

## Animal diversity

### Phylum chordata :

- Phylum chordata was created by Balfour in 1880.
- Originated prior to cambrian period.
- Fundamental chordate characters are **notochord**, **dorsal tubular nerve cord**, **gillslits** & **post and tail**
- Notochord** originates from **mesoderm**.
- Present below the nervcord and above the alimentary caual as a middorsal solid rod like structure.
- Covered by outer elastic sheath, inner fibrous sheath and filled by vacuolated cells.
- Persistent throughout life in cephalochordata ,cyclostomes and some fishes.
- Replaced by vertebral column in vertebrates during development.
- Nuclei pulposi** are remains of notochord present at the centre of inter vertebral discs in mammals.

### **Dorsal tubular nerve cord** originates from ectoderm

- Present above the notochord and out side the coelom
- Forms into anterior brain and continues as spinal cord in vertebrates

### **Gill slits**-originate both from ectoderm and endoderm

- Paired lateral openings of pharynx through which water is sent outside.
- Formed by the outpushings of endodermal lining of pharynx and inpushings of ectoderm from exterior with the intervening walls broken during development
- Persistant in protochordates, cyclostomes fishes and some aquatic amphibians throughout life.
- vascular and act as gills for respiration in fishes, aquatic urodeles and amphibian larvae.
- useful mainly for filter-feeding in protochordates.

### **Postanal tail** -is the posterior part of body behind anus or cloaca.

- without coelom and viscera
- notochord, nervcord & muscles are extending into the tail.

### **Other chordate characters are :**

- Ventral muscular myogenic heart
- Hepatic portal system
- Deuterostomous nature
- Radial and indeterminate cleavage

-Enterocoelomates but higher chordates are secondarily schizocoelomate in nature.

-Presence of creatine phosphate as muscle phosphagen

**Comparasion of chordates & non-chordates :**

<b>S.NO</b>	<b>Chordates</b>	<b>Non chordates</b>
1	Notochord present	Notochord absent
2	Dorsal, tubular, single, nonganglionated nerve cord	ventral, solid, double ganglionated nervecord
3	Ventral heart	Dorsal heart
4	Blood flow is anterior to posterior in dorsal blood vessels and posterior to anterior in ventral blood vessels	Blood flows from posterior to anterior in dorsal vessels and anterior to posterior in ventral vessels
5	Muscle phosphagen is creatine phosphate	Muscle phosphagen is arginine phosphate or both argininephosphate and creatine phosphate
6	Haemoglobin is present in blood corpuscles	Respiratory pigment dissolved-in plasma
7	Gill slits present	Gill slits absent

**Classification of phylum chordata**

**Sub phylum I. Urochordata/ Tunicata**

- Marine
- Sedentary or free swimming
- Solitary or colonial
- Body covered by test made of tunicin
- Notochord and nervecord present in larval stages and absent in adults
- Numerous gill slits
- Filter feeders
- Endostyle helps in feeding
- Heart tubular, functions alternately as branchial and systemic heart
- Open circulation
- Hermaphrodite, development indirect

**Divided into 3 classes:**

- Class i) Ascidiacea - Eg. Herdmania  
Ascidia  
Botryllus  
Ciona
- Class ii) Thaliacea - Eg. Salpa  
Doliolum  
Pyrosoma
- Class iii) Larvacea/Appendicularia- Eg. Oikopleura

**Subphylum-II: Cephalochordata**

- Marine, solitary, burrowing forms
  - “Typical chordates”
  - Notochord extends from anterior end to posterior end
  - Paired fins absent
  - Filter feeders with numerous pharyngeal gill slits
  - Endostyle present
  - Closed circulation but heart, respiratory pigment & blood corpuscles absent.
  - Excretion by protonephridia with solenocytes
  - Unisexual, gonoducts absent
  - Development indirect
- Eg. Branchiostoma (=Amphioxus), Asymmetron

**Subphylum III: Vertebrata (or craniata)**

- Chordates with vertebral column
- Vertebrae surround the dorsal nerve cord
- Divided into superclasses Agnatha and Gnathostomata, basing on presence and absence of jaws.

**Superclass Agnatha:**

- Jaw less vertebrates
- Paired appendages absent
- Single nostril

**Class 1 : Ostracodermi**-extinct agnathan group

- Ancestors of fishes
- Eg. Cephalaspis, Hemicyclaspis

**Class 2: Cyclostomata** - extant group

- Includes lampreys, myxines

- Exoskeleton absent
  - Body elongated eel like with circular suctorial mouth
  - Paired fins absent
  - 6-14 pairs of gill pouches
  - Notochord persistent
  - Cartilaginous endoskeleton
  - 2-chambered heart and mesonephric kidneys
  - Single gonad and gonoducts absent
  - Development indirect with ammocoete larva in lampreys
  - Direct development in hag fish.
- Eg: Petromyzon(Lamprey) -ectoparasitic, sanguivore
- exhibits **anadromous** migration during breeding season
- Myxine (Hag fish or slime eel)- necrophagous

**Super class-II: Gnathostomata-** Jawed vertebrates

- Paired fins or limbs present
- Paired nostrils present
- Internal ear with 3 semicircular canals
- Includes pisces and tetrapods
- Pisces and amphibians are called Ichthyopsida
- Reptiles and aves are called Sauropsida
- Pisces, amphibians and reptiles are poikilotherms
- Aves and mammals are homeotherms
- Pisces and amphibians are anamniotes
- Reptiles, aves and mammals are amniotes

**PISCES**

- Most diverse and the largest group of vertebrates
- Study of fishes is called Ichthyology
- Originated during silurian period
- Devonian period is “age of fishes”
- Ostracoderms are the ancestors of fishes
- Acanthodians are the earliest group of fishes which gave rise to osteichthyes (bony fishes)
- Placoderms gave rise to chondrichthyes (cartilaginous fishes)
- Body is streamlined and differentiated into head, trunk and tail
- Body covered by mesodermal scales
- Skull monocondylic

- Vertebrae amphicoelous
- Locomotion by unpaired and paired fins
- Teeth homodont, acrodont and polyphyodont
- Respiration by gills
- Heart 2-chambered and described venous heart and branchial heart
- Single circuit circulation
- Kidneys mesonephros
- Brain covered by single meninx called meninx primitiva
- Cranial nerves 10 pairs
- Lateral line sense organs/Neuromast organs present for rheoreception.

Pisces include 2 extant classes

**Class i) Chondrichthyes-**

- Marine fishes with cartilagenous endoskeleton
- Body covered by placoid scales
- Caudal fin heterocercal
- Mouth ventral
- Gills lamelliform and without operculum
- Air bladder absent
- Ureotelic animals and many exhibit physiological uraemia (an adaptation to live in hypertonic medium)
- Pelvic fins bear claspers, acting as copulatory organs
- Fertilisation internal
- Many are viviparous

Eg: Scoliodon (Dog fish)

Scyllium (Shark)

Rhinodon (Whale shark)

Carcharodon (Great white shark)

Sphyrna (Hammer headed shark)

Torpedo (Electric ray)

Dasyatis/Trygon(Sting ray)

Pristis (Saw fish)

Chimaera (Rat fish)

**Class ii) Osteichthyes-**

- Marine or freshwater or brackish water fishes with bony endoskeleton
- Body covered by cycloid, ctenoid, ganoid or cosmoid scales

- Caudal fin diphyccercal or homocercal
- Mouth terminal
- Gills filamentous and covered by operculum
- Airbladder present
- Air bladder acts as lung, if connected to pharynx, otherwise acts as hydrostatic organ
- Ammonotelic animals
- Fertilisation external
- Mostly oviparous

Eg. Labeo, Catla, Exocoetus (flying fish), Hippocampus (sea horse), Clarias (magur)  
Echeneis (sucker fish), Betta splendens (siamese fighting fish), Pterophyllum  
(Angel fish), Ophiocephalus (murrel), Hilsa, Anabas (climbing perch), Harpodon (Bombay duck)

### **Tetrapoda:**

- Mostly terrestrial, aquatic or amphibious
  - Two pairs of pentadactyl limbs present
  - Lungs are the chief respiratory organs
- It includes the classes Amphibia, Reptilia, Aves and Mammalia

### **Class Amphibia:**

- Earliest group of tetrapods and lead dual mode
- Evolved during devonian period and flourished during carboniferous period
- Osteolepid fishes are ancestors of amphibians
- Body divisions are head & trunk
- Skin soft without exoskeleton
- Two pairs of pentadactyl limbs without claws present
- Skull dicondylic
- Vertebrae procoelous (anurans), amphicoelous (apodans) and opisthocoelous (many urodeles)
- Sternum developed for the first time in this group
- Mouth large, teeth are homodont, acrodont, polyphyodont
- Respiration mostly through skin (cutaneous), buccal cavity (buccal respiration) or lungs (pulmonary respiration)
- Heart three chambered with sinus venosus on dorsal side and truncus arteriosus on ventral side.
- Incomplete double circulation
- Hepatic and renal portal systems are well developed
- Kidneys mesonephric; ureotelic
- Brain covered by outer duramater and inner piamater

- 10 pairs of cranial nerves
- Middle ear has single ossicle called columella auris which is modified hyomandibular
- Tympanum, lacrimal and harderian glands appeared for the first time.
- Eggs are mesolecithal and telolecithal
- Development mostly indirect

Amphibia includes 3 orders

- Order **Apoda**/Gymnophiona-caecilians or blind worms. Eg. Ichthyophis, Uraeotyphlus, Gegenophis, Typhlonectes
- Order **Urodela**/Caudata-Salamanders and newts, Eg. Salamandra, Necturus, Mud puppy Tylotriton (Himalayan newt), Ambystoma (tiger salamander), Amphiuma (congoeel), Cryptobranchus
- Order **Anura**/Salientia-frogs and toads

Eg. Bufo melanostictus (Indian toad) Rana (frog) Rhacophorus (Flying frog) Hyla (Tree frog)  
Alytes (Midwife toad) Ascaphus

### **FROG**

**order : Anura**

**Family : Ranidae**

- Freshwater in habitat
- Carnivores
- Poikilothermic anamniotes
- Frogs exhibit hibernation (winter sleep) and aestivation (summer sleep)
- Change the skin colour to match their surroundings which is called camouflage

### **Rana tigrina**

- Skin smooth, moist and scaleless
- Body divided into head and trunk
- Neck and tail are absent
- Eyes with immovable upper eyelid and the movable lower eyelid is drawn over the eye ball as nictitating membrane.
- Tympanum present behind and below each eye
- Forelimbs with four fingers, hindlimbs with five toes.
- Webbed feet help in swimming
- Sexual dimorphism: Male frogs have sound amplifying vocal sacs and a copulatory or amplexusory pad on the first digit of each fore limb.

### **Digestive system**

- Alimentary canal shorter as frog is carnivorous
- Mouth opens into large buccopharyngeal cavity

- Teeth present along the margin of upper jaw only called maxillary teeth
- Vomerine teeth are present on the roof of buccal cavity.
- Maxillary teeth are homodont, acrodont and polyphyodont
- Tongue bifid and useful for capturing the prey
- Buccopharyngeal cavity opens into oesophagus through gullet.
- Oesophagus is short and leads into stomach
- Cardiac sphincter present between oesophagus and stomach whereas pyloric sphincter present between stomach and duodenum
- Duodenum and ileum are anterior and posterior parts of small intestine.
- Rectum forms the large intestine which opens into cloacal chamber
- Cloacal chamber also receives ureters, urinary bladder and opens out by cloacal aperture.
- Villi in small intestine are foldings of columnar epithelium which increase the area of absorption.
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- Liver bilobed with gall bladder to store the bile juice
- Bile duct is formed by the union of hepatic ducts and cystic duct
- Pancreas is an irregular gland present between stomach and duodenum
- Pancreatic ducts join the bile duct forming hepatopancreatic duct which opens into duodenum.
- Bile helps in emulsification of fats and converts the acidic food to alkaline medium
- Digestion occurs by the action of pancreatic juice and intestinal juice (succus entericus)

### **Respiratory system:**

Respiration occurs by 3 methods.

**Cutaneous respiration-** occurs through moist, vascular skin and is the most important method of respiration

**Buccopharyngeal** respiration-occurs through moist vascular lining of buccopharyngeal cavity

**Pulmonary** respiration-occurs through lungs and buccopharyngeal cavity acts as “force pump”.

-Floor of the buccal cavity is raised and lowered by the contractions of petrohial and sternohyal muscles respiration.

-Glottis opens into laryngotracheal chamber which is connected to lungs by short bronchi



- Vocalcords are present in laryngotracheal chamber
- Laryngotracheal chamber is supported by ring like cricoid and two crescentic arytenoid cartilages.

### **Circulatory system:**

- Heart-3 chambered with two atria and single ventricle and covered by double layer pericardium
- Sinus venosus opens into right atrium whereas common pulmonary vein opens into left atrium.
- Atrioventricular aperture is the common opening through which the two atria open into ventricle.
- Atrioventricular aperture is guarded by 2 pairs of atrioventricular valves.
- Atrioventricular valves are attached to the wall of ventricle by chordae tendinae.
- Columnae carnae are the ridges of the thick muscular walls of ventricle.
- Conus arteriosus arises from the right side of ventricle.
- Pylangium and synangium are proximal and distal parts of conus arteriosus
- 2 sets of semilunarvalves are present, one set at the origin of conus arteriosus and second set between pylangium and synangium.
- Longitudinal spiral valve divides the conus arteriosus into dorsal, left cavum pulmocutaneum and ventral, right cavum aorticum

### **Arterial system:-**

- Consists of 3 pairs of aortic arches.
- Carotid arch supplies blood to head region.
- Systemic arches of both the sides meet each other to form dorsal aorta.
- Subclavian artery is a branch of systemic that supplies blood to fore limbs.
- Dorsal aorta gives many branches like coeliaco mesenteric artery that supplies blood to digestive system

Gonadial to gonads

Renals to kidneys and Iliacs to the posterior part of the body.

Femoral and sciatic are branches of iliacs that supply blood to hindlimbs.

### **Venous system:-**

Sinus venosus is formed by the union of two precavals/anterior or superior venacavae and post caval/posterior or inferior venacava

Pre caval is formed by:

- i)External jugular vein that collects blood from the muscles of tongue and jaws
- ii)Innominate vein that collects blood from orbit, brain and shoulder region.

iii) Subclavian vein which collects blood from the muscles of forelimbs and skin.

-Postcaval vein originates from the capillaries of kidneys and also collects blood from gonads and liver.

-Blood from the lungs is collected by pulmonary veins which open into left atrium as a common pulmonary vein

-Hepatic portal vein collects blood from alimentary canal, pancreas and releases into liver.

-Renal portal vein collects blood from lower parts of body and release them into kidneys.

-Blood of frog consists of plasma, erythrocytes, leucocytes and thrombocytes.

-RBC are oval, nucleated & relatively larger in size

**Lymphatic system**- consists of lymph capillaries, lymph vessels, lymphatic ducts, and lymph nodes.

-Lymph hearts are 2 pairs helping in pumping the lymph into veins.

**Integrating system**-consists of nervous and endocrine systems.

-Nervous system includes central nervous system (brain & spinal cord), peripheral nervous system (cranial nerves & spinal nerves) autonomous nervous system (sympathetic & parasympathetic)

Brain- consists of forebrain (or prosencephalon), midbrain (or mesencephalon) and hind brain (or rhombencephalon).

-Fore brain consists of a pair of olfactory lobes, a pair of cerebral hemispheres and diencephalon.

-Rhinocoels are ventricles of olfactory lobes.

-Para coels or lateral ventricles (1st and 2nd) are enclosed by cerebral hemispheres.

-Cerebral hemispheres control voluntary actions

-Dience phalon is concerned with perception of heat, cold, pain and integrity of autonomous nervous system.

-Diocoel (3rd ventricle) is enclosed by diencephalon

-Mid brain consists of a pair of hollow optic lobes (corpora bigemina) enclosing optocoels.

-Optic lobes control vision.

-Hind brain consists of cerebellum (maintains equilibrium) and medulla oblongata (controls involuntary actions)

-Fourth vertricle is enclosed by medulla

-Spinal cord is continuation of medulla.

-Spinal cord acts as middle man between brain and effectors.

-10 pairs of cranial nerves and 9 or 10 pairs of spinal nerves are present.

**Sense organs:**

Eyes-Retina contains rods for dimlight vision and cones for color vision.

Organs of hearing : Middle ear & internal ear are present

-Columella auris, the middle ear ossicle, meets the cartilaginous stapedial plate which fuses with fenestra ovalis of auditory capsule.

-Auditory capsule is formed by single prootic bone

-Internal ear/ membranous labyrinth consists of dorsal utriculus to which the 3 semicircular canals join and ventral sacculus.

-Auditory capsule is filled by perilymph and internal ear is filled by endolymph in which calcium carbonate particles, otoliths, are present

-Internal ears are also called statoacoustic organs.

**Excretory system:**

-Frogs are ureotelic

-Mesonephric kidneys with ciliated nephrostomes on ventral surface are present in adults

-Tadpole larva of frog has pronephric kidneys

-Ureter/mesonephric duct/Wolffian duct arises from the outer margin of kidney and open into cloacal chamber.

-In males, as ureters carry both urine and sperms, they are called urinogenital ducts

-Urinary bladder opens separately into cloaca below the openings of ureters

-Frogs excrete hypotonic urine

**Male reproductive system:-**

-Testes are covered by mesorchium and attached to kidneys

-Vasa efferentia from each testis open into Bidder's canal present in the kidney.

-Ureter acts vasdeferens

-Seminal vesicle is the swollen part of ureter just behind the kidney.

-Germinal epithelium is the lining of seminiferous tubules.

-Germinal epithelial cells undergo spermatogenesis

**Female reproductive system:**

-Mesovarium is peritoneal covering by which ovaries are attached to kidneys.

-Eggs are mesolecithal and telolecithal

-Ova are released into body cavity

-Oviduct/Mullerian duct opens into the body cavity by ciliated oviducal funnel called ostium.

-Ovisacs are posterior dilated parts of the oviduct that open into cloacal chamber near the ureter.

Copulation is called amplexus during which both male & female frogs release sperms and ova into the water

- Eggs released in large number called spawn and the spermatozoa released are called milt
- Fertilisation external
- Development includes a gill breathing, herbivorous, ammonotelic “tadpole larva” which metamorphoses into lung breathing, carnivorous, ureotelic adult frog.

### **Class: Reptilia**

- First group of true terrestrial tetrapods
- Labyrinthodont amphibians are the ancestors of reptiles
- Evolved during carboniferous period
- Mesozoic era is the “age of reptiles”
- Poikilothermic (ectothermic) amniotes which lay cleidoic eggs on land.
- Study of reptiles is called herpetology.
- Body divided into head, neck, trunk and tail with rough, dry skin covered by epidermal scales, shields etc.
- Two pairs of pentadactyl limbs with clawed digits
- Teeth homodont, acrodont, polyphyodont. Thecodont in crocodiles and edentate in chelonians
- Skull monocondylic with temporal fossae
- Each half of lowerjaw is made of six bones.
- Vertebrae procoelous; sacral vertebrae two in number
- Sternum broad plate like; ‘T’ shaped interclavicle present between the two clavicles.
- Inter costal muscles are associated with ribs
- Vascular cloaca helps in respiration in turtles
- Heart with incompletely divided ventricle (incompletely 4-chambered) but crocodiles have 4-chambered heart
- Sinus venosus present but conus arteriosus absent
- Three aortic arches- two systemics and one pulmonary arise directly from ventricle.
- Renal portal system present; RBC nucleated
- Kidneys metanephric; uricotelic vertebrates (terrestrial adaptation)
- 12 pairs of cranial nerves (10 pairs in snakes)
- Jacobson’s organs, olfactory in function, are well developed in lizards & snakes
- Males with copulatory organ (absent in Sphenodon)
- Mesonephric duct/ Wolffian duct acts as vasdeferens
- Cloaca 3 chambered with anterior coprodaeum, middle urodaeum and posterior proctodaeum,
- Fertilisation internal

- Eggs cleidoic, megalecithal & telolecithal
- Cleavage meroblastic and discoidal
- Mostly oviparous; eggs develop on land as they are amniotes
- Crocodilians are the largest living reptiles.

Extant reptiles are grouped under 4 orders

**order 1: Chelonia** - Eg. Chelone(turtle), Testudo(tortoise), Trionyx(terrapin), Chrysemys (terrapin), Dermochelys (Leatherback turtle)

**order 2: Rhynchocephalia**-Eg Sphenodon (Living fossil)-endemic species in Newzealand

-Commonly called “Tuatara” lizard(Hatteria)

**Order 3: Squamata** : 2 sub orders

**Suborder (i) Lacertilia**-Lizards

Eg. Calotes (Garden lizard), Hemidactylus (Wall lizard), Chamaleon, Draco(Flying dragon), Heloderma (Venomous lizard), Uromastix, Varanus(Monitor lizard), Phrynosoma (Hornedtoad), Ophiosaurus (Glass snake; limbless lizard).

-Komododragon of Indonesia is the largest lizard.

**Suborder (ii) Ophidia:**

**Poisonous snakes:** Naja naja (cobra), Ophiophagus hannah(king cobra)

Bungarus (krait), Daboia/Vipera russeli(chain viper), Echis carinata (saw scaled viper; phoorsa), Hydrophis (sea snake); Calliophis (coral snake)

**Non poisonous snakes:** Ptyas (Rat snake), Tropidonotus/Natrix(Grass snake or pond snake), Python(Ajgar) etc.

**Order 4: Crocodilia/Loricata:** Largest living reptiles Eg. Crocodylus, Alligator, Gavialis(Indian gharial), Caiman etc

### **Class: Aves:**

- Feathered, bipedal, homeothermic(endothermic) amniotes
- T.H. Huxley called them “glorified reptiles”
- J.Z Young called them “the masters of air”.
- Originated during Jurassic period from Theropod dinosaurs
- Modern birds evolved during Cretaceous period.
- Study of birds is called Ornithology
- Dr. Salim Ali is called “Bird man of India”.
- Body divided into head, long neck, trunk, tail and covered by epidermal feathers, scales on legs, rhamphotheca on beak,
- Preen gland is the only cutaneous gland present
- Forelimbs modified into wings, hind limbs with 4 clawed digits.

- Pneumatic bones with air cavities (flight adaptation).
- Skull monocondylic
- Vertebrae heterocoelous
- Synsacrum is formed by the fusion of last thoracic, lumbar, sacral and anterior caudal vertebrae.
- Pygostyle is formed by the fusion of posterior caudal vertebrae and supports the tail.
- Sternum has keel or carina for the attachment of flight muscles (absent in ratitae birds).
- Furcula, a 'v' shaped structure is formed by the union of clavicles and inter clavicle and is called "wish bone" or "merry thought bone".
- Ribs are double headed in birds, crocodiles & mammals and uncinat processes are present in birds.
- Flight muscles are pectoralis major for downward stroke and pectoralis minor for upward stroke of wings.
- Teeth absent
- Oesophagus dilates into crop
- Stomach consists of anterior proventriculus and posterior ventriculus / gizzard.
- Cloaca is 3 chambered as in reptiles.
- Larynx is without vocalcords.
- Syrinx, present between trachea and bronchi, is for sound production.
- Lungs are without alveoli
- Airsacs are 9 (unpaired inter clavicular and 4 paired sacs) associated with lungs.
- Airsacs facilitate continuous oxygenation of blood and pneumaticity of bones.
- Heart 4 chambered with only right systemic arch and pulmonary arch
- Sinus venosus and conus arteriosus absent
- Renal portal system reduced
- RBC nucleated
- Kidneys metanephric ,three lobed;uricotelic,
- Urinary bladder absent(present in ostritch)
- Brain** with 2 meninges, duramater and, pia-arachnoid
- Olfactory lobes are poorly developed (olfactory sense well developed in Kiwi)
- Optic lobes are large
- Cranial nerves are 12 pairs.
- Eyes with sclerotic plates and "comb like" pecten in vitreous chamber (Pecten absent in Kiwi)
- Middle ear has only columella auris
- Right ovary and right oviduct are reduced

- Copulatory organs absent except duck, geese, ratites etc
- All are oviparous
- Eggs megalecithal, telolecithal and cleidoic
- Cleavage meroblastic, discoidal
- Young ones are precocious in ratite birds, altricial in flying birds.

Eg. Archaeopteryx lithographica-extinct lizard bird of Jurassic period; connecting link between reptiles and aves.

Struthio camelus (African ostrich)- largest bird

Apteryx (kiwi)-National bird of Newzealand

Rhea americana (American ostrich) Dromaeus & Casuarius - live in Australia.

Ratitae exhibit discontinuous distribution :

**Flying birds** : Corvus (crow), Columba(pigeon),Pavo cristatus (peacock),Coracias bengalensis (Blue jay), Passer (sparrow), Psittacula (parrot), Neophron(Vulture) Eudynamys (koel), Bubo(owl),Alcedo(king fisher),Milvus(kite),Dinopium(Wood pecker), Gallus(Fowl),Aqurilla(eagle),Aptenodyptes(penguin) etc

**Class:Mammalia:**

- Advanced, hairy, most diverse, homeothermic ammiotes which nourish the youngones with milk secreted by mammary glands.
- Originated during triassic period from Therapsid reptiles
- Coenozoic era is “the age of mammals”
- Study of mammals is called mammology
- Largest animal is the blue whale Balaenopterus musculus
- Body divided into head, neck, trunk, tail and covered by hair (hair reduced in whales, armadillos)
- Skin with sweat glands/ sudoriferous glands,sebaceous glands, scent glands etc.
- Mammary glands are modified sweat glands.
- Skull dicondylic; each half of lower jaw is formed by a single bone dentary.
- Vertebrae are amphiplatyan; only 7 cervical vertebrae [6 in Cholepus, (2 toed sloth) & Trichechus (manatee) & 9 in Bradypus( 3 toed sloth)]
- Buccal cavity is separated from nasal cavity by secondary bony palate.
- Teeth are heterodont, thecodont &diphyodont
- Four pairs of salivary glands (3 pairs in man)
- Epiglottis present ; Larynx is the sound producing organ

- Heart 4 chambered; left systemic arch and pulmonary arch arise from left and right ventricles respectively.
- RBC circular (oval in camels, llamas) biconcave and enucleated
- Renal portal system absent
- Brain and spinal cord covered by three meninges duramater, arachnoid and piamater.
- Corpus callosum connects the two cerebral hemispheres.
- Optic lobes are four and are called corpora quadrigemina.
- Cranial nerves are 12 pairs.
- Eyes with movable eyelids and eye lashes
- External ear or pinna present
- Middle ear ossicles are three, malleus, incus and stapes
- Internal ear with spirally coiled cochlea which bears “organ of corti” for hearing
- Kidneys are metanephric; ureotelic
- Ureters open into urinary bladder.
- Nephrons have Henle’s loop; urine hypertonic
- Testes extra abdominal present in scrotal sacs (except monotremes, cetaceans, seacows elephants etc)
- Fertilization internal, viviparous (except monotremes).
- Placenta formed by chorion and allantois in eutherians
- Period of intra uterine development is called gestation period.

Class Mammalia includes two subclasses:

**Sub class 1:Prototheria** (order:Monotremata) Oviparous mammals without external ear.

Eg: Echidna/Tachyglossus (Spiny ant eater)Ornithorhynchus (duck billed platypus)

**Sub class 2: Theria**-viviparous mammals

-includes metatheria and eutheria

**Metatheria** (Marsupials)- found in Australia & S.America(discontinuous distribution)

Pouched mammals.

-Marsupial with true chorio-allantoic placenta is Perameles

Eg. Macropus (kangaroo),Didelphis(opposum)Perameles (marsupial bandicoot)

Notoryctes(Marsupial mole)Thylacinus(tasmanian wolf) Caenolestes (opposum rat)

**Eutheria**- true placental mammals

Eg. Pteropus (flying fox)Elephas(elephant)Antelope(state animal of A.P)Macaca(monkey),

Rattus(rat),Canis(dog),Felis(cat),Funambulus(squirrel),Equus(horse),Delphinus(dolphin),

Camelus(camel), Hystrix (Porcupine).



## Classification of phylum chordata

### Sub phylum I. Urochordata/ Tunicata

- Marine
- Sedentary or free swimming
- Solitary or colonial
- Body covered by test made of tunicin
- Notochord and nervecord present in larval stages and absent in adults
- Numerous gill slits
- Filter feeders
- Endostyle helps in feeding
- Heart tubular, functions alternately as branchial and systemic heart
- Open circulation
- Hermaphrodite, development indirect

### Divided into 3 classes:

- Class i) Ascidiacea
  - Eg. Herdmania
  - Ascidia
  - Botryllus
  - Ciona
- Class ii) Thaliacea
  - Eg. Salpa
  - Doliolum
  - Pyrosoma
- Class iii) Larvacea/ Appendicularia- Eg. Oikopleura

### Subphylum-II: Cephalochordata

- Marine, solitary, burrowing forms
  - “Typical chordates”
  - Notochord extends from anterior end to posterior end
  - Paired fins absent
  - Filter feeders with numerous pharyngeal gill slits
  - Endostyle present
  - Closed circulation but heart, respiratory pigment & blood corpuscles absent.
  - Excretion by protonephridia with solenocytes
  - Unisexual, gonoducts absent
  - Development indirect
- Eg. Branchiostoma (=Amphioxus), Asymmetron

**Subphylum III: Vertebrata (or craniata)**

- Chordates with vertebral column
- Vertebrae surround the dorsal nerve cord
- Divided into superclasses Agnatha and Gnathostomata, basing on presence and absence of jaws.

**Superclass Agnatha:**

- Jaw less vertebrates
- Paired appendages absent
- Single nostril

**Class 1 : Ostracodermi**-extinct agnathan group

- Ancestors of fishes
- Eg. Cephalaspis, Hemicyclospis

**Class 2: Cyclostomata** - extant group

- Includes lampreys, myxines
- Exoskeleton absent
- Body elongated eel like with circular suctorial mouth
- Paired fins absent
- 6-14 pairs of gill pouches
- Notochord persistent
- Cartilaginous endoskeleton
- 2-chambered heart and mesonephric kidneys
- Single gonad and gonoducts absent
- Development indirect with ammocoete larva in lampreys
- Direct development in hag fish.

Eg: Petromyzon(Lamprey) -ectoparasitic, sanguivore

- exhibits **anadromous** migration during breeding season

Myxine (Hag fish or slime eel)- necrophagous

**Super class-II: Gnathostomata**- Jawed vertebrates

- Paired fins or limbs present
- Paired nostrils present
- Internal ear with 3 semicircular canals
- Includes pisces and tetrapods
- Pisces and amphibians are called Ichthyopsida
- Reptiles and aves are called Sauropsida
- Pisces, amphibians and reptiles are poikilotherms

- Aves and mammals are homeotherms
- Pisces and amphibians are anamniotes
- Reptiles, aves and mammals are amniotes

### **PISCES**

- Most diverse and the largest group of vertebrates
- Study of fishes is called Ichthyology
- Originated during silurian period
- Devonian period is “age of fishes”
- Ostracoderms are the ancestors of fishes
- Acanthodians are the earliest group of fishes which gave rise to osteichthyes (bony fishes)
- Placoderms gave rise to chondrichthyes (cartilaginous fishes)
- Body is streamlined and differentiated into head, trunk and tail
- Body covered by mesodermal scales
- Skull monocondylic
- Vertebrae amphicoelous
- Locomotion by unpaired and paired fins
- Teeth homodont, acrodont and polyphyodont
- Respiration by gills
- Heart 2-chambered and described venous heart and branchial heart
- Single circuit circulation
- Kidneys mesonephros
- Brain covered by single meninx called meninx primitiva
- Cranial nerves 10 pairs
- Lateral line sense organs/Neuromast organs present for rheoreception.

Pisces include 2 extant classes

#### **Class i) Chondrichthyes-**

- Marine fishes with cartilagenous endoskeleton
- Body covered by placoid scales
- Caudal fin heterocercal
- Mouth ventral
- Gills lamelliform and without operculum
- Air bladder absent

-Ureotelic animals and many exhibit physiological uraemia (an adaptation to live in hypertonic

-Pelvic fins bear claspers, acting as copulatory organs

-Fertilisation internal

-Many are viviparous

Eg: Scoliodon (Dog fish)

Scyllium (Shark)

Rhinodon (Whale shark)

Carcharodon (Great white shark)

Sphyrna (Hammer headed shark)

Torpedo (Electric ray)

Dasyatis/Trygon(Sting ray)

Pristis (Saw fish)

Chimaera (Rat fish)

### **Class ii) Osteichthyes-**

-Marine or freshwater or brackish water fishes with bony endoskeleton

-Body covered by cycloid, ctenoid, ganoid or cosmoid scales

-Caudal fin diphyccercal or homocercal

-Mouth terminal

-Gills filamentous and covered by operculum

-Airbladder present

-Air bladder acts as lung, if connected to pharynx, otherwise acts as hydrostatic organ

-Ammonotelic animals

-Fertilisation external

-Mostly oviparous

Eg. Labeo, Catla, Exocoetus (flying fish)Hippocampus (sea horse),Clarias (magur)

Echeneis (sucker fish), Betta splendens (siamese fighting fish),Pterophyllum(Angel

fish),Ophiocephalus (murrel),Hilsa, Anabas (climbing perch),Harpodon(Bombay duck)

### **Tetrapoda:**

-Mostly terrestrial, aquatic or amphibious

-Two pairs of pentadactyl limbs present

-Lungs are the chief respiratory organs

It includes the classes Amphibia, Reptilia, Aves and Mammalia

**Class Amphibia:**

- Earliest group of tetrapods and lead dual mode
  - Evolved during devonian period and flourished during carboniferous period
  - Osteolepid fishes are ancestors of amphibians
  - Body divisions are head & trunk
  - Skin soft without exoskeleton
  - Two pairs of pentadactyl limbs without claws present
  - Skull dicondylic
  - Vertebrae procoelous (anurans), amphicoelous (apodans) and opisthocoelous (many urodeles)
  - Sternum developed for the first time in this group
  - Mouth large, teeth are homodont, acrodont, polyphyodont
  - Respiration mostly through skin (cutaneous), buccal cavity (buccal respiration) or lungs (pulmonary respiration)
  - Heart three chambered with sinus venosus on dorsal side and truncus arteriosus on ventral side.
  - Incomplete double circulation
  - Hepatic and renal portal systems are well developed
  - Kidneys mesonephric; ureotelic
  - Brain covered by outer duramater and inner piamater
    - 10 pairs of cranial nerves
    - Middle ear has single ossicle called columella auris which is modified hyomandibular
    - Tympanum, lacrimal and harderian glands appeared for the first time.
    - Eggs are mesolecithal and telolecithal
    - Development mostly indirect
- Amphibia includes 3 orders
- Order **Apoda**/Gymnophiona-caecilians or blind worms. Eg. Ichthyophis, Uraeotyphlus, Gegenophis, Typhlonectes
  - Order **Urodela**/Caudata-Salamanders and newts, Eg. Salamandra, Necturus, Mud puppy  
Tylotriton (Himalayan newt), Ambystoma (tiger salamander), Amphiuma (congoeel), Cryptobranchus
  - Order **Anura**/Salientia-frogs and toads  
Eg. Bufo melanostictus (Indian toad) Rana (frog) Rhacophorus (Flying frog) Hyla (Tree frog)  
Alytes (Midwife toad) Ascaphus

**FROG**

**order : Anura**

**Family : Ranidae**

- Freshwater in habitat
- Carnivores
- Poikilothermic anamniotes
- Frogs exhibit hibernation(winter sleep) and aestivation (summer sleep)
- Change the skin colour to match their surroundings which is called camouflage

**Rana tigrina**

- Skin smooth,moist and scaleless
- Body divided into head and trunk
- Neck and tail are absent
- Eyes with immovable upper eyelid and the movable lower eyelid is drawn over the eye ball as nictitating membrane.
- Tympanum present behind and below each eye
- Forelimbs with four fingers, hindlimbs with five toes.
- Webbed feet help in swimming
- Sexual dimorphism: Male frogs have sound amplifying vocal sacs and a copulatory or amplexusory pad on the first digit of each fore limb.

**Digestive system**

- Alimentary canal shorter as frog is carnivorous
- Mouth opens into large buccopharyngeal cavity
- Teeth present along the margin of upper jaw only called maxillary teeth
- Vomerine teeth are present on the roof of buccal cavity.
- Maxillary teeth are homodont, acrodont and polyphyodont
- Tongue bifid and useful for capturing the prey
- Buccopharyngeal cavity opens into oesophagus through gullet.
- Oesophagus is short and leads into stomach
- Cardiac sphincter present between oesophagus and stomach whereas pyloric sphincter present between stomach and duodenum
- Duodenum and ileum are anterior and posterior parts of small intestine.
- Rectum forms the large intestine which opens into cloacal chamber
- Cloacal chamber also receives ureters, urinary bladder and opens out by cloacal aperture.
- Villi in small intestine are foldings of columnar epithelium which increase the area of absorption.

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- Villi in small intestine are foldings of columnar epithelium which increase the area of absorption.
- Liver bilobed with gall bladder to store the bile juice
- Bile duct is formed by the union of hepatic ducts and cystic duct
- Pancreas is an irregular gland present between stomach and duodenum
- Pancreatic ducts join the bile duct forming hepatopancreatic duct which opens into duodenum.
- Bile helps in emulsification of fats and converts the acidic food to alkaline medium
- Digestion occurs by the action of pancreatic juice and intestinal juice (succus entericus)

### **Respiratory system:**

Respiration occurs by 3 methods.

**Cutaneous respiration**- occurs through moist, vascular skin and is the most important method of respiration

-**Buccopharyngeal** respiration-occurs through moist vascular lining of buccopharyngeal cavity

-**Pulmonary** respiration-occurs through lungs and buccopharyngeal cavity acts as “force pump”.

-Floor of the buccal cavity is raised and lowered by the contractions of petrohial and sternohyal muscles respiration.

-Glottis opens into laryngotracheal chamber which is connected to lungs by short bronchi

-Vocalcords are present in laryngotracheal chamber

-Laryngotracheal chamber is supported by ring like cricoid and two crescentic arytenoid cartilages.

### **Circulatory system:**

-Heart-3 chambered with two atria and single ventricle and covered by double layer pericardium

-Sinus venosus opens into right atrium whereas common pulmonary vein opens into left atrium.

-Atrioventricular aperture is the common opening through which the two atria open into ventricle.

-Atrioventricular aperture is guarded by 2 pairs of atrioventricular valves.

-Atrioventricular valves are attached to the wall of ventricle by chordae tendinae.

-Columnae carnae are the ridges of the thick muscular walls of ventricle.

- Conus arteriosus arises from the right side of ventricle.
- Pylangium and synangium are proximal and distal parts of conus arteriosus
- 2 sets of semilunar valves are present, one set at the origin of conus arteriosus and second set between pylangium and synangium.
- Longitudinal spiral valve divides the conus arteriosus into dorsal, left cavum pulmocutaneum and ventral, right cavum aorticum

#### **Arterial system:-**

- Consists of 3 pairs of aortic arches.
- Carotid arch supplies blood to head region.
- Systemic arches of both the sides meet each other to form dorsal aorta.
- Subclavian artery is a branch of systemic that supplies blood to fore limbs.
- Dorsal aorta gives many branches like coeliaco mesenteric artery that supplies blood to digestive system
- Gonadial to gonads
- Renals to kidneys and Iliacs to the posterior part of the body.
- Femoral and sciatic are branches of iliacs that supply blood to hindlimbs.

#### **Venous system:-**

Sinus venosus is formed by the union of two precavals/anterior or superior venacavae and post caval/posterior or inferior venacava

Pre caval is formed by:

- External jugular vein that collects blood from the muscles of tongue and jaws
- Innominate vein that collects blood from orbit, brain and shoulder region.
- Subclavian vein which collects blood from the muscles of forelimbs and skin.

-Postcaval vein originates from the capillaries of kidneys and also collects blood from gonads and liver.

and liver.

-Blood from the lungs is collected by pulmonary veins which open into left atrium as a common pulmonary vein

-Hepatic portal vein collects blood from alimentary canal, pancreas and releases into liver.

-Renal portal vein collects blood from lower parts of body and release them into kidneys.

-Blood of frog consists of plasma, erythrocytes, leucocytes and thrombocytes.

-RBC are oval, nucleated & relatively larger in size

**Lymphatic system**- consists of lymph capillaries, lymph vessels, lymphatic ducts, and lymph nodes.

-Lymph hearts are 2 pairs helping in pumping the lymph into veins.

**Integrating system**-consists of nervous and endocrine systems.



-Nervous system includes central nervous system (brain & spinal cord), peripheral nervous system (cranial nerves & spinal nerves) autonomous nervous system (sympathetic & parasympathetic)

Brain- consists of forebrain (or prosencephalon), midbrain (or mesencephalon) and hind brain (or rhombencephalon).

-Fore brain consists of a pair of olfactory lobes, a pair of cerebral hemispheres and diencephalon.

-Rhinocoels are ventricles of olfactory lobes.

-Para coels or lateral ventricles (1st and 2nd) are enclosed by cerebral hemispheres.

-Cerebral hemispheres control voluntary actions

-Dience phalon is concerned with perception of heat, cold, pain and integrity of autonomous nervous system.

-Diocoel (3rd ventricle) is enclosed by diencephalon

-Mid brain consists of a pair of hollow optic lobes (corpora bigemina) enclosing optocoels.

-Optic lobes control vision.

-Hind brain consists of cerebellum (maintains equilibrium) and medulla oblongata (controls involuntary actions)

-Fourth ventricle is enclosed by medulla

-Spinal cord is continuation of medulla.

-Spinal cord acts as middle man between brain and effectors.

-10 pairs of cranial nerves and 9 or 10 pairs of spinal nerves are present.

### Sense organs:

Eyes-Retina contains rods for dimlight vision and cones for color vision.

Organs of hearing : Middle ear & internal ear are present

-Columella auris, the middle ear ossicle, meets the cartilaginous stapedial plate which fuses with fenestra ovalis of auditory capsule.

-Auditory capsule is formed by single prootic bone

-Internal ear/ membranous labyrinth consists of dorsal utriculus to which the 3 semicircular canals join and ventral sacculus.

-Auditory capsule is filled by perilymph and internal ear is filled by endolymph in which calcium carbonate particles, otoliths, are present

-Internal ears are also called statoacoustic organs.

**Excretory system:**

- Frogs are ureotelic
- Mesonephric kidneys with ciliated nephrostomes on ventral surface are present in adults
- Tadpole larva of frog has pronephric kidneys
- Ureter/mesonephric duct/Wolffian duct arises from the outer margin of kidney and open into cloacal chamber.
- In males, as ureters carry both urine and sperms, they are called urinogenital ducts
- Urinary bladder opens separately into cloaca below the openings of ureters
- Frogs excrete hypotonic urine

**Male reproductive system:-**

**Male reproductive system:-**

- Testes are covered by mesorchium and attached to kidneys
- Vasa efferentia from each testis open into Bidder's canal present in the kidney.
- Ureter acts vasdeferens
- Seminal vesicle is the swollen part of ureter just behind the kidney.
- Germinal epithelium is the lining of seminiferous tubules.
- Germinal epithelial cells undergo spermatogenesis

**Female reproductive system:**

- Mesovarium is peritoneal covering by which ovaries are attached to kidneys.
- Eggs are mesolecithal and telolecithal
- Ova are released into body cavity
- Oviduct/Mullerian duct opens into the body cavity by ciliated oviducal funnel called ostium.
- Ovisacs are posterior dilated parts of the oviduct that open into cloacal chamber near the ureter.

Copulation is called amplexus during which both male & female frogs release sperms and ova into the water

- Eggs released in large number called spawn and the spermatozoa released are called milt
- Fertilisation external
- Development includes a gill breathing, herbivorous, ammonotelic "tadpole larva" which metamorphoses into lung breathing, carnivorous, ureotelic adult frog.

**Class: Reptilia**

- First group of true terrestrial tetrapods
- Labyrinthodont amphibians are the ancestors of reptiles
- Evolved during carboniferous period
- Mesozoic era is the "age of reptiles"

- Poikilothermic (ectothermic) amniotes which lay cleidoic eggs on land.
- Study of reptiles is called herpetology.
- Body divided into head, neck, trunk and tail with rough, dry skin covered by epidermal scales, shields etc.
- Two pairs of pentadactyl limbs with clawed digits
- Teeth homodont, acrodont, polyphyodont. Thecodont in crocodiles and edentate in chelonians
- Skull monocondylic with temporal fossae
- Each half of lowerjaw is made of six bones.
- Vertebrae procoelous; sacral vertebrae two in number
- Sternum broad plate like; 'T' shaped interclavicle present between the two clavicles.
- Inter costal muscles are associated with ribs
- Vascular cloaca helps in respiration in turtles
- Heart with incompletely divided ventricle (incompletely 4-chambered) but crocodiles have 4-chambered heart
- Sinus venosus present but conus arteriosus absent
- Three aortic arches- two systemics and one pulmonary arise directly from ventricle.
- Renal portal system present; RBC nucleated
- Kidneys metanephric; uricotelic vertebrates (terrestrial adaptation)
- 12 pairs of cranial nerves (10 pairs in snakes)
- Jacobson's organs, olfactory in function, are well developed in lizards & snakes
- Males with copulatory organ (absent in Sphenodon)
- Mesonephric duct/ Wolffian duct acts as vasdeferens
- Cloaca 3 chambered with anterior coprodaeum, middle urodaeum and posterior proctodaeum,
- Fertilisation internal
- Eggs cleidoic, megalecithal & telolecithal
- Cleavage meroblastic and discoidal
- Mostly oviparous; eggs develop on land as they are amniotes
- Mostly oviparous; eggs develop on land as they are amniotes
- Crocodilians are the largest living reptiles.

Extant reptiles are grouped under 4 orders

**order 1: Chelonia** - Eg. Chelone(turtle), Testudo(tortoise), Trionyx(terrapiin),Chrysemys (terrapiin),Dermochelys (Leatherback turtle)

**order 2:Rhynchocephalia**-Eg Sphenodon (Living fossil)-endemic species in Newzealand

-Commonly called "Tuatara" lizard(Hatteria)

**Order 3: Squamata** : 2 sub orders

**Suborder (i) Lacertilia**-Lizards

Eg. Calotes (Garden lizard), Hemidactylus (Wall lizard), Chamaleon, Draco (Flying dragon), Heloderma (Venomous lizard), Uromastix, Varanus (Monitor lizard), Phrynosoma (Hornedtoad), Ophiosaurus (Glass snake; limbless lizard).

-Komododragon of Indonesia is the largest lizard.

**Suborder (ii) Ophidia:**

**Poisonous snakes:** Naja naja (cobra), Ophiophagus hannah (king cobra)

Bungarus (krait), Daboia/Vipera russeli (chain viper), Echis carinata (saw scaled viper; phoorsa), Hydrophis (sea snake); Calliophis (coral snake)

**Non poisonous snakes:** Ptyas (Rat snake), Tropidonotus/Natrix (Grass snake or pond snake), Python (Ajgar) etc.

**Order 4: Crocodylia/Loricata:** Largest living reptiles Eg. Crocodylus, Alligator,

Gavialis (Indian gharial), Caiman etc

**Class: Aves:**

-Feathered, bipedal, homeothermic (endothermic) amniotes

-T.H. Huxley called them “glorified reptiles”

-J.Z Young called them “the masters of air”.

-Originated during Jurassic period from Theropod dinosaurs

-Modern birds evolved during Cretaceous period.

-Study of birds is called Ornithology

-Dr. Salim Ali is called “Bird man of India”.

-Body divided into head, long neck, trunk, tail and covered by epidermal feathers, scales on legs, rhamphotheca on beak,

-Preen gland is the only cutaneous gland present

-Forelimbs modified into wings, hind limbs with 4 clawed digits.

-Pneumatic bones with air cavities (flight adaptation).

-Skull monocondylic

-Vertebrae heterocoelous

-Synsacrum is formed by the fusion of last thoracic, lumbar, sacral and anterior caudal vertebrae.

-Pygostyle is formed by the fusion of posterior caudal vertebrae and supports the tail.

-Sternum has keel or carina for the attachment of flight muscles (absent in ratitae birds).

-Furcula, a ‘v’ shaped structure is formed by the union of clavicles and inter clavicle and is called “wish bone” or “merry thought bone”.

- Ribs are double headed in birds, crocodiles & mammals and uncinatate processes are present in birds.
  - Flight muscles are pectoralis major for downward stroke and pectoralis minor for upward stroke of wings.
  - Teeth absent
  - Oesophagus dilates into crop
  - Stomach consists of anterior proventriculus and posterior ventriculus / gizzard.
  - Cloaca is 3 chambered as in reptiles.
  - Larynx is without vocalcords.
  - Syrinx, present between trachea and bronchi, is for sound production.
  - Syrinx, present between trachea and bronchi, is for sound production.
  - Lungs are without alveoli
  - Airsacs are 9 (unpaired inter clavicular and 4 paired sacs) associated with lungs.
  - Airsacs facilitate continuous oxygenation of blood and pneumaticity of bones.
  - Heart 4 chambered with only right systemic arch and pulmonary arch
  - Sinus venosus and conus arteriosus absent
  - Renal portal system reduced
  - RBC nucleated
  - Kidneys metanephric ,three lobed;uricotelic,
  - Urinary bladder absent(present in ostritch)
  - Brain** with 2 meninges, duramater and, pia-arachnoid
  - Olfactory lobes are poorly developed (olfactory sense well developed in Kiwi)
  - Optic lobes are large
  - Cranial nerves are 12 pairs.
  - Eyes with sclerotic plates and “comb like” pecten in vitreous chamber (Pecten absent in Kiwi)
  - Middle ear has only columella auris
  - Right ovary and right oviduct are reduced
  - Copulaory organs absent except duck, geese, ratites etc
  - All are oviparous
  - Eggs megalecithal, telolecithal and cleidoic
  - Cleavage meroblastic, discoidal
  - Young ones are precocious in ratite birds, altricial in flying birds.
- Eg. Archaeopteryx lithographica-extinct lizard bird of Jurassic period; connecting link between reptiles and aves.
- Struthio camelus (African ostritch)- largest bird

Apteryx (kiwi)-National bird of Newzealand

Rhea americana (American ostritch) Dromaeus & Casuarius - live in Australia.

Ratitae exhibit discontinuous distribution :

**Flying birds** : Corvus (crow), Columba(pigeon),Pavo cristatus (peacock),Coracias

bengalensis (Blue jay), Passer (sparrow), Psittacula (parrot), Neophron(Vulture)

Eudynamys (koel), Bubo(owl),Alcedo(king fisher),Milvus(kite),Dinopium(Wood pecker),

Gallus(Fowl),Aqurilla(eagle),Aptenodyptes(penguin) etc

**Class:Mammalia:**

- Advanced, hairy, most diverse, homeothermic ammiotes which nourish the youngones with milk secreted by mammary glands.
- Originated during triassic period from Therapsid reptiles
- Coenozoic era is “the age of mammals”
- Study of mammals is called mammology
- Largest animal is the blue whale Balaenopterus musculus
- Body divided into head, neck, trunk, tail and covered by hair (hair reduced in whales, armadillos)
- Skin with sweat glands/ sudoriferous glands,sebaceous glands, scent glands etc.
- Mammary glands are modified sweat glands.
- Skull dicondylic; each half of lower jaw is formed by a single bone dentary.
- Vertebrae are amphiplatyan; only 7 cervical vertebrae [6 in Cholepus, (2 toed sloth) & Trichechus (manatee) & 9 in Bradypus( 3 toed sloth)]
- Buccal cavity is separated from nasal cavity by secondary bony palate.
- Teeth are heterodont, thecodont &diphyodont
- Four pairs of salivary glands (3 pairs in man)
- Epiglottis present ; Larynx is the sound producing organ
- Heart 4 chambered; left systemic arch and pulmonary arch arise from left and right ventricles
- Heart 4 chambered; left systemic arch and pulmonary arch arise from left and right ventricles respectively.
- RBC circular (oval in camels, llamas) biconcave and enucleated
- Renal portal system absent
- Brain and spinal cord covered by three meninges duramater, arachnoid and piamater.
- Corpus callosum connects the two cerebral hemispheres.
- Optic lobes are four and are called corpora quadrigemina.

- Cranial nerves are 12 pairs.
- Eyes with movable eyelids and eye lashes
- External ear or pinna present
- Middle ear ossicles are three, malleus, incus and stapes
- Internal ear with spirally coiled cochlea which bears “organ of corti” for hearing
- Kidneys are metanephric; ureotelic
- Ureters open into urinary bladder.
- Nephrons have Henle’s loop; urine hypertonic
- Testes extra abdominal present in scrotal sacs (except monotremes, cetaceans, seacows elephants etc)
- Fertilization internal, viviparous (except monotremes).
- Placenta formed by chorion and allantois in eutherians
- Period of intra uterine development is called gestation period.

Class Mammalia includes two subclasses:

**Sub class 1:Prototheria** (order:Monotremata) Oviparous mammals without external ear.

Eg: Echidna/Tachyglossus (Spiny ant eater)Ornithorhynchus (duck billed platypus)

**Sub class 2: Theria**-viviparous mammals

-includes metatheria and eutheria

**Metatheria** (Marsupials)- found in Australia & S.America(discontinuous distribution)

Pouched mammals.

-Marsupial with true chorio-allantoic placenta is Perameles

Eg. Macropus (kangaroo),Didelphis(opposum)Perameles (marsupial bandicoot)

Notoryctes(Marsupial mole)Thylacinus(tasmanian wolf) Caenolestes (opposum rat)

**Eutheria**- true placental mammals

Eg. Pteropus (flying fox)Elephas(elephant)Antelope(state animal of A.P)Macaca(monkey),

Rattus(rat),Canis(dog),Felis(cat),Funambulus(squirrel),Equus(horse),Delphinus(dolphin),

Camelus(camel), Hystrix (Porcupine).