CHORDATES

Phylum chordata include primarily the vertebrata (craniata) and proto-chordata (acraniata). The proto-chordates are mostly of small sizes and are marine. The vertebrates include practically all living animals of medium to large size notable some huge sharks and whales are included. Most of the chordates are free-living and none is practically parasitic.

There are about 65,000 know living chordates besides the fossils remains of many extinct forms. These animals exhibit some common characteristic which shows their common ancestors. But there is a considerable controversy surrounding the origin of chordates.

CHORDATES CHARACTERS

In chordates, at some time in their life history, exhibit the following 3 primary diagnostics characters

1) NOTOCHORD: a notochord is an elastic, solid skeletal rod and lying below, the nerve and above the alimentary canal. Its made up of vacuolated cell enclosed in one or two sheets of connective tissues. It serves as a primitive internal skeleton and acts as a rigid

Gill Cleft – One of a series of slit openings in the pharynxes of fishes through which water passes

rigid axis but permits movement of the body. It may persist throughout life as in lancelet, lamprey and some fishes or it may be replaced partially or completely by a backbone or vertebrae column.

ii) Dorsal tubular (or hollow) nerve chord – There is a dorsal hollow fluid-filled nerve chord. They may form by in-folding of a mid-dorsal stream of ectoderm and its generally seen below the surface. It ~~has~~ lies below the notochord and outside the coelom. It has a hollow canal running from one end to another. This dorsal, tubular nerve chord persists throughout the life of most chordate but, in a few degenerate before maturity.

iii) Gill Cleft are paired openings leading from the pharynx to the exterior. Outpushing of the endoderm lining of pharynx meets and fuse with ectodermal inpushings from the

visceral cleft — series of slot like openings in the wall of pharynx b/w branchial arches of fish

~~exterior in intervening walls being broken down the exterior in intervening~~ intervening walls being broken down thus Gill clefts are ~~form~~ formed. Such Gill cleft effect appear during development of every chordate but in many aquatic forms, they are lined with vascular lamellae which forms gills for respiration.

In terrestrial chordates which never breathes by gills, traces of gill cleft exists during early development but most of them disappear before adult life.

Gill cleft are ~~also~~ also called "gill slits" or pharyngeal cleft. In lower chordates, the visceral clefts are used as feeding mechanism but for higher chordate, the gill cleft often form some endocrine glands.

Higher chordates also possess the following characteristics.

(i) Ventral heart: In most chordates, circulation occurs by a muscular heart. The heart is ventral in position and the flow of blood in dorsal vessels

is from the anterior to posterior and in the ventral vessels from the posterior to the anterior side. In higher chordates, the heart lies in the pericardial cavity which is a modified part of a coelom.

(ii) Hepatic Portal System. The veins begins as capillaries in tissues and finally join another vein or enter the heart but, the food laden blood comes from the alimentary canal through a hepatic portal vein which capillaries in the liver. The hepatic portal vein which capillarizes in the liver. The hepatic portal does not only begin but also ends in capillaries. It also acts as effluent (afferent) and effluent (efferent) vessels that's why it's called Hepatic Portal Vein.

(iii) Red blood cells: Most chordate have red-blood corpuscles or erythrocytes having haemoglobin or respiratory pigments.

Upeta

iv) Post anal tail: The posterior part of the body takes the form of a segmented post anal tail which is a posterior elongation of the body. It has no coelom and contains no viscera but has extending muscles, chords and notochord (backbone in Rat).

Presence of a tail is perhaps due to aquatic habitat of the primitive chordates. The tail is flexible and muscular, it acts as an organ of locomotion in water and in terrestial forms, it's is ~~much~~ much more modified or reduced in the adults. The highe chordata, in addition to the above features, may have several characteristics features which may be common in other phyla. These are (i) Cephalization (ii) Bilateral symmetry (iii) Triploblastic condition (iv) Possession of coelom (v) metameric segmentation.

SUB PHYLUM HEMICHORDATA

GENERAL CHARACTERISTICS OF HEMI-CHORDATA

(1) They are Marine, Worm like and soft body animals.
(2) Body is divided into proboscis, collar and trunk
(3) The notochord occurs only in the anterior end of the body. Recently, it has been called "buccal diverticulum" due to its doubtful nature.
(4) There are numerous gill-slit.
(5) Nervous tissues lies embedded in the epidermis and occur both on the Dorsal and ventral surfaces.
(6) Coelom is usually divided into 3 distinct portion corresponding to the three regions.
(7) Blood Vascular system is very simple.
(8) Sexes are seperate and the development may be direct or indirect.

CLASSIFICATION

Hemichordata have been divided into Four (4) classes

(1) Enteropneusta — 70 species

Sessil Sessiles Sessiles

Solitary – always lives of single

Sedentary – must live attached to something

- They are solitary and burrowing worm like marine forms commonly known as Acorn or ~~tong~~ tongue-worms.
- The body consist of the usually division i.e proboscis seperated by narrow stalk from ringed shaped collar which is succeeded by an elongated trunk.
- Two rows of hepatic ~~ceca~~ caeca are present in the middle of the trunk,

Eg Balanoglossus, Saccoglossus etc

(2) ~~Pteropra~~ Pterobranchia – 10 to 20 species

- They are sedentary, solitary, colonial and marine form
- The proboscis bears ciliated tentacles to produce ciliary feeding currents of water
- Collar bears two or more tentacilated arms
- There is one pair of gill slits or none.
- Alimentary canal is U-shaped with dorsal anus ~~at~~ situated near the mouth.
- Gonads are few in number and reproduction is by budding.

Ordovician — 485.4 — 443.4 million years ago

(3) Planetosphaeroidea

- These are known only by a ~~lar~~ round transparent veligic larva related to Tornaria larva
- The larva have branching arborescent ciliated bands on the surface
- The Alimentary Canal of larva is U-shaped
- The Adult form is yet Unknown

(4) Graptolita

- These are extinct colonial Hemi-Chordata
- They are mainly known from the fossil structure of ~~thecal~~ their ~~tooth~~ tubes
- Each animal is housed in "zoids"
- These were abundant in the ordovician and silurian period.

REPRESENTATIVE Animal.

Saccoglossus

- It is a soft Cylindrical, marine and burrowing animal.

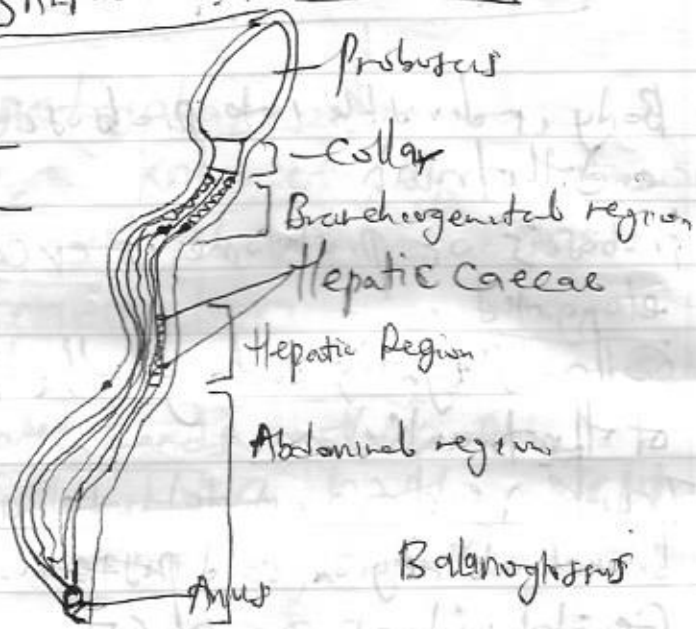
Saccoglossus Kowalevski

- Body is divisible into proboscis, collar and the trunk
- Proboscis or protosome is exceptionally elongated.
- Collar slightly overhangs the beginning of the trunk.
- Trunk is differentiated into anterior branchial region and posterior branchial region.
- Genital ridges are absent
- Hepatic caeca are not visible.
- Alimentary canal is straight and anus is present on the posterior ends of the body.
- Sexes are seperate & fertilization is external
- Development includes a free swimming tornaria larva.
- Saccoglossus is ~~formed~~ found in the Indo-Pacific Atlantic coast, New zealand and Australia, not available in Africa coast.

BALANOGLOSSUS GIGAS

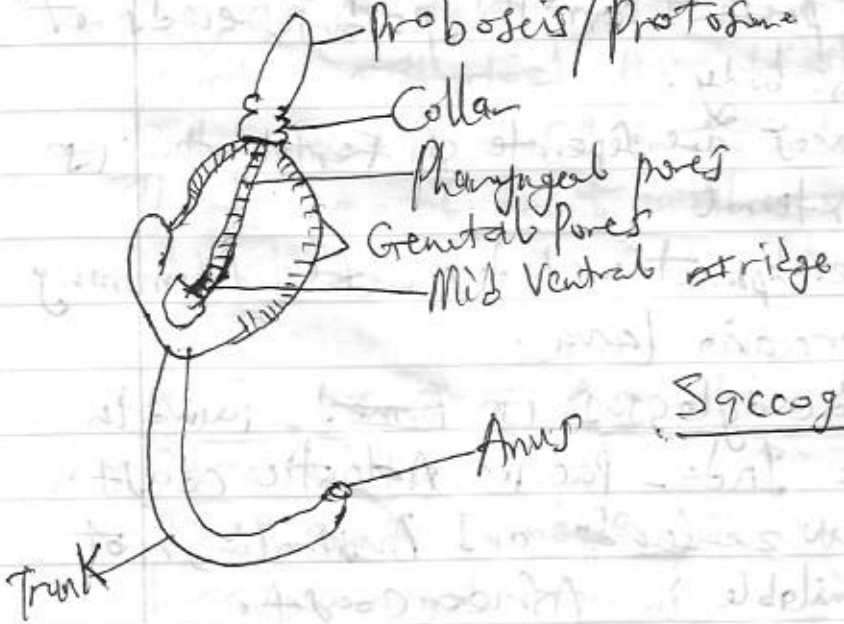
Saccoglossus

Balanoglossus



Balanoglossus

Representative Enteropneusta: Ciona



Saccoglossus

Pelagic — live near the surface or in the water column of coastal, ocean and lakewater but not in the bottom

SUB-PHYLUM UROCHORDATA

General Characteristics of Urochordata

(1) They are exclusively Marine commonly known as sea squirts.

(2) They are either solitary or colonial

(3) Fixed or free swimming and pelagic

(4) The body is covered by a cuticular tunic or test in adult stage.

(5) Notochord present in the larvae stages and absent in adult.

(6) Dorsal tubular nerve cord is present in the larva forms while degenerate in the form of small ganglion in adult

(7) There are numerous gill slit in the animals

(8) The heart is ventral, simple and tubular

(9) Coelom is completely absent, even the pericardial cavity is not coelomate

(10) Sexes are United — Hermaphrodite

Urochordata have been divided into 3 classes

(1) Class Larvacea

- They are free swimming and pelagic.
- Neotenic forms which retain the larva form through'out adult life.

test – Covering of a animal
tunic – Outer covering of a animal

- The test (or tunic) is temporary
- posterior parts of the body takes the form of a large locomotory appendage, the tail
- A single pair of gill slits is present
- The anus opens ventrally on the surface of the body
- Sexes are united (hermaphrodite)
- No Metamorphosis

(2) Class Ascidiacea

- Fixed or free swimming marine form
- They could be simple or compound solitary or colonial
- The adult are never provided with the locomotor appendages or tail and have no ~~traces~~ trace of notochord.
- The test (tunic) is permanent and is well ~~developed~~ developed
- Branchial sac is large and well developed with its wall perforated by numerous gill slits.
- Reproduction ~~go~~ are both asexual & sexual

Solitary Isolated

(3) Class Thaliacea

- They are free swimming, pelagic form, solitary or colonial
- Test (tunic) is permanent and transparent
- May be slightly or well developed
- Musculature of body wall is in the form of circular bands
- Branchial sac has either 2 large or many small gill slits.
- The tail and notochord are absent in Adult
- The life history of this group (class) exhibit an alternation of generation.

REPRESENTATIVE TYPE : CIONA

- It is solitary and is found in great abundant on rocks, ships etc in cold and temperate sea.
- It is 10 - 12 cm long with a cylindrical body.
- It is fixed by a broad foot like stalk

Ciona ~~intest~~ intestinalis — arteral — Auricle-atrium

or base

- Branchial and Arterial siphons are cylindrical, the former ~~branch~~ been higher up than the latter.
- The test is thin and transparent.
- The Mantle has longitudinal muscle band.
- The ~~heart has~~ pharynx have no internal folding
- The dorsal ~~lamina~~ lamella has languets.
- The stomach, oesophagus and intestine lies below the pharynx and not on one side.
- Hermaphrodite gonad is single lying in the intestinal loop

Sub-phylum Cephalochordata eg Branchiostoma lanceolatum off European shore

Branchiostoma virginiae - North America

GENERAL CHARACTERISTICS

Cephalochorda

- The class include several species of Lancelets/amphioxus.
- They are cosmopolitan in shallow marine and brackish water from tropical to temperate region
- They are small in size
- They are filter-feeding animals found in shallow water.
- A lancelet has a long body, pointed at both ends with a large notochord that extend almost from tip to tip and it occurs throughout life.
- They spend much of time buried in sand (live in seafloor). They are therefore said to have a sedentary life style.
- At one end is a mouth surrounded by prominent bristles and leading into a pharynx.
- The excretory system consist of segmentally arranged nephridia like many invertebrates.
- Fertilization is external
- Sexes are seperate.

- They have numerous gonads which are segmentally arranged unlike other chordates.
- They have no scales.
- They have no bones and cartilage as true fish have
- They possess a notochord which gives stiffness to the body.

Biology of lancelet

(1) Skeletal System: They have no skull, scales, bones and cartilages but they possess notochord

(2) Feeding and Respiration: Adult lancelets have two (2) oral tentacles and they are called "cirri". The animal use this cirri to select larger particles from the water.

Cillia in the pharynx generates a water current through the gill slits from where the water flows into the atrium and then to the exterior by ~~atripore~~. atripore.

An endostyle secrete a mucus sheath covering the gill slits, trapping small food

particles. The gill slits carries out the work of feeding and gaseous exchange.

(3) Excretion: Hepatic Caecum is present. Two nephridia are present for excretion.

(4) Reproduction: Sexes are separate. The gonads are ventrally from the frontal part of the intestine. The fertilization of the eggs is external. The eggs act as Ciliates "neurillae" and develop into free swimming larvae that resemble a tadpole larvae of Ascidian tunicates.

(5) Digestive System: Water is drawn in through the Mouth by the action of numerous beating cilia, passes through many small slits in the pharynx before exiting via the atriopore.

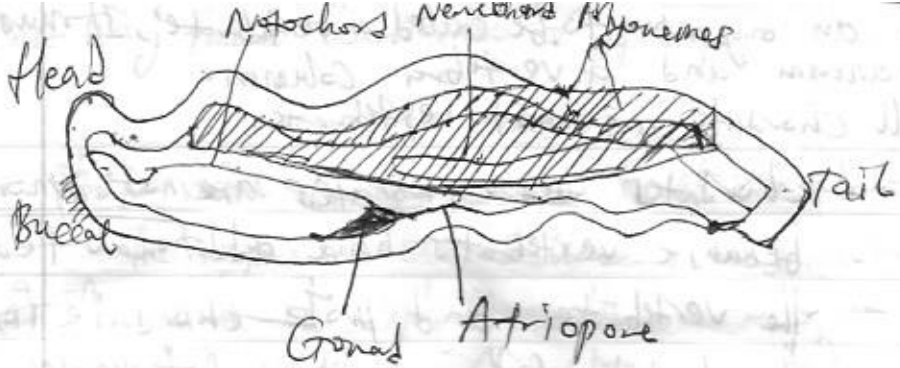
An organ called Endostyle along the Ventral surface of the pharynx produces mucus which moves to the dorsal groove of the pharynx and then swept back along with the particles trapped in it towards the animal stomach for digestion.

(2) Circulatory System: Blood is Colourless without haemoglobin. Blood Move forwards through a ventral vessel and backs through a dorsal vessel in a typical Chordate.

They have no major heart but many small enlargement of the vessel serves the function of the heart

(7) Nervous System: ~~Lancet~~ Lancelet have dorsal tubular nerve chord which is slightly enlarged in the anterior region forming a rudimentary brain. Nerves extend from the nerve chord to other parts of the body.

(8) Muscular System: The muscles as in fishes are a series of Cone shaped blood that fit into each other like stacked paper cup called "Mysomers". The structure allows it to swim like a fish.



Lancelets

FISHES

Fishes are also called ~~Fisces~~ PISCES.

Characteristics

- They are vertebrate. Vertebrate is derived from the ~~pressure~~ presence or serially arranged vertebrae which comprise a major part of their axial ~~bodyskeleton~~ or backbone.
- Another diagnostic character is the elaboration of the anterior skeletal elements into a "Cranium" or "SKULL" which houses various sense organs and a complex brain. Animals with a cranium are called "Craniata".
- A vertebrate must possess a cranium and a ~~vat~~ vertebral column through which a nerve chord passes.

* For an organism to be called a "vertebrate", It must have a cranium and a vertebra column.
* All chordate are not vertebrate

- Chordates and vertebrates are not synonymous because vertebrates have additional features, the vertebrate and proto-chordate form the chordates. Other features of vertebrate are vertebrate occupy both aquatic and terrestrial habitat. The body is typically made of a head, trunk and postanal tail.
- Body covering or integument is a stratified epithelium made up of an outer epidermis and an inner dermis.
- Vertebrate have jointed endoskeleton made up of bone and cartilage.
- Respiration by lower vertebrate is by gill while in terrestrial vertebrate is by lungs.
- Vertebrate have well developed heart.
- Excretion is by well-developed kidney
- Anterior end of the nerve chord is enlarged to form a brain.
- Vetebrate have special sense organs, a pair of eye and a pair of auditory organ.
- Sexes are seperate in Vertebrates

- Most living fishes are member of group Teleostei

Fishes are the largest group of vertebrate. The Major sub-classes under Pisces include

(i) Agnatha or Cyclostomata
(ii) Chondrichthyes (Cartilaginous fish)
(iii) Osteichthytes (Bony Fishes)

Sarcopterigus (Flesh lobed fin fishes)
flesh

Actinopterigus (Ray-finned fish)

Chondriostei Holostei Teleostei
(Most Common fishes found around)

Fishes (pisces)

The ~~Teleost~~ are most numerous of all vertebrates. They are found in Marine, freshwater and brackish aquatic environment.

Agnatha or Cyclostoma

Agnatha means "without jaws". They are mostly extinct fishes, but the only

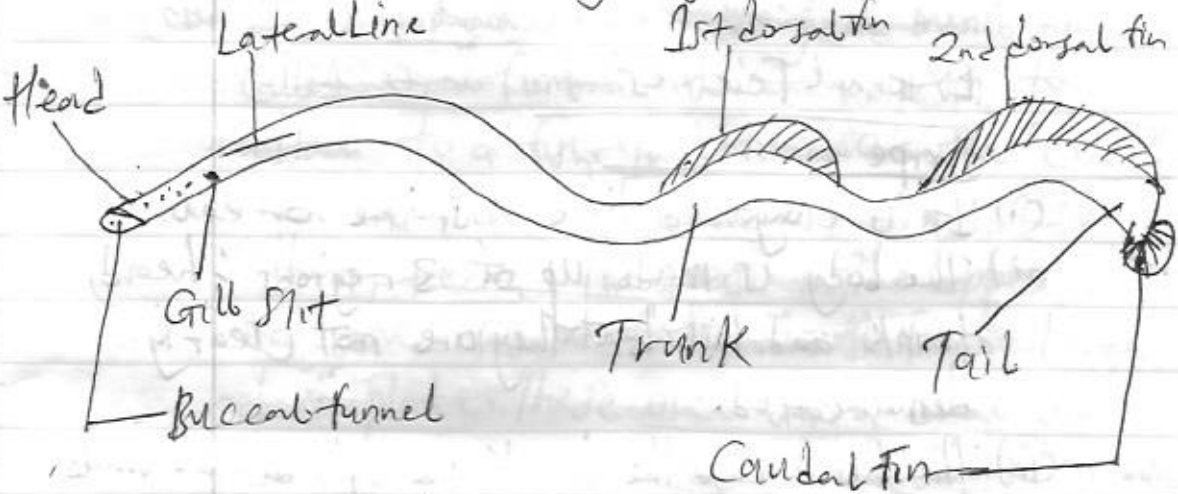
class of this group is "Cyclostomata". The name is derived from their circular mouth. (Greek Cyklos — circular, Stoma — Mouths).

They have functional mouth which is circular without functional jaws. They can be rightly called "Jawless fishes". They are the most primitive of existing ~~vertebrates~~ vertebrates.

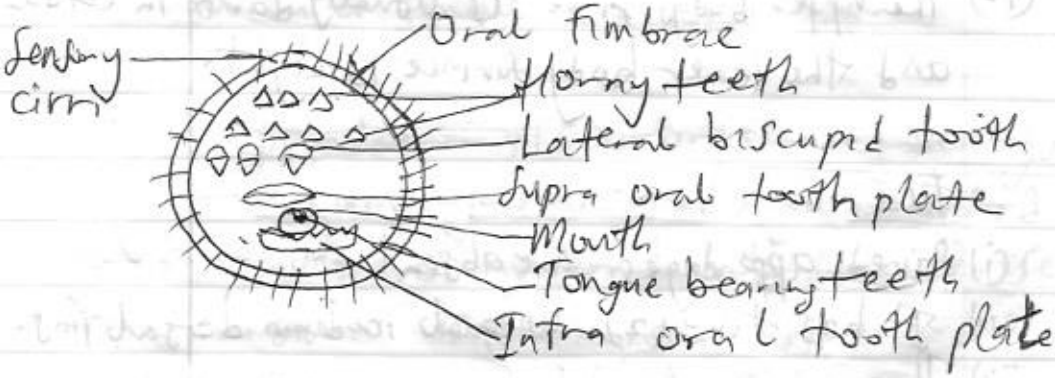
Phylum Chordata
Subphylum Vertebrata
Group Agnatha
Class Cyclostomata
Order Petromyzoniformes
Family Petromyzonoidae
Genus ~~Marinus~~ Petromyzon
Specie ~~Petromyzon~~ Marinus

The two orders to be discussed are Petromyzoniformes & Myxiniformes

Petromyzoniformes e.g. Lamprey
Myxiniformes e.g. Hag fish



Lamprey: Petromyzon marinus



DISTRIBUTION

Lamprey are world wide in distribution. There are 2 types: Petromyzon marinus and Lampetra fluviatilus

and Lampretra fluviatilus. The latter is an example of freshwater Lamprey.

External features

Shape

(i) It is elongated like a snake or eel.
(ii) The body is made up of 3 regions: head, trunk and tail but they are not clearly demarcated.
(iii) The head and the trunk are cylindrical while the tail is laterally compressed.
(iv) The upper body surface is usually dark in colour and the lower body surface is light.

Fins

(i) Paired appendages are absent.
(ii) It has two (2) unequal medium dorsal fins.
(iii) There is a caudal fin around the tail.

Buccal funnel

(i) The anterior body end or head bears a

ventrally directed large cup-like depression called the "buccal funnel".

(ii) It is surrounded by a marginal membrane called "Oral fimbriae" which help it to attach to a fish. In between are the "cirri".

(iii) There are rows of conical teeth called "Horny teeth". The teeth in the upper and lower sides of the mouth form large tooth plate. These are "Supra oral and Infra oral tooth plate". A small circular mouth opening is found in the centre with a tongue bearing teeth.

~~Appendag~~ Appertures or Openings

→ Lamprey has 7 small rounded opening of external gill slits. Posses a small mid-dorsal nostril.

— It has a mouth and Cloaca.

Respiration

— There are 7 gills in spherical gill

* In Adult, Water passes through the gill slits but in Larvae, Water passes through the Mouth pouches.

- Blood in gill Capillaries take in Oxygen and releases CO_2 and water in gill pouches.
- Each gill pouch has an external slate through which Water passes.
- In adult lamprey, the Mouth is attached to another fish (parasitic). (external parasite)
- Velum prevent Water in the pharynx from entering the breeal Cavity.
- In Larvae, respiratory Water enters through the Mouth and passes out through the gill slits as in true fishes.

REPRODUCTION

- Lamprey (Petromyzon marinus) lives in the sea and spawn in fresh Water (River).
- Petromyzon has a peculiar breeding habit and breed only once in its life time.
- During Migration, from the sea to the fresh Water, feeding stops.
- They Use the fat stored in the Muscles and

beneath the skin.

- On getting to the river, the male attaches itself to the female.
- Eggs are layed by the female and fertilized by the male.
- After spawning, the eggs are covered with sand and both parents die.
- Fertilization is external and the larva are called ammocoete.
- The larva is now living in a fresh water. It is a filter feeder, reminiscent of branchiostoms.

MYXINIFORMAE

Myxine or Hag fish

- Myxine has mouth with 4 pairs of tentacles and gill slit.
- It has no buccal funnel like Lamprey.
- Gill pouches are between 6-15 pairs
- Dorsal fins is absent
- It lays few and large eggs.

- Development is direct into a young adult <No larva Stage>.
- Myxini lives exclusively in the Marine environment
- The body is elongated, eel-like like a snake and without scales
- The body is differentiated into "head, trunk and tail", similar to lamprey. Suctorial Mouth is terminal and the eyes are degenerated and covered with thick skin.
- The tentacles / cirri which are found around the Mouth are supported by cartilage and their function is "sensory" because their eyes are weak.
- There is a large mucus gland that opens on the side of the body and it secretes enormous quantity of slime. Hence, another common name "The slime eel".
- The Fimbriae develop mid-ventral fin.
- Myxine attacks injured or dead fish and burrows into the body of the animal for flesh consumption. This gives them the name "Borer".

- Myxine is an internal parasite
- Unlike lamprey, hag fishes do not migrate to freshwater to spawn. They spawn in marine ~~enviro~~ environments
- The eggs hatch into a ~~mixture~~ miniature adult without passing through the larval stage.

Similarities With Cephalochordate

- They lack jaw like the cephalochordate
- They have numerous gill slits
- They have straight and simple canal.

Vertebrate features of Agnatha

- Formation of the head bearing eyes.
- Presence of the cranium housing brain.
- Stratifying epithelium
- Presence of gills used primarily for Respiration.

Difference Between Petromyzon & Myxine

(1) Lamprey has a Mouth with rasping tongue
Mouth in Myxine has sensory tentacles

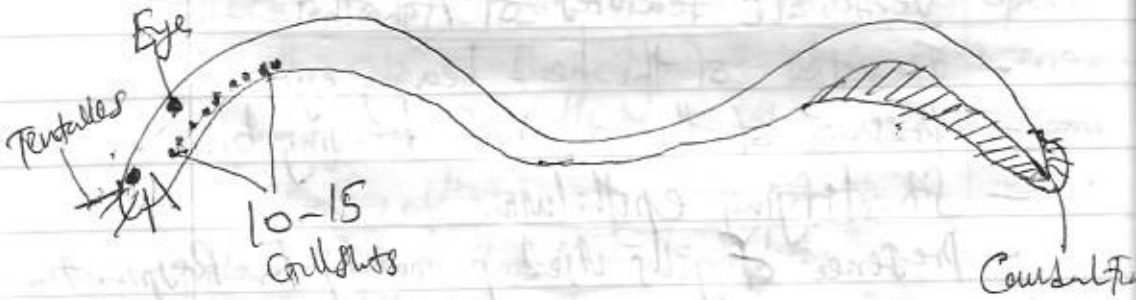
(2) In Petromyzon, gill slits is about 7 pairs
In Myxine, gill slits is between 6-15 pairs

(3) In Petromyzon, buccal funnel is well developed
In Myxine buccal funnel is absent.

(4) Dorsal fin is ~~absent~~ present in Petromyzon, absent in Myxine

(5) Petromyzon is external parasite of fish,
Myxine is internal scavenger of fish.

(6) Petromyzon is Unisexual (male & female).
Myxin is ~~hermaphroditic~~ hermaphroditic.



Myxine or Hagfish

OSTEICHTHYES [BONY FISH].

The name is taken from the word "Osteon" [bone] and "Ichthyes" [fish].

General Characteristics

- The body is covered with flattened scales although some are scaleless.
- Jaws are present in the Osteichthyes.
- Skeleton is made up of bone. Only a few have cartilagenous skeleton.
- The gill chamber is covered by an operculum.
- Lungs & swim bladder are developed as an outpocket of the gut.
- Osteichthyes are true bony fishes and they inhabit both fresh water and marine environment.
- The osteichthyes gave rise to the land vertebrates or tetrapods.
- The most distinctive feature of the osteichthyes is the possession of sac-like diverticulum from the gut which mainly function as lung.
- Example is in the crossopterygii and

* Lung – Crossopterygii
* Swim bladder – Actinopterygii

as a swim bladder in the Actinopterygii.

– Example of the bony fish is Tilapia.

Representative Osteichthyes : Tilapia

BIOLOGY OF TILAPIA

Habitat: Tilapia is an edible fish. It is common in fresh water, especially in rivers or lakes. A few are found is salt water like the brackish environment of the Lagos lagoon. The whole body is covered by scales and it is laterally compressed along the entire length. The mouth is terminal and small.

– The upper and lower ~~teeth~~ jaws have teeth
– The eyes are large but their is no eye lid.
– There are 2 small nostrils in front of the eye and operculum or gill cover is seen on both side of the head
– The trunk extends from the operculum to the anal opening or beginning of the caudal fin.

- Two lateral lines are present on each side of the body.
- The dorsal fin is single and long and has both spines about 15 and 18 spines and dorsal fin followed by soft rays.
- The skin is covered by Cycloid scales embedded in the dermis and it is ~~cover~~ covered by thin epidermis.

* Respiratory System
- When the operculum is lifted, the bright red gill are seen.
- Four gills lie on each side of the head below the operculum (This is site for respiration).
- ~~Gills~~ Unlike the dog fish (Chondrichthyes) the gills are not in pouches because the septum has been reduced but loose gill filaments hang down from the gill arches
- The anterior body of the arch projects

2 (two) rows of short ~~gill~~ teeth-like processes called GILL RACKERS, they serve to protect the delicate filament.

- Exchange of oxygen, Carbon (IV) oxide occur at the gill filament.

* Swim bladder:

- Tilapia possesses a swim bladder. It is a hydrostatic organ being directly below the vertebra column.
- It is silvery white in colour.
- In tilapia, the hydrostatic organ has no connection with oesophagus, this condition is referred to as "PHYSOCLISTIC" condition but in physostomous fish such as Clarias, a pneumatic duct connects the swim bladder to the oesophagus.

* Feeding

- Tilapias are herbivore, it feeds on plant material e.g plankton in water or water weed.

Difference b/w physoclistic & physostomatous fishes

- The intestine of tilapia is very long and coiled (an adaptive feature of herbivorous fish).

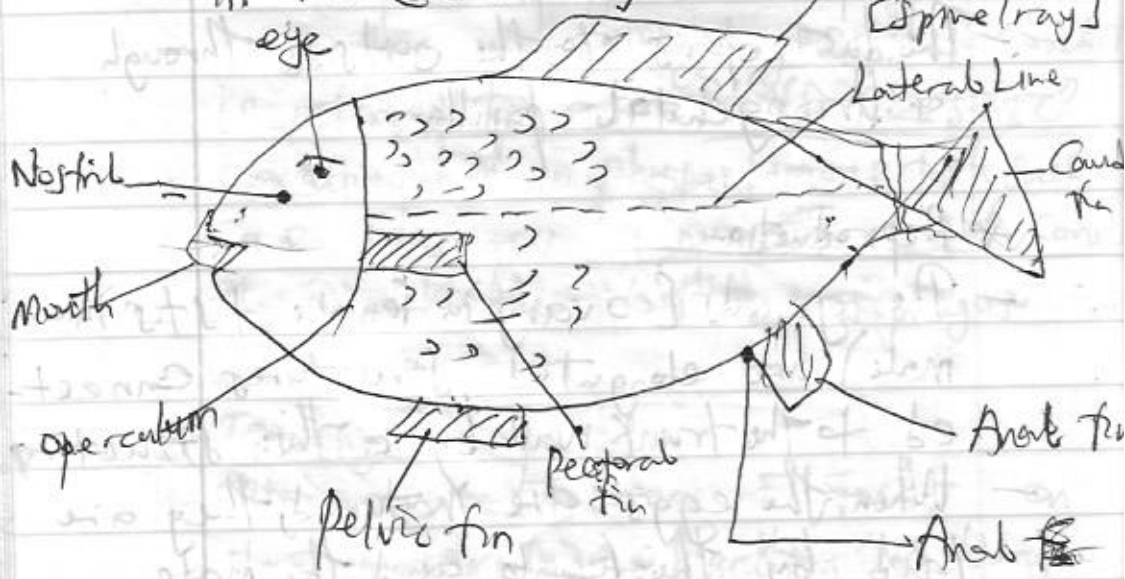
* <u>Urinogenital System:</u>
- The Urinogenital System consists of elongated thin kidneys which lie close to the vertebra column.
- Posteriorly, a short mesonephric duct comes out from each kidney which then unite to form a common mesonephric duct and a small urinary bladder is present in tilapia.
- The duct opens to the outside through a <u>Urinogenital papilla</u>.

* <u>Reproduction</u>
- The gonads (ovary in female, testis in male) are elongated structures connected to the trunk wall by a thin structure.
- When the eggs are matured, they are laid by the female and the male fertilizes the egg.

- Fertilization is external. Based on fertilization, they are divided into 2 groups; one guarding the eggs from predators and is called TILAPIA OR GURAMI. The other that carry the eggs in their mouth to incubate it until they hatch before releasing and are called Sarotherodon.

Economic Importance

- Good source of protein
- Can also be cultivated & generates income for farmers
- Source of Work for the people living in farm (Culturists)



Based on fertilization, Tilapia has been divided into two classes

(1) The Guarders: Membe of this class lay their eggs and guard it, they are also called "Tilapia".

(2) The Sarotherodon: Member of this class brood their eggs in their mouth Until shortly after the eggs hatches. They are also called "Brooders". Young Fishes are called "Fry".

CLASS CHONDRICHTHYES

Origin of fish

- Fish evolved during the Cambrian Period and they have no jaws.
- They become important Unit during Silurian and Devonian periods.
- Myllo Kuminga is one of the earliest fishes from Early Cambrian period.
- It had respiratory gills formed by pharyngeal gill slits located in a set of pouches and had no paired fins
- During early Ordovician, Ostracoderms diversified in the oceans.
- They were small (12-35cm), jawless, finless, torpedo shaped aquatic vertebrates.
- Those filter feeders had armoured protection around the eyes and had 8 gill openings
- They were extinct in Devonian period.
- Hagfish and Lampreys are relatives of Ostracoderms.
- They are extant members of Ostracoderms
- Hagfish and Lampreys have long cylindrical bod

cartilage skeletons, no paired fins, jawless and they are predators

- Lampreys hatch in fresh water and many lives entirely in fresh water. While some lampreys migrate to the sea but must return to fresh water to reproduce
- Lampreys have a sucker-like mouth.
- Myxini have a partial cranium (skull) but no vertebrae
- Hag fish and lampreys are classified as Agnatha (no jaws) or the Cyclostomata (round mouth).

ORIGIN OF JAWED FISH (GNATHOSTOMATA)

- Conodonts were evolved during Late Cambrian period and were the first jawed fishes.
- They ranged from 1-40cm, had a eel-like body, a notochord, cranium, myomeres, fin rays, and large eyes.
- No gills but gas exchange was done through the skin.

- Their bony armor was an adaptation to protect from other animals.
- These bottom dwelling fish were known as Gnathostomata (jawed fish).
- They went extinct in end of the Devonian Period.

* In the Middle Silurian, fish with jaws and teeth evolved and four groups branched out

(1) Placodermi
- They were extinct
- They were the first jawed fish, armoured with heavy plates.
- They had strong jaws to be carnivorous
- They have paired pectoral & pelvic fins

(2) Acanthodii
- Were extinct during Devonian period
- Small feeders

(3) Chondrichthyes - (extant, sharks, rays and Chimaeras)

(4) Osteichthyes (extant, highly evolved bony fishes)

CHONDRICHTHYES

- are one of the best known groups of fish remaining since Devonian Period.
- One of the extinct genera of Chondrichthyes is Cladoselache.

* Cladoselache
- Extinct (416-360 mya)
- pelagic marine predator from the Devonian
- It was shark-like in appearance.
- they are about 2m long with large gape and three pronged teeth.
- Cladoselache lacked the rostrum of modern sharks.
- A contemporary genus of Cladoselache was Xenacanthus (fresh water shark).

* Xenacanthus
- bottom dweller with robust fins and a heavily calcified skeleton
- Xenacanthus appeared in the Devonian and died out in the Trassic (250-200 mya)

Characteristics of Chondrichthyes

- They are jawed fish.
- Jaws were adapted from the front elements of the gills.
- They have 5-7 gill slits on both sides of the pharynx
- It lacks the gill covers found in bony fishes.
- Body is covered with placoid (tooth like) scales.
- Teeth were adapted from bony scales near the skin of the mouth.
- Jaws helped them with many new strategies for survival like tearing & gulping.
- The stronger paired fins helped them with swimming capabilities and allowed them to balance and maneuver well in water which facilate both predation & escape.
- Mostly ectothermic - have body temperatures similar to temperature of water around them.
- Class Chondrichthyes contain about 850 species of skates, rays, sharks, chimeras and rat fishes.

Chondrichthyes

- 800 spp — Elasmobranchi eg Sharks, Skates and rays
- 30 spp — Holocephali eg Chimeras and ratfishes

Sub class Elasmobranchi

- Galeomorpha
- Squalomorpha
  - Order Squaliformes eg (dogfish, sharks)
  - order Hexanchiformes (Cow Sharks)
  - Pristiophoriformes (Saw Sharks)
- Batoidea

Others several orders of sub class Elasmobranchi

(1) Heterodontiformes eg Horn Sharks
(2) Orectolobiformes eg Nurse Sharks, Whale Sharks
(3) Lamniformes eg Mackerel Shark, Mako Shark
(4) Carcharhiniformes eg Requiem Sharks (Blacktip, Whitetip, Reef, Bull Sharks), Tiger Shark & Barking Shark.

Subclass Elasmobranch

- They includes Sharks, Skates and rays.
- Other than having general characteristics such as no operculum to cover the 5-7 gill slits, no swim bladder, cartilaginous skeleton, heterocercal caudal fin, placoid scales, osmoregulation by retaining Urea, claspers in males for internal fertilization, teeth arranged in rows and spiral valve in the intestine
- * They have following special characteristics such as very small eyes and jaw articulation in two (2) ways.

(1) Hyostylic (single connection of upper jaw to neurocranium – adds protrusibility).

(2) Amphistylic (two connection points – anterior to posterior).

- Embryonic development with physiological care which include oviparous, ovoviviparous, viviparous.
- Elasmobranchs produce precocial young with high survival rates.
- Slow growing long lived ~~with high survival~~ rates

and reaches sexual maturity at a late age.
- This reproductive strategy is why Elasmobranch can not sustain an intensive fishery.

(1) SUPER ORDER GALEOMORPHA (GALEOID SHARK)
- Dominant carnivores of shallow and warm parts of the ocean
- Have an anal fin.
- About 279 species with size ranging from 1m to perharps 18m in length.
- They include large pelagic predators with blade-like teeth in their jaws.

(2) SUPER ORDER SQUALOMORPHA (SQUALOID SHARKS)
- They are smaller, mostly live in cold, deep water.
- They include various species of Dogfish, Mega mouth, angel sharks and cookie-cutter sharks
- About 124 species size ranging from 15cm to 7m.

Super Order - Squalomorpha

- Squaliformes
  eg dog fish sharks
- Hexanchiformes
  6 and 7 - gill sharks (cow shark)
- Pristiophoriformes
  eg saw sharks

(3) Super Order Batoidea

- They includes skates and rays.
- Rays and skates live on the ocean floor.
- Pectoral fins are enlarged into wing like fins; they swim slowly.
- At least 534 species including Electric rays, Manta rays, sting rays, skates
- 6 m long and up to 6 m wide.
- Sting rays have a venomous spine.
- Electric ray family can feed on fish that have been stunned with electric shock of over 300 volts
- Sawfish rays have a large anterior "saw" that they use to slash through schools of fish.

Skates (Order Rajiformes)

- Pelvic fin divided into 2 lobes
- Stocky tail without stinging spine.
- Enlarged, thorn like scales (bucklers) along the midline of back.
- Males have rows of enlarged scales near the eyes & wing tips.

Rays (Order Myliobatiformes)

- One-lobed pelvic fin
- Whip-like tail, Usually with stinging spine
- No bucklers along back or ~~tail~~ tail.

SUB CLASS HOLOCEPHALI

- It represent Chimaeras and Ratfishes.
- Other than the general characteristics of Chondrichthyes like having cartilaginous skeleton, placoid scales, claspers in males, a spiral valve in the intestine and an oil filled liver.

* Distinctive characteristics of Holocephali are
- Spiracle absent and gills covered by single operculum.

- Teeth are plate-like, non-deciduous and have large eyes.
- Cloaca lacking and has a separate urinogenital pore.
- Jaw articulation is holostylic (autostylic) i.e fused to neurocranium.
- All are oviparous.

* Placoid Scales

- Living species of sharks have their skin entirely covered in dermal placoid scales, which are small tooth-like structures (enamel, dentine & pulp just like real teeth).
- Scales gives sharks skin a tough, leathery & abrasive feel and skin is also very streamlined.
- These scales point towards the tail and help to reduce friction from surrounding water when the shark swims.
- Placoid scales have modified as spine of sting ray, dorsal spine of dogfish and defensive spines in the skate and teeth.

* Shark teeth
- Placoid scales are modified in the mouth to produce the rows of replaceable teeth.
- Each tooth in a shark can be rapidly replaced as it becomes worn or damaged.
- Teeth are not embedded in the jaw but arranged on a spiral or whorl shaped cartilaginous band in which replacement teeth are always developing behind a functional tooth
- Teeth in young sharks may be replaced as often as once every 8 days.
- The type of teeth a shark possesses is dictated by the prey it eats.
- Sharks that feed on crustaceans, mollusks and similar hard shelled prey have dense arrays of flattened teeth designed for crushing.
- fish feeders have long pointed needle-like teeth for gripping
- sharks that feed on large prey such as mammals have pointed lower teeth and triangular serrated upper teeth for cutting.

- Plankton feeder such as basking sharks have small non functional teeth.

* Heterocercal Caudal fins are important in identifying species

Chondrichthian success story

- buoyancy adaptation, No swim bladder, Fatty liver helps in controlling buoyancy

Amphibians
- Urodela (Tailed amphibians eg Newts & Salamanders).
- Anura (Tailless amphibians; Toads & frogs)
- Apoda (Legless eg Caecilians).

- Urodeles – still have an elongated body form, a well developed tail & sinuous mode of locomotion.
- Anura (tailless amphibians eg Toad & frogs) with their compact body, elongated hind leg and lack of tail are highly specialised for hopping or jumping mode of life.
- Apoda (few genera of small, legless, blind tropical burrowers which resembles earthworms.

* The jaw teeth are without sockets and typically.
- pleurodont (attached to the side of the jaw)
- Homodont (Uniform)
- Polyphodont (Replaced many times)

* The mixing of the blood is avoided in the ventricle cos of the viscous nature of blood & spongy texture of the ventricle

* The spiral valve in the Conus arteriosus is so placed that it allows the deoxygenate blood from the right side of the ventricle to go into the pulmocutaneous arch and mixed blood from the middle of the ventricle into systemic arch & oxygenates blood from the left side of the ventricle into the Carotid arch which has a broken carotid

AMPHIBIANS

The first group of vertebrate to live out of water are the amphibians. Transition of vertebrate from water to land involved the following changes:

(1) Modification of the body for moving on land but still retaining the ability to swim.
(2) Development of limbs in place of paired fins.
(3) Conversion of scaly skins of fishes into glandular respiratory surface.
(4) Replacement of gills by lungs
(5) Modification of the circulatory system to provide for pulmonary circulation.
(6) Strengthening of skeleton to support the body outside water
(7) Changes in the metabolism and excretion to form less toxic nitrogenous waste (urea instead of ammonia).
(8) Acquisition of sense organs that can function in both water and air i.e the eyes are with lids and has lachrymal glands for dust prevention.

Amphibians are the first colonizer of Land However, first attempt at colonizing Land are a group of fishes called crossopterygii (fresh ~~fish~~)

(a) The middle ear is formed to receive airborne waves/vibration, the olfactory organ develop internal nares/opening in the buccal cavity so that respiration can occur without opening the mouth

(b) The neuromast (lateral line system) are lost as it can only detect water-borne vibration.

There are 7 mechanical problems on Land (problems the first land vertebrate faced): (1) Respiration (2) Gravity/Support (3) Locomotion (4) Sense Organs (5) Dessication/Dryness (6) ~~Reproduction and~~ (7) Temperature fluctuations. 5 – 7 are problems they are not able to solve

In aquatic animals, fertilization is external which is hard on Land because of Dessication.

Aquatic animals excrete urea (CNH_3).

* Amphibians excrete uric acid. During

hot they aestivate — in summer. They hibernate.
Amphibians evolved from crossopterygians (the lobed finfishes) which flourished in fresh water lake and ponds of the devonian period i.e at a time alternating between drought and flood. Crossopterygians are pre-adapted to live in two ways:

* Possession of lungs which enable them to utilize atm O_2 when pool dried up or when Oxygen become depleted.
* Possession of leaf-shaped lobed fin which is used as paddle to waddle accross land in search of pool that still contain water. They have skeletal elements that foreshadowed the Pentadactyle limb of tetrapods.

<u>Limitation of Toad as a Terrestrial Animal</u>: Toad aren't completely adapted to life on Land. They have the following characteristic features which restrict them to moist habitat and prevent them from fully exploiting the terrestrial environment. They depends on cutaneous respiration which permits water loss. They are ~~able~~ unable to produce concentrated Urine in order to conserve water. They couldn't develop a dessication resistance land eggs. They are unable to reproduce under truly terrestrial

conditions because they lack the need for internal fertilization. On land, sperms can't be spread over egg as in water, thence, they spend their larva stage in water and adult stage on land, this is express in their name AMPHIBIA meaning Double life (Water & Land). Amphi = Double bio = life. They must return to Water to breed. Movement to Land brought brought greater risk of encountering thermal extreme of temperature.

~~Amphibio~~ Amphibians lack internal mechanism for regulating their temperature, hence, cannot cope with temperature fluctuation, that is why they aestivate in dry season (tropical zones), to prevent dehydration, While in temperate zone, they hibernate during Winter to avoid freezing.

Columella auris is homologous with hyomandibular of fishes

DIAGNOSTIC FEATURES OF TOADS

* SKIN; no scales, but their is epidermal gland which helps to keep the skin moist for cutaneous respiration. It also contain poison glands for protection. The head is called on a single cervical vertebrae (atlas) articulation with two condyls ~~on~~ skull. The ear consist of a single auditory ossicles which is called the ~~atlas~~ columella auris which evolved from the hyomandibular of fishes.

The ear drum (tympanic membrane) is present in most anurans, the teeth is without ~~scales~~ socket, it may be pleurodont i.e attached to the side of the jaw, may be homodont i.e uniform or may be polyphodont i.e replaced many times. The limbs are totally orientated (naturally) and it is modified for jumping, swimming and it is build in pentadactyl plan.

Incompletely seperates in
some Urodeles & Apodans

Pleurodont attachment of teeth

The heart consist of incompletely seperated atria (auricle) (2) and a single ventricle. The red blood cells are biconvex, oval & nucleated. The egg is without shells, no embryonic membrane fertilization is external i.e no intromitent organ; their is the presence of larva which metamorphosis into adult.

The body consist of the head and the trunk, no neck and tail, the head consist of the terminal mouth a pair of eye with eyelids and nictating membranes, two external nares and two tympanic membrane on either side of the head. The parotic gland (flask shaped poisonous) is located behind the ear drum and secrete bitter fluid when toad is irritated for protection. The forelimbs are short with 4 digits and the hind limb are long for jumping and bears long webbed digits for swimming. The trunk bears cloaca, the skin consist of two layers and

differentiate from fishes because there are no scales. The first layer is the epidermis with little or no cornification ~~cos~~ because it ~~serves~~ serves for respiration hence, the skin is prone (vulnerable) to water loss. In correlation with the use of skin for ~~respi~~ respiration, flask-shaped gland secrete mucus to keep the skin moist, the gland also produce bitter secretion and thus serve for protection.

Melanophores effect

The DERMIS in the second layer of the skin is supply with abundant blood vessels across the pigment cells (btw the dermis & epidermis) called Melanophore effect - Colours changes for camouflage.

SKELETON

~~SKELETON~~ AND LOCOMOTION

The skeleton is better developed and highly ossified (bony), in correlation with ~~lapping~~ leaping and jumping method of locomotion, the vertebral column is better develop than in fishes. The vertebral column is seperated into different vertebra

to allow better freedom of movement without loss of strength

MODIFICATION OF THE VERTEBRAE COLUMN

(1) The central of each vertebrae are thoroughly ossified

(2) Successive vertebrae are interlocked by overlapping articular processes.

(3) Shortening of the vertebrae column in frog & ~~tail~~ toads.

(4) The vertebrae column consist of 9 ~~vertb~~ vertebrae, the atlas, seven other vertebrae and Urostyle. The Urostyle is for attachment of Jumping Muscles

(5) The forelimbs are use as support when the animal is at rest, they are use as ~~shock~~ shock absorbers during landing.

(6) The humerus, fused radius & the Ulna are stout and short

(7) The hindlimbs are used for propulsion and is built on ~~pentad~~ pentadactyl limb plan.

(8) The elongation of proximal tarsals i.e Astragulus & Calcaneum. give the hind limb extra joint which enable the toad leap.

(9) The metatarsals and the phalanges are elongated, the digits are webbed (adaptation for swimming)

(10) 3 methods of locomotion i.e Swimming, Walking & leaping all are called "appendicular movement"

* GUT AND FEEDING

The gut is modified for carnivorous habit, it is short unlike the tad poles which is herbivorous with relatively long gut. They feed on insect by their sticky tongue hinged in front. Toad has no teeth on the jaw of the roof of the buccal cavity unlike frog. The buccal cavity is characterised by 4 main feature which are absent in fishes.

(1) They have internal nares

(2) Eustachian tube opening

(3) Sticky tongue

(4) Opening of the glottis (opening into Larynx) and vocal cords

ventricle responsible for sluggish movement

* RESPIRATION : employs 3 surfaces for respiration
(1) Skin which is vascularized and moist.
(2) buccal cavity
(3) Lungs : which are not used during normal activity, it do not consist of the alveoli unlike the mammals and hence has a small surface area. Ventilation of the lung is by buccal force pump mechanism

* CIRCULATION : is by the heart and the aortic arches because from the shift : from gill — lungs, the heart and aortic arches of fishes been modified in toads. Incomplete or partial circulation of blood in a heart evolve. The atrium of auricle is divided into two halves, the left half receive oxygenated blood from lungs through pulmonary veins while the right half receive deoxygenated blood from the body through the sinus venosus. The triangular structure, the sinus venosus is the triangula-

frogs tend to be moist, slimy and jump whereas toads tend to be warty, dry and walk

Structure into ~~which~~ which the 3 venae cavae open (the right, left and posterior vena cava). These are independent. The presence of the single ventricle (which the oxygenated and deoxygenated mix (meet). The meeting of blood is partially divided in 3 main ways.

(1) The spongy ventricular muscles tend to keep the two types of blood apart

(2) A spiral valve inside the conus ~~arteriosus~~ arteriosus and the Truncus arteriosus direct deoxygenated blood to the pulmocutaneous vessel & carotid arches

(3) There is a slight difference in the time that the 2 types of blood enter the ventricle

In correlation with the shift from gill to lungs, aortic arches becomes reduce in number. Aortic arches I & II are lost in toads which are present in fishes. The aortic arches III is the carotid arch supply the head, the aortic arch IV which is systematic supply body, aortic arches V totally lost, aortic arches VI which is the pulmocutaneous arches supplies respiratory surfaces

Aortic arch VI — { pulmonary arches supply respiratory surface
new vessels (not in fish) — returns oxygenated blood to heart

(Lungs and skin) Aortic arch VII is new vessels and is pulmonary vein (not in fish) ~~which~~ which returns oxygenated blood to the heart.

SENSE ORGANS

Better developed which receive air borne stimuli not water borne as in fishes. The neuromast (lateral line) are lost as they can only detect water borne stimuli of vibration. Eye with lid & lachrymal gland which moist the eye for dust protection. The middle ear is evolved from spiracles of fishes (first branchial ~~arch~~ arch) to receive airborne wave of vibrate since the neuromast of fishes is no longer suitable. The hyomandibular arches of fishes is transformed into a single ear ossicle, the ~~column~~ columella (auris) (stapes) which transmit sounds or vibration from the middle ear to the inner ears. The olfactory organs develop internal nares an opening in the buccal cavity, so as to ensure respiratory activities without mouth.

AORTIC ARCHES ; Correlated with the shift from gills to lungs, the following changes occur in the aortic arches

— The Aortic arches were reduced in number — 1st, 2nd & 5th being lost

— The remaining 3 aortic arches (III, IV & VI) are continuous tubes uninterrupted by gill capillaries

— 3rd pair of Aortic arches form part of the blood supply to head as Carotid arch

— 4th pair of aortic arches form systemic arch — the main supply to the viscera & body through the dorsal aorta.

— 6th pair forms pulmocutaneous arch supply respiratory surface lung & skin

AVES (BIRDS)

Birds are the 2nd largest of the vertebrate after fishes. We have different species of them, as much as 9,700.

Similarities Between Birds & Reptiles

(1) The skulls of birds and reptiles have a single occipital condyle at their first neck (a small bony knob). This is not the case as in mammals that have two soft knobs

(2) Birds & Reptiles have a lower jaw consisting of 5 or 6 bones whereas the lower jaw of mammals has one (1) bone (dentary)

(3) They both have single middle ear bones called stapes whereas mammals have 3 middle ear bones.

(4) They both excrete their nitrogenous waste as uric acid whereas mammals excrete theirs as urea.

(5) They lay similar yolked eggs with early embryo development on the surface by shallow cleavage divisions

(6) They both have sclerotic rings which are rings that grow around the eyes and support them therefore, birds are called "glorified reptile" with the above structure.

CHARACTERISTICS OF AVES

Structural & Functional Uniformity in Aves

(1) The single distinguishing feature of birds from other living animals is the possession of feathers

(2) All birds have forelimbs modified into wings although not all wings are for flight

(3) All birds have hindlimbs adapted for walking, swimming, perching

(4) All birds have keratinized beaks lacking teeth

(5) All birds lay eggs

Features	Birds	Reptiles except Crocodiles
Heart	4-chambered	3-chambered (Crocodiles 4)
Bones	Hollow pneumatic bones that allow them to fly	Heavy Bones
Mouth	Light beak with no teeth	Jaws are heavy with presence of teeth
Metabolism	Endothermic (Warm-blooded)	Ectothermic (cold blooded)

Characteristics of the Aves

- Body is usually spindle-shaped with 4 division, the head, trunk, neck & tail where the ~~head~~ neck is elongated & S-shaped
- They have 4 forlimbs modified as wings & hind limbs adapted for walking, swimming & perching & have a foot with pot-holes

Sometimes 2 or 3

- They have epidermal covering of feather and leg scales.
- Have thin integuments of epidermis & dermis
- Absence of sweat Gland
- Presence of Oil or preen gland at the base of their tail
- They have fully ossified skeleton with air Cavity.
- Each Jaw is covered with a Keratinized sheet for a beak with no teeth
- Have well developed nervous system with 12 pairs of cranium nerves and a brain with Large cerebellum & optic lobes
- Have a circulatory system of 4 chambered heart with 2 atria & 2 ventricles

- Have seperated pulmonary & systematic circuits.
- ~~Endoderm~~ Endothermic
- Sexes ~~are~~ seperate & fertilization are internal
- ~~Ventilat~~ Respiration is by use of Lungs (para-bronchi) with thin air-sacs among the viscera organ and skeleton
- They have a ~~Sring~~ (voicebox)
- Have a excretory system of Metanephric Kidney
- They have well developed nerve system with 12 pairs of cranial nerves and a large cerebellum and Large optic lobe

STRUCTURAL AND FUNCTIONAL ADAPTATION FOR FLIGHT.

Just like the aeroplane was built to fly high up in the sky that is how the birds were made to fly. However birds have some adaptive feature which make it easy for them

- They have more power and less weight
- They feed and they are able to maintain their body temperature and
- They reproduce

<u>Feathers</u>: are very light structures and posses remarkable toughness and tensile strength. A typical feather has a hollow quill (or calamus), a shaft (rachis), barbs and barbules.

<u>Types of feathers</u>

Depending on function, there are the following type of feathers.

(1) Contour feather: This gives the bird the outward form.

(2) Flight feather: extend beyond the body and are used in flight.

(3) Filoplume feather: Exists on birds without a definite function e.g feather found around beaks of birds.

(4) Down feather: essentially used for conservation of heat; found around the breast region.

(5) Powder down feather: Powdery in nature, possess mettalic lustre found on birds like parrots, hawks, heron etc.

SKELETAL SYSTEM OF BIRDS

A major structural requirement for flight is a light & sturdy skeleton. The bones of birds are predominantly light, delicate and surrounded with air cavities, such pneumatized bones are very strong. The skull of a bird is built lightly and mostly fused into one piece. The brain case & the orbit (where the eye stays) are large enough to accomodate a bulging brain and large eyes are needed for quick motor coordination and super vision. As a whole, however, the skeleton of a bird is not lighter than that of a mammal of a similar

size. The difference is in the ~~distribution~~ distribution of mass.

Where the skull & the pneumatized wing bones are ~~is~~ especially light, the leg bones are heavier than those of mammals. This lowers the birds centre of gravity which therefore improve aerodynamic stability

- They lay eggs

Adaptation for flight include

- High metabolic rate, high body temperature coupled with energy rich diet and high efficiency respiratory ~~system~~ system which consists of a system of air sacs arranged to provide constant one-way flow of air through the lungs.
- Powerful flight and leg muscles arranged to fly, muscle weight near the birds centre of gravity.

— An efficient high pressure circulation, keen eyesight, good hearing capabilities & outstanding coordination for flight, metanephric kidney that produces Uric acid as the principal nitrogenous waste.

CLASS

CLASS MAMMAL

Mammals include familar animals such as whales, rats, bats, dogs & cats etc. They are at the highest Level of organization. The Word Mammals come from the Latin Word "Mamma" which means 'breast' (mammary gland). Mammals are believed to have ~~exist~~ evolved from Therapsida which are mammalian-like reptiles.

Mammals are 3 types which are (1) Monotremes (lay eggs), Marsupial (have pouches) and Placentive (have placenta).

Mammals are more advanced than their reptile ancestor because they have capabilities in term of

(1) Temperature regulation (Warm blooded)
(2) Brain (3) Sense Organs (well developed).
(4) Vertical, Upright Limbs (5) Reproduction.

Characteristics of Mammals

- Their body is covered
- The head is carried on two (2) ~~occ~~ occipital Condyle.

epiphysis is the rounded end of a long bone

- They have dentary bone forming the lower jaw.
- They produce dentary bone forming the lower jaw.
- They produce sound using their vocal cords
- Their teeth are replaced, differentiated & socketed i.e. thelodont (socket), heterodont (differentiated) and diphyodont (replaced)
- They have cheeks on the buccal cavity
- The ~~limps~~ limbs are vertical in orientation
- Their long bones have "~~epiphyses~~" "epiphysis"
- The heart is four-chambered heart, but a right aortic arch is absent and their erythrocytes lack nuclei.
- There is a presence of diaphragm Innovation
- The egg is minute and develop in the uterus
- They are homoiothermic (warm-blooded, constant internal temperature).

Biology of Rattus rattus: Representative Mammal.

- Habits & Habitats: Rats are found in almost every places where there are human activities. Sometimes, they are carrier of disease e.g Lasar fever. They destroy properties.
- External feature: The body is covered with hair. It has a head, neck, trunk and a long tail
- They have prominent incisors and vibrissae (whiskers)
- They have a nostril & eyes
- On the thorax in the female, they have 6 pairs of mammary gland: 3 pairs in thorax and 3 pairs on the abdomen
- They have anal and Urinogenital openings seperate (i.e they lack cloaca)
- The tail is almost hairless but some epidermal scales are present.
- The forelimbs have 4-clawed digits while the hindlimb has 5-clawed digits.

Limbs < fore, hind

Whiskers are used for sensitivity

Skin

Skin consist of epidermis & dermis. Hair which is found on skin is an epidermal structure for insulation. On the skin are sebaceous and sweat glands. Only the palm-surface & footsole lacks hair.

SKELETON & LOCOMOTION

They consists of 2 parts: axial and appendicular skeleton. Axial skeleton consist of skull & vertebra column. Appendicular skeleton consists of limbs and the limbs girdle. Mammalian skull has the following 7 diagnostics feature which distinguish them from other animals.

(1) Large brain case (cranium)
(2) Two occipital condyles (Amphibious too)
(3) Teeth are heterodont
(4) The lower jaw is made of a single bone called "dentary bone".
(5) There are malleus, incus and stapes in the ear
(6) Possess secondary palates which are absent in other Chordate (Present in Crocodilia too).
(7) There is a complete set of bony plate.

Locomotion

- Have 4-footed locomotion; Shorter forelimbs.
- Have horizontal forelimbs which they use for food handling & burrowing
- They have a longer hind limb used for running while the tail serve for balancing
- Rats are "plantigrade": all four limbs are held on the ground for movement.
- Rats are versatile in their locomotion; can walk, run, jump, climb.

Gut & feeding

- Rats are typically herbivorous but they can virtually eat anything.
- They store their food in cheek - used as pouches
- Digestive system consist of buccal cavity, pharynx, oesophagus, stomach, intestine & anus. The intestine is made of duodenum, ileum, caecum and rectum.

Other parts of the digestive system include salivary gland, pancreas and liver. They have gall bladder. The caecum and colon are the site for

bacterial digestion of food while undigested food passes out to the rectum & finally through the anus.

- Rats undergo "Coprophagy" pass food through the alimentary canal twice.
- The dental formular is 1/1, 0/0, 3/3 (16)
- The space between the incisor and molar is called "diastema".

Respiration

Rat undergo inspiration & expiration process of breathing. During inspiration, air is drawn into the nostrils and into the nasal cavity. Air is warm to body temperature. It is also moistened and filtered. Air goes into pharynx and into the glottis and into the 2 lungs which are unequal. The left is smaller than the right because of the presence of Liver.

On the thorax, are the thoracic ribs between which are the intercoastal muscle. Alternate contraction of these muscles bring about ventilation (breathing in and out) with diaphragm assisting during respiration.

CIRCULATION

They have double circulatory system, 4-chambered heart but lack right aorta. Deoxygenated blood are carried from the right ventricle to the lung by the pulmonary artery while oxygenated blood are returned to the heart via the pulmonary vein.

Excretion

They use metanephric kidney, from the kidney arise the ~~water~~ ureter which open to the urinary bladder. The bladder opens out through the urethra. In males, the ureter opens out through the kidneys. The kidneys produce concentrated urine. The kidney produce concentrated urines unlike the birds which produce uric acid.

REPRODUCTION

The Male

During the breeding season, the testes of the male rats descends into the scrota sac where the temperature is lower for the ripening of spermi-

Each testes is secured to the scrota sac by a ~~cord~~ cord known as "Gubernaculum".
The seminiferous tubules of the testes is connected to the epididymis when the sperms mature and are stored. There is the ~~vasa efferent~~ vasa - efferentia around the Ureter and this opens into the Urethra.

There is also the seminal vessicle which is close to the bladder and opens into the vas deferens. Connected to the seminal ~~vesse~~ vessels are prostrate, Cowpers and perineal glands. The prostrate gland produce most of the fluid in which the sperms are discharged. Cowpers gland also produce seminal fluids while perineal glands secrete additional fluid to the sperm to form semen.

~~The~~ The female

There is a pair of ovary attached posterior ly to the Kidneys. At the end of the ovaries we have oviduct. The first part of the oviduct is the fallopian tube ~~which~~ which ~~wid~~ widens

to form the Uterus. The two Uteri join the vagina which is dorsal to the Ureter. The ~~Ute~~ Whole genital region forms the vulva (vulva) perineal glands occur at the top of the Ureter and near the opening of the Urethra is the "Chloris".

Rat are ~~faster~~ fast breeder with enormous potential for reproductive capabilities. The rats have a breeding cycle of 4-5 days, gestation of 22 days and maturity of 4 weeks.

Reproduction of Rat in 1 Month

They produce 12 youngones in 1 Month. At birth, the young rats are helpless, blind and hairless. They are nursed by milk produced by the Mammary gland of the Mother. Therefore, they show parental care.

CENTRAL NERVOUS SYSTEM & SENSE ORGANS

They have large cerebral hemisphere which is for thinking. They also have cerebellum for coordinating muscular activities. They have thalamus and hypothalamus which plays a role of homoestatic control of the ~~gland~~ endocrine gland. They have optic lobe (for sight).

The sense of smell (olfactory lobe) is the most important of all sense organ. The eye is basically like that of other chordates. It has more rods than cones (they are sensitive to light & colours respectively). The mammalian ear show advances over other vertebrates by the following.

(1) Pinna (2) 3 auditory ossicles in the inner ear (incus, malleus & stapes) (3) The cochlea is long & coil.

Sound also play an important role in the life of mammals as such, the larynx is well developed.

PHYLUM HEMICHORDATA

Hemi — Half and
— Greek Hemi — Half and Latin Chordata — chord
— Bilaterally symmetrical, true coelom, open Blood system
- All lives marine environments
— However Modern Science has proven that none of them possess a post anal tail or a Notochord
— 90 species — living in benthic zone in their adult form
— Body plan is tripartite; 1st section — Protosome (modified Proboscis), Collar that bears tentacles in Pterobranchia but not in Enteropneusta and lastly the trunk which contains the digestive & Reproductive Organ.

Class Enteropneusta

— More than 70 species
— Typical Acorn Worms, Burrowing Worms
— Blood is Colourless and have no ~~red~~ respiratory pigment

Class Pterobranchia

— 10 to 20 species.
— Proboscis is Modified into a shield — Used for Locomotion
— Collar produced 1 and 9 pairs of tentacles

PLANOGASTEROPODA

— Small, rounded transparent pelagic larvae, as tornaria larvae
— Larva body is covered by ciliary band

GRAPTOLITE

— Any Member of an extinct group of colonial aquatic, colonial invertebrates that 1st became appearance during Cambrian Period
— Have fossils show a gradual development through time and evolutionary relationship

Saccoglossus Kowalevski

— Muscular proboscis and a collar that may be used to burrow into soft sand or Mud
— Class Enteropneusta (Acorn Worm)
family Harrimanidae

- Notochord – Rod like structure located in the mid dorsal line between the gut and the dorsal nerve cord, outside the coelom. It is derived from CHURDAMESODERM. It is made up of one of vacuolated cells surrounded by an inner thick sheath of fibrous, connective tissue and outer thin sheath of elastic connective tissue. Firm but flexible. Gives support to the body and provides space for attachement of muscles. Partly or wholly replaced by vertebral column in the adult stage

- Dorsal tubular Nerve Chord – Dorsal to the notochord outside the Coelom. Derived from the neural ectoderm. Nerve chord of chordates is single, dorsal, tubular, fluid filled and nonganglionated. In higher chordates, it is differentiated into an anterior brain and posterior spinal ~~chord~~ chord.
- Gill cleft, Gill slits, Pharyngeal clefts, branchial clefts

- Subphylum Hemichordata ; Notochord is present in the anterior one half of the body. Representative animal is Balanoglossus
- Sub phylum Urochordata ; Notochord is present in tail region. Representative animal is Herdmania
- Subphylum Cephalochordata — representative is called Amphioxus

Acrania - which lack cranium, jaws, vertebral column and paired appendages. They are generally referred to as Protochordates.

Protochordata comprised of 3 subphyla.

Hemichordata Urochordata Cephalochordata

Class Larvacea

- Are so named because they retain the larval "tadpole" form of a tunicate for their entire lives

QUESTION

- Difference b/w ~~Balagnos~~ Balanoglossus & Saccoglossus.