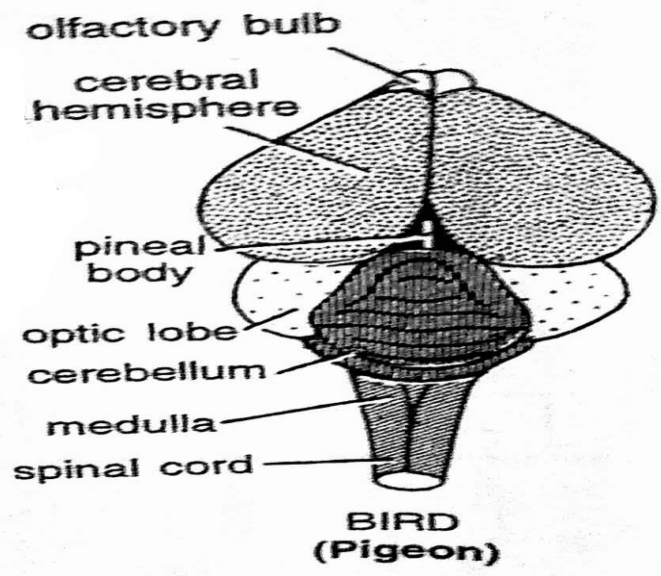
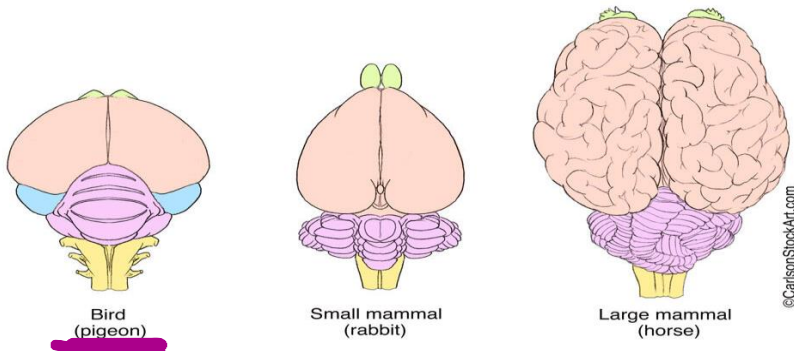
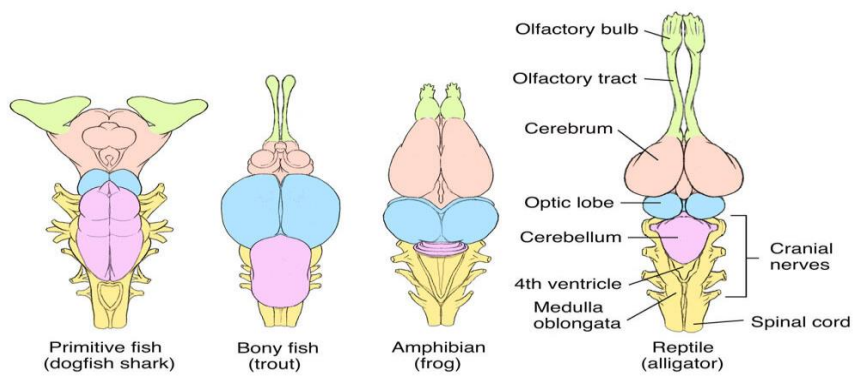
- ❖ The brain of Amphibian (frog) shows many contrasts from that of dogfish. Brain covered by **bony cranium**. Brain simple, elongated and flattened, 3 times longer than broad- made up of forebrain, midbrain and hindbrain.
- ❖ **Brain protected by 2 membranes-** thin inner piamater and thick outer dura mater
- ❖ **Forebrain:** The cerebral hemispheres are more separate from one another than in fishes. A **deep median longitudinal fissures** divides the cerebrum into 2 long oval cerebral spheres- shows greater development in accordance with more complex activities of locomotion, hibernation, breeding etc.
- ❖ Corpus callosum absent
- ❖ **Smaller olfactory lobes with short tract, attached at front of cerebrum demarcated by slight constriction (poor sense of smell)** and **larger optic lobes** indicate a greater reliance on sight rather than smell.
- ❖ Surface smooth without folds fissures and lobes.
- ❖ A small pineal body is present in all the modern Amphibians.
- ❖ **Midbrain:** Dorsal surface made up of 2 large uncovered round and hollow optic lobes
- ❖ The walls of midbrain are thickened and reduce the lumen into a narrow passage called aqueduct.
- ❖ **Hindbrain:** cerebellum is **poorly developed-small, narrow dorsal transverse band** present, beneath optic lobes. Cerebellum is undivided.
- ❖ Medulla is small, conical, hollow and uncovered.
- ❖ Cranial nerves =10 pairs





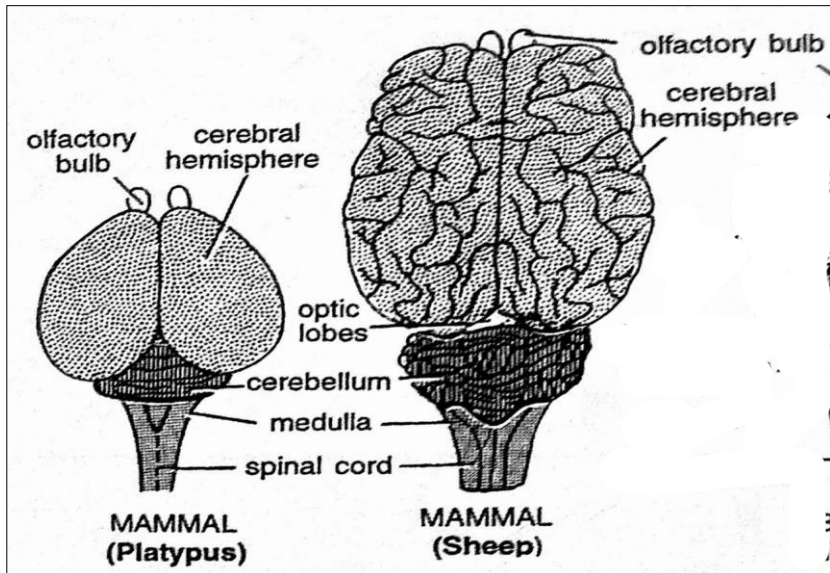
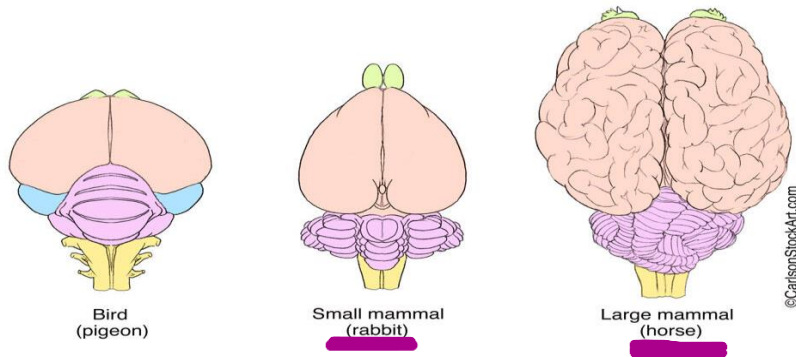
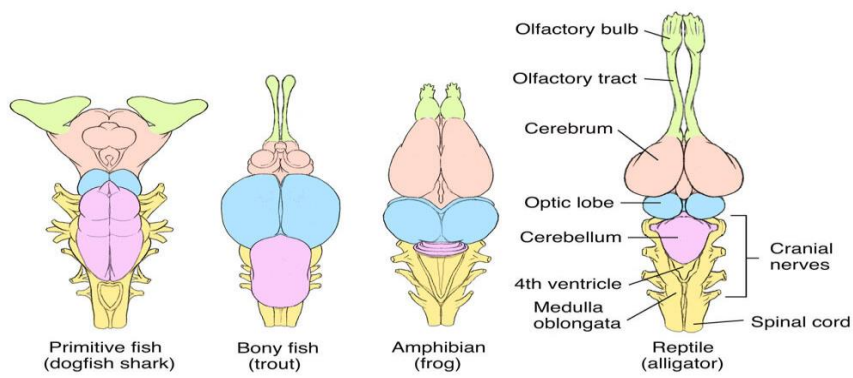
REPTILIANS:

- ❖ Reptilian brain shows advancement in size and proportions over that of Amphibians because of complete terrestrial mode of life. Bony cranium.
- ❖ Brain **elongated and narrow** but **comparatively larger** similarly made of forebrain, midbrain and hindbrain.
- ❖ Brain covered by **two membrane like Amphibians**
- ❖ **Forebrain:** Telencephalon increases to become the **largest part of the brain** (i.e. cerebrum)
- ❖ 2 long Olfactory lobe are connected in front of cerebral hemispheres which are **larger than in amphibians**
- ❖ **2 oval cerebral hemispheres divided by a mid longitudinal fissure- surface smooth. Corpus callosum absent**
- ❖ A fine vomeronasal nerve from the organ of Jacobson goes to the olfactory bulbs.
- ❖ A pair of auditory lobes is found posterior to optic lobes which are not hollow.
- ❖ Para pineal body often called parietal eye is found in sphenodon but **vestigial or absent** in other reptiles.
- ❖ **Midbrain:** 2 medium, oval, dorso-laterally hollow optic lobes present- remains **uncovered**
- ❖ **Hindbrain:** Cerebellum is somewhat pear shaped and larger than in Amphibians. Undivided form
- ❖ Third ventricle is reduced to a narrow cerebral aqueduct.
- ❖ Medulla oblongata developed, triangular, hollow and mostly uncovered.
- ❖ Cranial nerve =12 pairs



AVES:

- ❖ Bony cranium-forebrain, midbrain and hindbrain, covered by 2 meninges
- ❖ Avian brain is **proportionately larger and more complex** than that of a Reptile, and is **short and broad**.
- ❖ **Forebrain:** Olfactory lobes are small and conical due to poor sense of smell. Attached anteriorly and largely covered by cerebrum.
- ❖ Two cerebral hemispheres are larger, smooth and project posteriorly over the diencephalon to meet the cerebellum separated by deep fissure
- ❖ The enlargement of cerebral hemispheres is due to very large and complex corpora striata which are characteristic of birds. The cerebral hemispheres are responsible for an intelligent behavior in birds
- ❖ The dorsal thalamus is even more developed than in Reptiles.
- ❖ **Midbrain:** Optic lobes on midbrain, Optic nerves, chiasma and tracts are large and well developed in correlation with keen sight.
- ❖ Squeezed between the cerebrum and cerebellum, the optic lobes have uniquely lateral position, - large, spherical hollow .
- ❖ **Hinbrain:** The Cerebellum is very large than in other vertebrates except some mammals. Cerebellum is divided into 3 lobes- a large median vermis and 2 small lateral flocculi
- ❖ Medulla oblongata small hollow, concealed beneath cerebellum
- ❖ Cranial nerves=12 pairs



MAMMALS:

- ❖ The brain reaches **its highest development in mammals** with better integration and mastery over the environment
- ❖ Bony cranium, brain relatively largest, complex and most advanced. Nearly twice as long as broad. Made up of 3 parts- Forebrain, Midbrain and Hindbrain.
- ❖ Covered by 3 layers or meninges-piamater, arachinoid and dura mater
- ❖ **Forebrain:** The cerebral hemispheres are **smaller and smooth** in Prototheria (*Platypus, echidna*) and **larger in Metatheria** (Kangaro, opossum) and become greatly enlarged separated by deep fissure and divided into distinct lobes in Eutheria (man)--Copus callosum present
- ❖ In mammals such as man and sheep, **surface of cerebral hemispheres (forebrain)** is immensely convoluted with a number of **elevations(gyri) separated by furrows (sulcus)**. This folding increases the surface area or gray matter containing nerve cells, **resulting in greater intelligence**.
- ❖ Olfactory lobes are relatively small but clearly defined and covered by the hemispheres and attached at front of cerebrum.
- ❖ **Diencephalon and midbrain** are also completely covered by the cerebral hemispheres.
- ❖ Optic lobes divided forming 4 small almost solid spherical bodies called **corpora quad-drigemina**, mostly **covered by cerebral hemispheres**-- includes the **superior and inferior colliculi**), responsible for reflexive visual and auditory processing.
- ❖ **Hindbrain:**
- ❖ Cerebellum is large, surface conspicuously folded. Transverly elongated covers medulla
- ❖ Cerebellum is divided into lobes- a median vermis, 2 lateral lobes terminating into flocculus.
- ❖ The medulla oblongata lies ventrally and is much thickened and broad, triangular, hollow and tapering and covered partly by cerebellum. It has centers which control respiration, heart beat.
- ❖ Cranial nerves= 12 pairs

Prototheria-egg laying mammals **Metatheria-** give birth to underdeveloped young that developed in pouch **Eutheria-** placental mamals (give birth to fully developed young)

**COMPARATIVE ACCOUNT
OF
BRAIN IN VERTEBRATES**

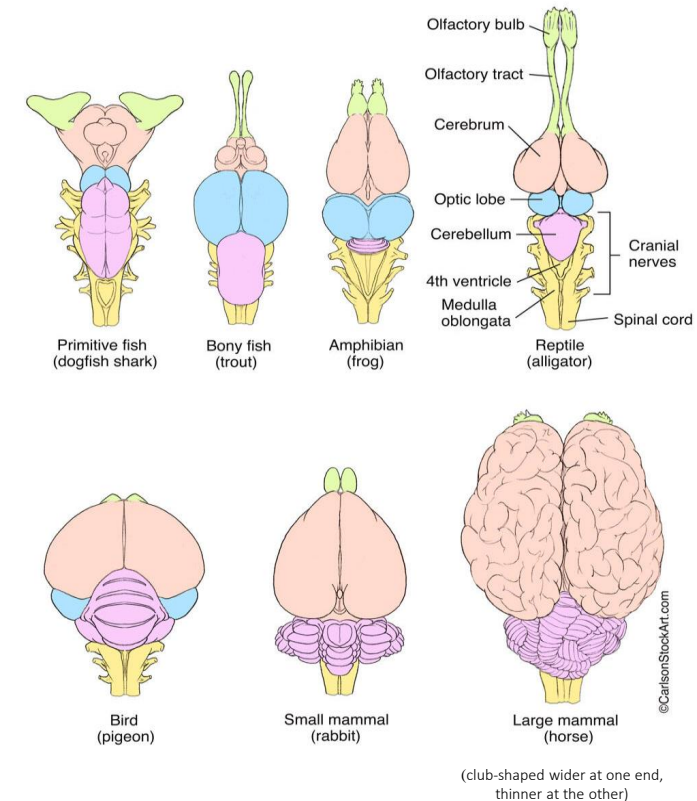
COMPARATIVE ACCOUNT OF BRAIN IN VERTEBRATES

Characters	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
1. Cranium	Brain enclosed within cartilaginous cranium	Bony cranium	Bony cranium	Bony cranium	Bony cranium
2. Size and main parts	Brain simple, elongated, flattened, thrice as long as broad Made up of 3 parts-Forebrain, Midbrain and Hindbrain	Brain simple, elongated, flattened, thrice as long as broad Made up of 3 parts-Forebrain, Midbrain and Hindbrain	Brain elongated as in frog Made up of 3 parts-Forebrain, Midbrain and Hindbrain	Brain relatively larger and more complex than in reptiles. Made up of 3 parts-Forebrain, Midbrain and Hindbrain	Brain relatively largest complex and most advanced. Nearly twice as long as broad Made up of 3 main parts-Forebrain, Midbrain and Hindbrain
3. Meninges	Brain protected by a single membrane (Meninx primitive)	Protected by 2 membranes Piamater and Duramater	Protected by 2 membranes Piamater and Duramater	Protected by 2 membranes Piamater and Duramater	Protected by 3 membranes Piamater, arachnoid and Duramater

COMPARATIVE ACCOUNT OF BRAIN IN VERTEBRATE

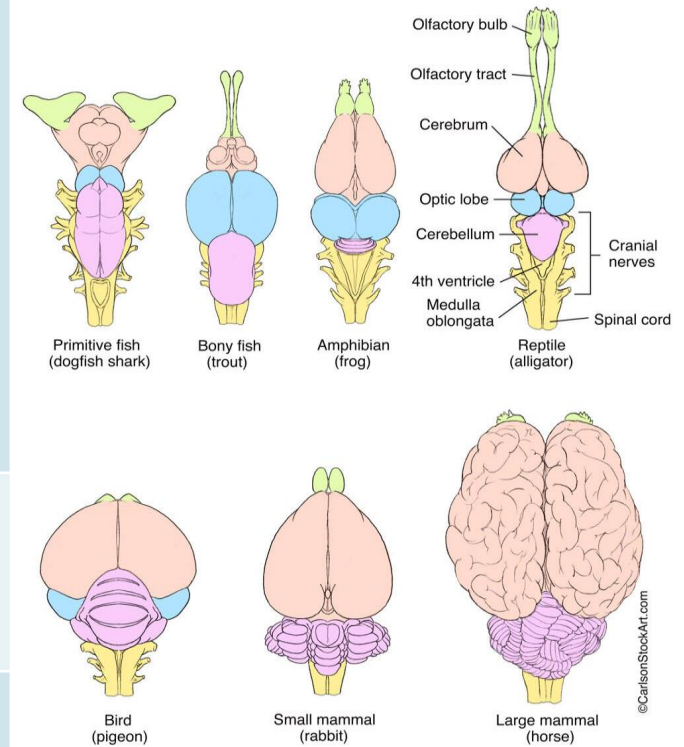
FOREBRAIN (A: OLFACTORY LOBES)

Characters	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
4. Position	Attached to anterolateral sides of cerebrum, hence widely separated	Attached side by side in front of the cerebrum, demarcated by slight constrictions	Attached side by side in front of the cerebrum	Attached anteriorly to cerebral hemisphere, and largely covered by them	Attached distinctly to anterior end of the cerebrum.
5. Shape and size	Large, bilobed and highly developed (sense of smell highly developed)	Small and slightly spherical due to poor sense of smell	elongated Small in proportion	Small , conical due to small sense of smell	Small, elongated due to poor sense of smell
6. Parts	Olfactory tract or peduncle and bilobed olfactory bulb	No differentiation between tract and bulb	Each drawn out into a narrow slender peduncle or tract bearing distally a bulb	No differentiation between tract and bulb	Olfactory tract remain covered beneath cerebrum Club shaped bulbs
7. Olfactory ventricles	Cavities called Rhinocoel spacious	Rhinocoel small and narrow	Rhinocoel narrow	Rhinocoel absent <small>their sense of smell is less important than their vision and hearing. Their brains have evolved to prioritize flight efficiency and sharp eyesight instead of strong olfactory abilities.</small>	Rhinocoel present



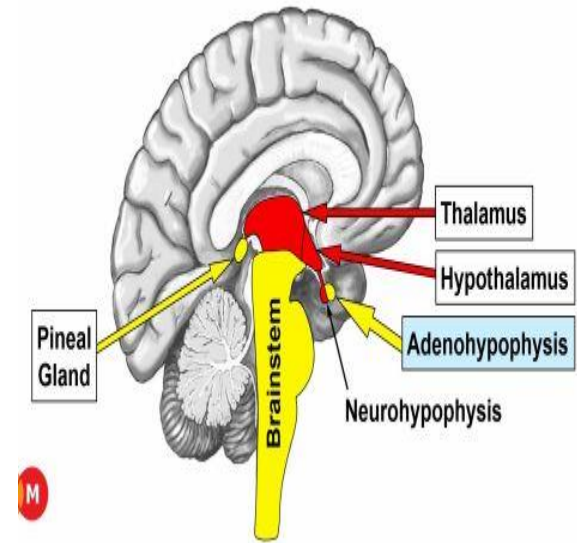
FOREBRAIN (B: CEREBRAL HEMISPHERE)

Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
8. Size and shape	Cerebrum is large somewhat rectangular. It has no median groove dividing it into right and left hemisphere	Two long, oval cerebral hemispheres divided deep median longitudinal fissure divides cerebrum into	Two oval cerebral hemispheres divided by mid longitudinal groove	Two very large , pyriform cerebral hemispheres separated by a deep sagittal fissure Covers olfactory lobe in front.	Two large, pyriform greatly developed separated by deep sagittal fissure Overlaps olfactory lobes in front and midbrain behind
9. Surface	Smooth without folds, fissures and lobes	Smooth without folds, fissures and lobes	Smooth without folds, fissures and lobes	Smooth without folds, fissures and lobes	Surface bears folds and fissures and divided into 4 lobes
10. Cerebral Cortex	Absent, Grey matter forms the lining of the lateral ventricles	Shows beginning of cerebral cortex	Poorly developed	Poorly developed	Very well developed
11. Corpus callosum	Absent	Absent	Absent	Absent	Present

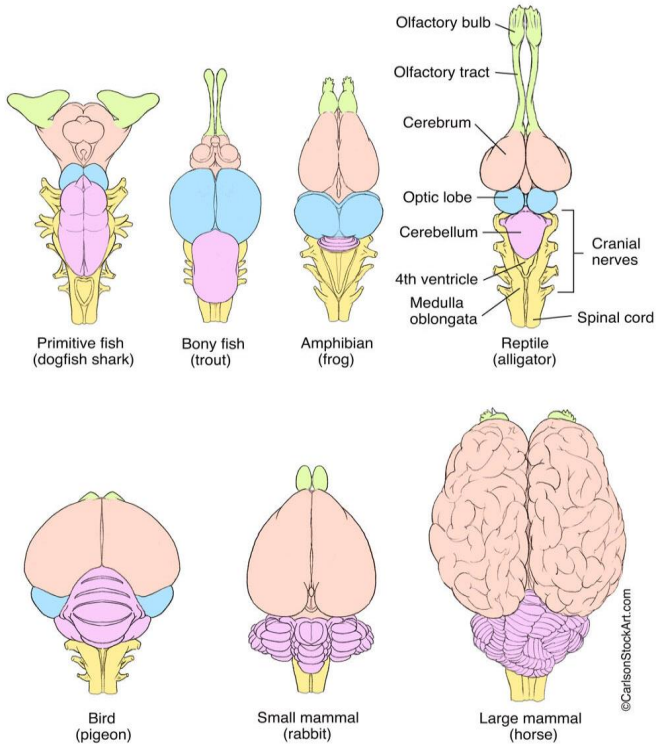


FOREBRAIN (C: DIENCEPHALON)

Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
12. Shape and Size	Small, narrow and dorsally covered by cerebellum	Short, rhomboidal and not covered dorsally by cerebellum	Small rounded and covered dorsally by cerebral hemispheres and optic lobes	Dorsal surface covered by cerebrum and cerebellum	completely covered dorsally by cerebral hemisphere
13. Epiphyseal apparatus	From dorsal roof arises a long and slender stalk carrying a small rounded pineal body. No parietal organ	Pineal stalk is short In tadpoles, bears a small spherical pineal body inside skull and in adult frog, pineal body separates and lies above skull No parietal organ	It includes an anterior parietal organ And posterior pineal gland	Pineal stalk short bears small spherical and delicate pineal body Parietal organ absent	Pineal stalk slender bears small rounded pineal body Parietal organ absent
14. Pituitary Body	Infundibulum bears posteriorly an oval prominent hypophysis and together forms Pituitary body	Infundibulum bears posteriorly a flattened oval hypophysis and together forms Pituitary body	Infundibulum and a posterior hypophysis together forms Pituitary body	Infundibulum and posterior hypophysis forms the pituitary which lacks an intermediate lobe	Infundibulum and posterior hypophysis forms the pituitary which have an intermediate lobe



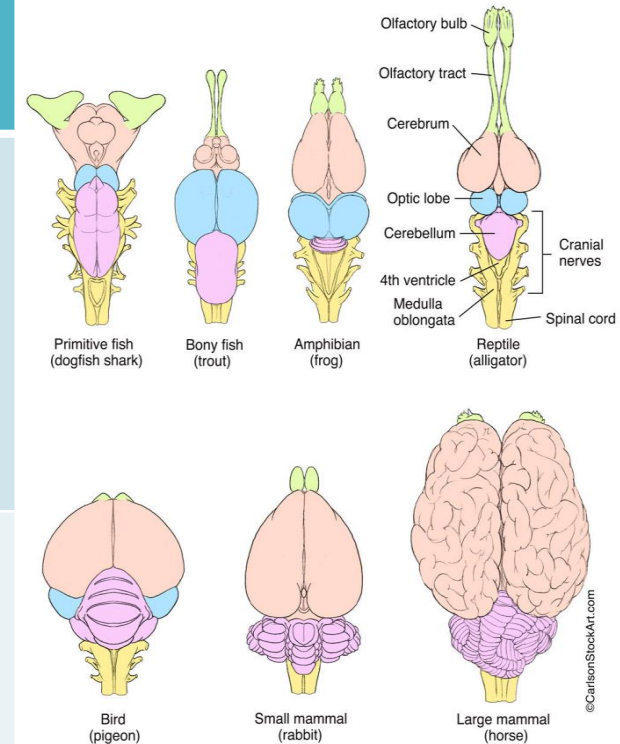
MIDBRAIN



Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
15. Optic lobes	Dorsal side contains two large optic lobes or corpora bigemina, hollow with optocoel, which remains mostly covered by cerebellum	Dorsal surface contains two large, rounded, hollow optic lobes with optocoel Remains uncovered	Two medium oval dorso-laterally placed hollow optic lobes present which remains uncovered	2 large, spherical hollow laterally displaced optic lobes present	Optic lobes divided into 4 small solid spherical bodies called corpora quadrigemina almost completely covered by cerebral hemispheres Optocoel absent

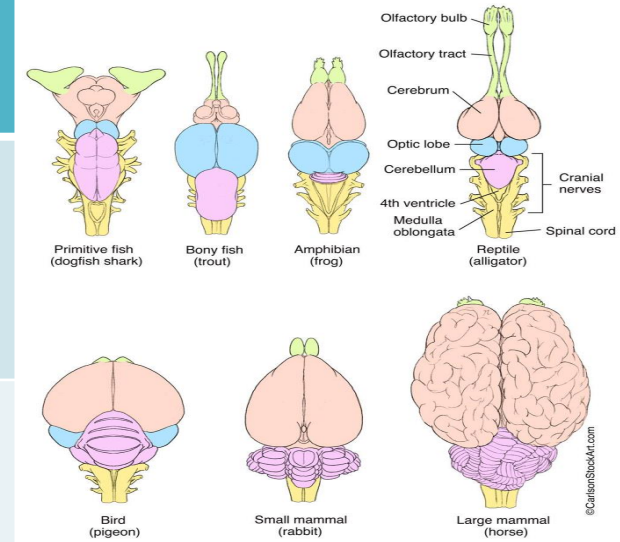
HINDBRAIN (A) CEREBELLUM

Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
16. Shape and size	Large, elongated rhomboidal dorsal structure overlapping midbrain (optic lobe) and Diencephalon anteriorly and Medulla posteriorly	Small, narrow dorsal transverse band just behind optic lobes	Small flat, and somewhat conical structure	Very large elongated antero-posteriorly , covering midbrain in front and medulla behind	Very large transversely elongated , covering midbrain and medulla
17. Division	Made up of 3 lobes divided by 2 transverse furrows	It is undivided	Undivided	Divided into 3 lobes A large median vermis and two small lateral flocculi	Divided into 5 lobes- a median vermis, two lateral lobes each terminating into flocculus
18. Surface	Dorsal surface bears irregular folds	Surface is smooth without folds	Smooth without folds	Surface folded	Surface highly folded



HINDBRAIN (B) MEDULLA OBLONGATA)

Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
19. Shape and size	Large, hollow contains metacoel, triangular gradually tapering behind, partly under cerebellum	Small triangular hollow and uncovered	Small , triangular, hollow slightly covered	Small, hollow concealed by cerebellum	Broad, triangular , tapering and covered by cerebellum
20. Restiform Bodies	Medulla bears antero laterally a pair of irregular thin walled , hollow outgrowths- the restiform bodies	Absent	Absent	Absent	Absent



Characters`	FISH (Dogfish)	AMPHIBIA (Frog)	REPTILIA (Lizard)	AVES (Pigeon)	MAMMALIA (Rabbit)
21. CRANIAL NERVE	10 pairs	10 pairs	12 pairs	12 pairs	12 pairs