Bachelor of Science

(B.Sc. – CBZ)

Animal Diversity - II (Chordates)

(DBSZCO203T24)

Self-Learning Material

(SEM II)

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Course Code: DBSZCO203T24
Animal Diversity-II (Chordates)

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COURSE INTRODUCTION

This book serves as an introduction to the diverse and captivating group of animals known as chordates, which includes some of the most familiar and extraordinary creatures on Earth.Animals with a backbone are called vertebrates, and they are a diversified group Fish, amphibians, reptiles, birds, and mammal are among them. The course Animal Diversity II (Chordates) is of 3 Credits. This course is divided into 11 units and each Unit is divided into sub topics.

Worldwide, there are more than 60,000 species of vertebrates that are still alive. From fish-like origins some 300 million years ago to the diversity of today, they have undergone evolutionary change. This book is designed to give a learner the fundamental understanding of the diversity of the phylum chordata with emphasis on their origin, key characteristics, classification, distribution and functioning.

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Course Outcomes: After the completion of the course, the students will be able to:

1. Identify the animals according to their taxonomic classification and recall the characteristics of each phylum.
2. Compare the body organization from phylum hemichordate to mammalian.
3. Determine the connecting links between phylums.
4. Sketch the general characters of each phylum.
5. Support the conservation of endangered animals.
6. Assemble the animals according to hierarchy and to be able to construct flow-chart for the same.

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UNIT-1

INTRODUCTION TO CHORDATES- GENERAL CHARACTERISTICS AND OUTLINE CLASSIFICATION

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Learning Outcomes

Student will be able to

1. Describe characteristics features of chordates
2. Explain the structure and functions of different organisms of chordates
3. Describe different larval forms in protochordates
4. Explain and describe metamorphosis in Urochordata

1.1 Introduction

As a diverse group of animals, chordates share numerous essential traits at various stages of their life cycles. Overview of chordates is as follows.

1. **Notochord**: The existence of a notochord at some stage of development is one of the characteristics that distinguish chordates. A flexible structure that resembles a rod that offers support and structure is called the notochord. While it is present only during embryonic development in certain chordates (humans, for example), it is present throughout life in other chordates (particular fish, for example).
2. **Dorsal Nerve Cord**: The dorsal nerve cord, a tubular bundle of nerve fibers on the dorsal (rear) side of the animal, is present in chordates. This structure gives rise to the spinal cord in vertebrates, an essential part of the nervous system.
3. **Pharyngeal Slits or Pouches**: Pharyngeal slits, also known as pouches, are throat-area apertures seen in chordates. These structures are commonly utilized by aquatic chordates for breathing or filter-feeding. These structures are altered to produce

different features in terrestrial chordates like humans, such as the Eustachian tube in mammals.

4. **Post-anal Tail**: Most chordates tail grows which past anus at some stage during life cycle development. Tail remains till adulthood in certain animals, although it may be reabsorbed in others throughout development.

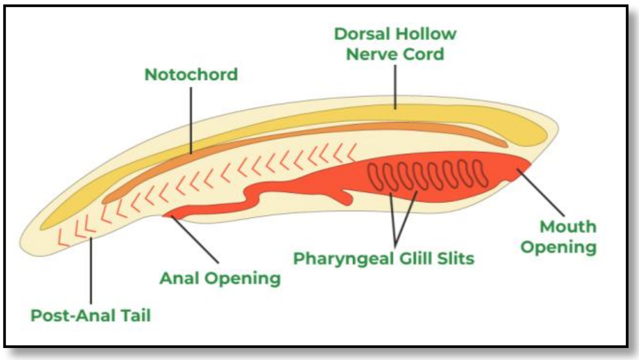


Fig.1 Morphological structure of a Chordate

Chordates are further classified into three subphyla:

1. **Urochordata (Tunicates)**: These are marine creatures that only have a notochord as larvae. Usually using their pharyngeal slits to filter-feed, they cling to rocks or other substrates
2. **Cephalochordata (Lancelets)**: Little sea creatures known as lancelets live their entire lives with their notochord. They also have pharyngeal slits and a dorsal nerve cord. Filter-feeding, lancelets dig into sand or silt.
3. **Vertebrata (Vertebrates)**: The most well-known class of chordates are vertebrates, which include fish, amphibians, reptiles, birds, and mammals. The vertebral column, which develops in place of the notochord, is what distinguishes them. In comparison to other chordates, vertebrates frequently have more developed sensory organs, a more intricate neurological system, and higher levels of mobility and cognition.

1.2 General characteristics and outline classification

Gaining knowledge about chordates can help one better understand the diversity and evolutionary ties among animals. Chordates demonstrate the amazing diversity and adaptability of life on Earth, ranging from basic marine invertebrates to extremely sophisticated animals. The two groups that make up the phylum Chordata are Craniata (Euchordata), Acrania (Protochordata) & have contras traits.

Group A. Acrania (Protochordata) (Gr. a, absent; kranion, head, or, Gr. protos, first; chorde. cord). All chordates are marine tiny lacking the head, cranium, neck, vertabral column, mandibles, and brain. Approximately 2,000 species are found in marine environment based on on the notochord location. The Acrania is separated into three subphyla: Hemichordata, Urochordata, and Cephalochordata.

Subphylum 1. Hemichordata (Gr. hemi, half; chorde, cord).the three areas of the bodythe collar, the trunk, and the proboscis. Notochord uncertain, brief, restricted to arid proboscis, and not homologous with chordate

Class 1. Enteropneusta (Gr. enteron, gut; pneustos, breathed). Body large and worm-like.Many slits on the Gill. Tongue worms or acorns.70 species, 15 genera, and 3 families.Saccoglossus,Balanoglossus.

Class 2. Pterobranchia (Gr. pteron, feather; branchion, gill).body is small and tightly packed. Gill-slits one or both sides.stomach in a U shape. Pterobranchs consist of twenty species, three genera, and two orders. Rhabidopleura, Cephalodiscus.

Class 3. Planctosphaeroidea This class, Planctosphaera pelagica, is represented by transparent, spherical, and specialized tornaria larvae with an L-shaped alimentary canal and widely branched ciliary bands. This shape is thought to represent certain unidentified hemichordates in their larval state.

Subphylum II.Urochordata or Tunicata (Gr. oura, a tail; L. chorda, cord).

In only tadpole-like larvae are there notochord and nerve cord. Sessile and covered in a protective tunic, adult sac-like.Tunicates.

Class 1. Ascidiacea : Sessile tunicates have muscles dispersed throughout the tunic. Individual, collective, or complex. Gill-clefts are common. Sea squirts, or ascidians. 1,200 species, 12 families, 37 genera, 3 orders, and 2 subclasses.Molgula, Ciona, and Herdmania

Class 2. Thaliacea : swimming freely or in the ocean; they have circular muscles in their tunic. Occasionally colonial.chain tunicates or salps. 30 species, 3 orders, 5 families, and 9 genera.Salpa, Pyrosoma, Doliolum.

Class 3. I.arvacea or Appendicularia. tiny, clear, and suspended in midair. Many traits from larvae, like as the tail, are retained in adults. Just a pair of gill slits.30 species, 5 genera, 2 families, and 2 orders.Oikopleura.

Subphylum III. Cephalochordata (Gr. kephale, head; L. chorda, cord).

Nerve cord & notochord are present throughout the life along the entire length of the body.

Class Lcptocardii : A Fish shaped body segmented by many gill slits and different myotomes. digging and swimming freely. Lancelots.30 species, 2 genera, 1 class, and 1 family. Asymmetron, Branchiostomu (=Amphioxus). About eight species have been recognized under the genus Branchiostoma and six species have been recognized from the genus Asymmetron.

Class 4. Graptolita : The Ordovician and Silurian eras produced a large number of fossil graptolites, such as Dendrograptus, which are frequently classified as an extinct class under Hemichordata. Their colony behavior and tubular chitinous skeleton suggest a resemblance to Rhabdopleura.

Group B. Craniate (Euchordata) : Aquatic or terrestrial, larger-than-average chordates or vertebrates that have a distinct head, a spinal column, jaws, and a brain that is shielded by a cranium or skull. There is only one subphylum in the Craniata: the Vertebrata.

Subphylum IV. Vertebrata (L. vertebratus, backbone) a backbone made up of overlapping vertebrae that supplements or replaces the notochord. Divide the body into the head, neck, trunk, and tail. typically dioecious. animals with backbones. largest subphylum of chordates, with over 46,500 species. Agnatha and Gnathostomata are the two divisions that make up the subphylum Vertebrata.

Class 1.Ostracodcrmi.(Gr. ostrakon, shell; derma, skin).

The world's first vertebrates, known as ostracoderms, were several extinct orders of primitive, strongly armored, prehistoric animals from the Paleozoic epoch. Drepanaspis and Cephaiaspis.

Class 2.Cyclostomata.(Gr. cyklos, circular; stoma, moutheel-shaped body devoid of jaws, lateral fins, and scales. circular and suctorial mouth shape.Gills in pairs of five to sixteen.Scavengers and parasites.forty-five species. Hagfish (Myxine) and lampreys (Petromyzon).

Division II.Gnathostomata (Gr. gnathos, jaw; stoma, mouth).animals with paired limbs and real jaws. Some taxonomists further subdivide Gnathostomata into two superclasses for convenience. While all four-footed terrestrial gnathostomes belong to the superclass Tetrapoda, all fish and fish-like aquatic gnathostomes are classified under the superclass Pisces. Fish of the superclass J. Pisces (L. piscis).aquatic animals with paired or midline fins, gills, and scaly skin that resemble fish.

Class 1. Placodermi. There were numerous extinct orders of Paleozoic primordial, early jawed fishes that had a movable bone head shield articulated with a trunk shield. Placoderms. Dinichthys Climatius.

Class 2.Chondrichthves. (Gr. chondros, cartilage; ichthys, fish).primarily maritime. Endoskeleton cartilaginous.Scales of placoid skin. Operaculum does not cover gull slits. Male pelvic claspers.Fish that are cartilaginous.About 600 different species. Chimaera (ratfish), Scoliodon (dogfish).

Class 3.Osteichthyes.(Gr. osteon, bone; ichthys, fish).both marine and freshwater. Bony endoskeleton predominates. Skin with scales other than placoid, such as cycloid and ctenoid.operculum-covered gill slits. men who don't have claspers. fish with bones. Twenty thousand species.Hippocampus (sea horse), Protopterus (lungfish), and Labeo (rohu).

Super class 2. Tetrapoda (Greek: podos, foot; tetra, four). Land vertebrates having cornified skin and lungs, and two pairs of pentadactyle limbs.

Class 1.Amphibia.(Gr. amphi, both; bios, life).The larval stage often uses its gills to breathe. Adults breathe with their lungs and are usually terrestrial. Skin glandular, hydrated, and devoid of visible scales.Heart with three chambers.Reptiles with legs.About 2,500 different species.Ambystoma (salamander), Bufo (toad), and Rana (frog).

Class 2.Keptilia.(L. reptilis, creeping).Tetrapods on land.Dry skin with bony plates or ectodermal horny scales covering it.An unfinished four-chambered heart.frigid. breathing via the lungs. 7,00 species. Wall lizard Hemidactylus, spiny-tailed lizard Ummastix, cobra Naja, sphenodon, and crocodile Crocodilus.

Class 3. Aves. (L. avis, bird). Feathered flying vertebrates are the norm. wings evolved from the front limbs. There are no teeth in the beak. Heart with four chambers.warm-blooded. Birds roughly nine thousand species. Columba (pigeon), Struthio (African ostrich), and Gallus (bird).

Class 4. Mammalia.(L. mamma, breast).Hair covering the body.glandular skin. A female having milk-secreting mammary glands for nursing her young. Heart with four chambers.vertebrates that breathe air and have warm blood. 4,500 different species. Rams (rat), Homo (man), Macropus (kangaroo), and Echidna (spiny anteater).
Traditionally, the term "protochordata," also referred to as "protochordates," has been used to refer to two subphyla of invertebrates that are part of the phylum Chordata: Cephalochordata (lancelets) and Urochordata (tunicates). These groupings are distinguished by the fact that they lack the complete complexity of vertebrates but do possess some chordate body plan traits. This is a summary of these subphyla.

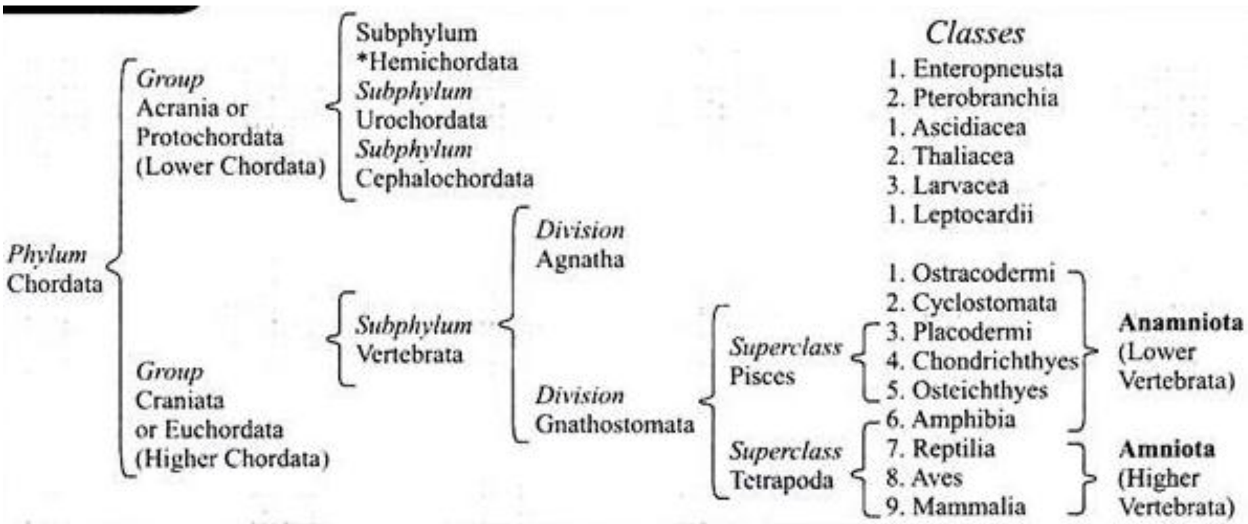


Fig.2 Outline classification of Chordata

1.3 Main differences between Chordata and Nonchordata

Chordata

- Notochord exists exclusively in the embryo or throughout life
- The central nerve system is middorsal and hollow.
- Pharyngeal gill clefts that exist in embryos or throughout life.
- The embryo's solid, muscular postanal tail typically remains in the adult.
- Ventral heart: The blood vascular system has advanced. In the dorsal artery, blood flows both forward and backward.
- The hepatic portal is operational.
- Red blood corpuscles' hemoglobin.

Nonchordata

- Notochord absent**.**
- The midventricular and solid central nervous systems.
- Lack of pharyngeal gill clefts; absence of the hepatic portal system.
- If present, dissolved hemoglobin in plasma
- A postanal tail is never truly a tail portion
- Dorsal heart.
- The blood vessel system was not established.
- The dorsal artery receives blood flow from the rear forward.

1.4 Origin of Chordates

i. Coelenterates Theory: gave rise to chordates, according to the coelenterate theory (a). It is thought that advanced features evolved to give rise to the chordates, while radial symmetry coelenteron, cnidoblasts, etc., vanished. According to this idea, chordatesmay have individually picked up higher characters. This theory is not plausible.

ii. Annelid theory: According to this idea, the chordates descended from a stock of annelids, which, like many chordates, exhibited traits including haemoglobin, lateral coelome, head, bilateral symmetry, entire digestive tracts, and closed circulatory systems. Turning an annelid upside down intensifies the similarity. However, the mouth would be dorsal, not like in chordates. The nature of annelid appendages and metamerism is different from chordate appendages. Other phyla that are not chordate also have a head, a complete digestive tract, and bilateral symmetry. In chordates, hemoglobin is found in the red blood corpuscles, whereas in annelids, it is dissolved in the plasma. Unlike the single, hollow, dorsal nerve cord of chordates, the nerve cord of an annelid is double and ventral. It is challenging to embrace this notion because there are several notable embryological distinctions between chordates and annelids.

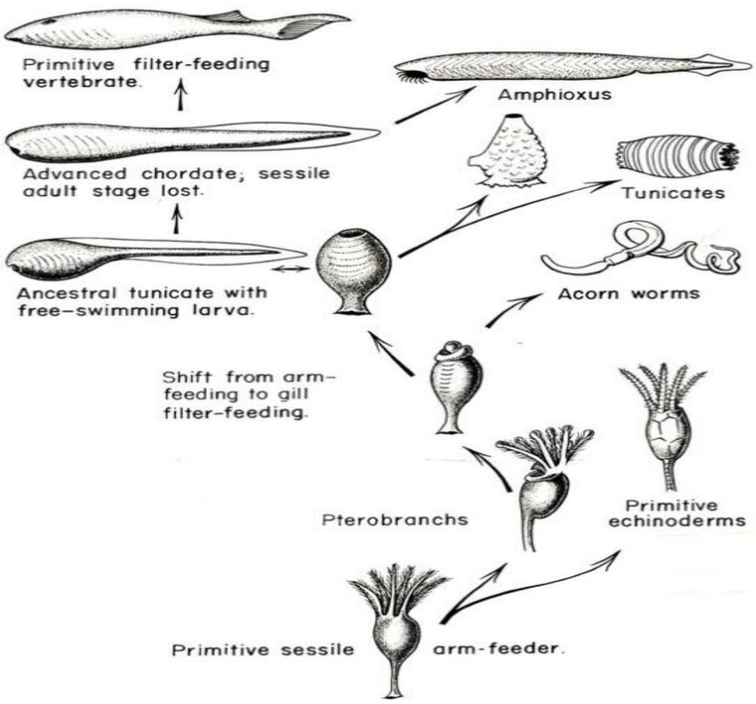


Fig. 3 Origin of Chordates

iii. echinoderm-hemichordate theory-for origin of chordates: According to it hemichordates, chordates, & echinoderms all are descended from a common ancestor. The following evidences form basis of this theory.

Embryological evidence: Enterocoelic coelome, mesoderm, and deuterostomous mouth are features shared by both chordates and echinoderms. The tornaria larvae of hemichordates and the bipinnaria larvae of several echinoderms are similar. The dorsal strip of ectoderm is where the central nervous system of chordates echinoderms develops.

Serogical evidence: The protines of chordates' and echinoderms' bodily fluids are similar. Thus, there is close relatedness between echinoderms & chordates. In adult echinoderms' radial symmetry will not tolerate their interaction with echinoderms with bilaterally symmetrical. In echinoderms radial symmetry develops secondary to essentially bilateral symmetry. Bilateral symmetry is present in both the early and primitive echinoderm larve**.**

1.5 Ancestory of chordates

It is possible that the distinct chordate body plan originated in deuterostome creatures prior to the Cambrian period. Traditionally, chordates have been classified as vertebrates, lancelets (cephalochordates), and tunicates; however, tunicates do not have a chordate body plan in their adult form. Both phyla are an outgroup to the remainder of the chordates, and hemichordates are the sister group of echinoderms.

The precise place of xenoturbella within the deuterostomes is still unknown, however they have lately been classified among the deuterostomes due to molecular data connecting them to hemichordates and echinoderms.m The postanal tail, dorsal nerve cord, notochord, endostyle, and pharyngeal gill are the five chordate traits which have occasionally been hypothesized to include comparable structures found in hemichordates; however, none of these characteristics are found in echinoderms and Xenoturbella, the hemichordates' closest cousins, indicating that they were lost throughout their evolution.

1.6 General Characteristics of Chordates

- None of the living forms—terrestrial, aquatic, or aerial—are completely parasitic. Metamerically segmented and bilaterally symmetrical.
- Most vertebrates have a well-developed exoskeleton.
- Three germinal layers—the ectoderm, mesoderm, and endoderm—make up the triploblastic bodywall.
- Animals classified as coelomates that are enterocoelic, schizocoelic, or truly coelomorphic.
- The notochord is a skeletal rod that appears at a certain point in the life cycle.
- Digestive system includes all of the glands involved.
- Vascular system shut down. Dorsal and ventral blood veins in the ventral heart. Well-developed hepatic portal system.
- Kidneys that are part of the proto-, meso-, or metanephric excretory system.

Self Assessment Questions

Q1. Which of these describes Jawless Fish's class?

i. Chordata

ii. Chondrichthyes

iii. Agnatha

iv. Osteichthyes

Q2. Following does not apply to Agnatha class?

i. Ectothermic

ii. External Fertilliation

iii. Nopaired Limbs

iv. No scales

Q3. In proboscis notochord is confined to

i. Urochordata

ii. Hemichordata

iii. Cephalochordata

iv. Chordata

Q4. Chondrichthyes have ----type

i. Chambered heart

ii. Closed circulatory system

iii. Clitellum

iv.. Radial symentry

v. All of the above

Q5. Illustration of animal belonging to Agnatha class is …...

i. Humanoid

ii. Red Trailed Fox

iii. Lamprey

iii. Rock Bass

Q6. The following do not represent an animal belonging to the Chondrichthyes class?

i. Skate

ii. Ray

iii Shark

iv. Sea Urchin

Q7. Rainbow trout be an example of?

i. Agnatha

ii. Osteichthyes

iii. Troutlopod

iv. Fishinidia

v. None of The Above

Q8. Frog belong to class?

i. Animmalia

ii. Agnatha

iii. Amphibian

iii. Frogania

Q9. The characteristics of the class include ectothermic, leathery eggs with an amniotic shell, internal fertilization, lungs, and two pairs of legs, scaly skin, and a 3.5 chambered heart.

i. Agnatha

ii. Osteichthyes

iii. Amphibian

iv. Reptiles

Answers

1.(iii) 2.(iii) 3.(ii) 4.(ii) 5 (iii) 6. (iv) 7.(ii) 8.(iii) 9.(iv)

UNIT-2

PROTOCHORDATA - GENERAL CHARACTERISTICS OF HEMICHORDATA

Table of Content

Learning Outcomes

Student will be able to:

1. Describe general characteristics of Hemichordata
2. Explain different classes and their characteristic features
3. Explain life cycle of Balanoglossus
4. Describe significance and importance of different organisms of Hemichordata

2.1 INTRODUCTION

Hemicordates are a small phylum of creatures that are unfamiliar to most people; there are only a few hundred species in total. Nonetheless, it is impossible to overstate their significance for our understanding of vertebrate evolution. The graptolites in hemichordate, is a well-known fossil rd that is used to connect rocks.

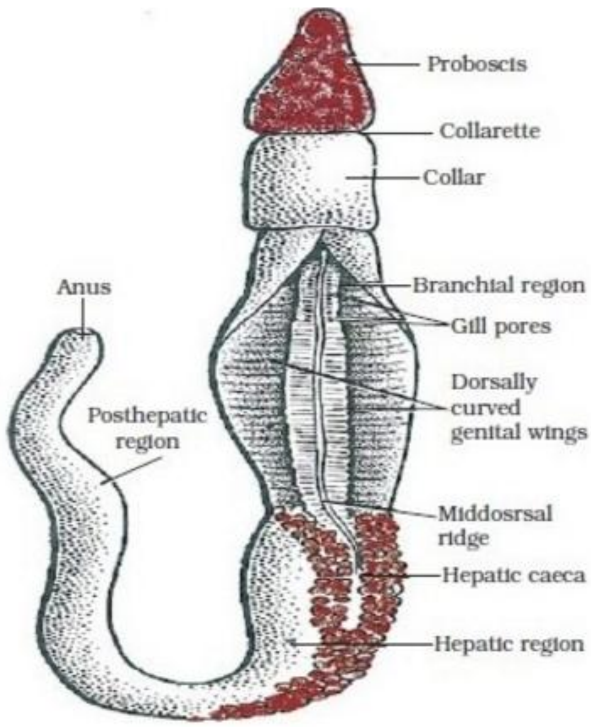


Fig. 2.1 Balanoglossus

Until recently, Hemichordata (Gr.hemi-half; chordde-cord) was considered as a subphylum of phylum Chordata and is recognized as a distinct phylum in invertebrates, closely related to Hemichordata, Echinodermata & Acelochordata.It consists of a tiny collection of soft primitivemarine vermiform.

Most chordates are tube-dwelling organisms. One characteristic that sets hemichordates apart is their tripartite, or triple, division of the body. The preoral lobe, located at the front of the body, is followed by a collar, and the word "hemichordate," which translates to "half chordate," is located on the posterior side. They have some of the common chordate traits, but not all of them.

The trunk, collar, and proboscis are the three uneven sections that make up the body and enterocoelous coelom.

Moreover, acorn worms have numerous bronchial apertures—up to 200 in certain species. They're sluggish burrowers, similar to earthworms that sift through sediment with their proboscis.They can be classified as suspension feeders (which gather suspended particles from the water) or deposit feeders (who eat silt and break down organic stuff like earthworms in soil). While the majority of these worms are much smaller, a few species have been known to grow up to 2.5 m (nearly eight feet) in length. Some have direct development, a tornaria larva exhibits it.

Hemichordates develop indirectly (i.e., there is a distinct larval form) and are dioecious (i.e., males and females, but they cannot be discriminated outwardly) by external fertilization. Most pterobranchs and at least some acorn worms reproduce asexually. Worms from acorns break off tiny fragments from the trunk, each of which has the potential to develop into a unique individual. Pterobranch colonies arise from the sexual reproduction of a single individual by budding. In pterobranchs, sexual reproduction results in non-feeding larvae that are raised within the colony (Cannon et al. 2009; Brusca and Brusca 2003)

2.2 General Characteristics

- Soft-bodied, worm-like, bilaterally symmetrical organisms those are solely marine in nature.
- An actual coelom (enterocoel) in the body cavity.
- The body is separated into the collar, trunk, and proboscis. There are many pairs of gill-slits.
- Nervous system typically diffuses, but can be varied and partially open; the digestive tube is complete, straight, or U-shaped.
- Has a Glomerulus, which is an excretory organ; most acorn worms reproduce sexually, with the sexes often remaining apart, but some also show asexual reproduction.
- External fertilization in seawateris indirect or direct development using a free-swimming Tornaria larva whichtiny particles in water.
- Etymology- Latin Chorda, a chord, and the Greek Hemi, for half

2.3 Classification

Hemichordata is divided into four classes which are as follows

Class-1 Enteropneusta (Gr.enteron, gut + pneustos, breathed).

- Known as "acron" or tongue worms & solitary, free-swimming, or burrowing creatures.
- They have numerous pharyngeal gill slits and resemble worms.
  Their alimentary canal is straight.
- In some cases, development involves tornaria larvae.
- They don't reproduce asexually. Examples include Spengelia, Balanoglossus, Protoglossus, Saccoglossus, and others.

Class 2 - Pterobranchia

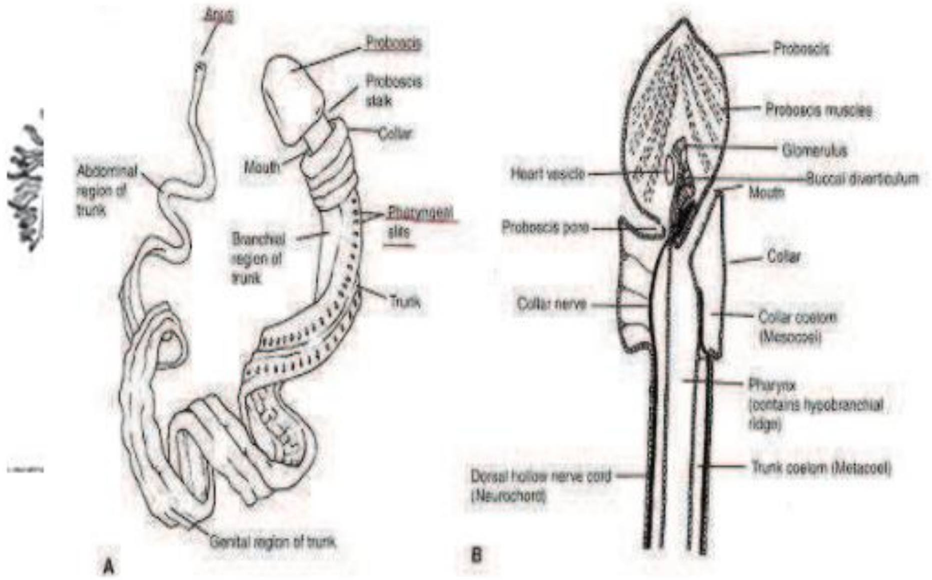


Fig. 2.3 A Spengilla B. Protoglossas

(Gr. Pteron, feather + branchion gill)

These organisms are in nature sessile and have a dorsal anus and a U-shaped alimentary canal.

Gill slits one pair or nonexistent, and resembling a proteoscis shield Asexual reproduction through budding (one pair of gonads, separate sexes)

Order 1 – Rhabdopleurida

Form Colony

Two tentaculated arms are present on collor

one gonad is present.

Slits in Gill are absent.

Eg.– Rhobdopleura

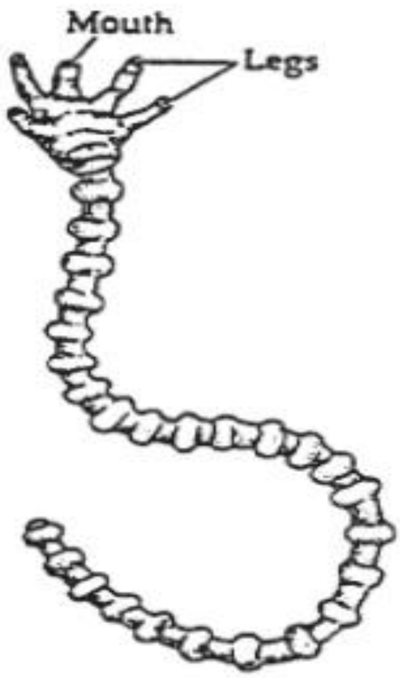


Fig. 2.4 Rhabdopleurida a single Zoids

Order 2 – Cephalodiscida

Zooids or Solitary &live in a common gelatinous layer.

2 gill slits are present

One pair of Gonad.

Eg.-Cephalodiscus

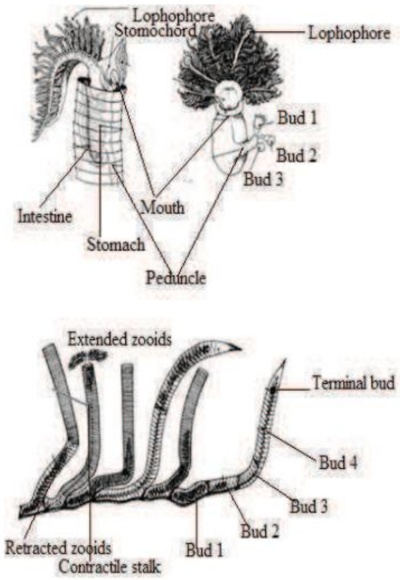


Fig. 2.5 Chephalodiscus

Class 3 - Planctosphairoidea

The only species of these is a translucent, spherical, pelgie larva that resembles a tornaria larva.

In larvae, the alimentary canal is U shaped.

Class 4 – Graptalita

These are mainly fossils.

These are colonial hemichordates that are extinct.

Their colony habits and tubular chitinous skeleton indicate a close resemblance to Rhobdopleura.

2.4 General study of balanoglossus (tongue worm)

Systematic Position

Phylum Chordata

Subphylum Hemichordata

Class Entreopneusta

Family Ptychoderidae

Type Balanoglossus

2.4.1 Habit and Environment

A marine tubicolous or burrowing hemichordate, Balanoglossus is found in shallow coastal waters of the intertidal zone, while some specimens are found in deeper water. The dwelling of Clavigerus is a U-shaped tube or burrow with two openings spaced 10–30 cm apart and two vertical limbs that are 50–75 cm deep.The animal's spirally coiled feces are hidden beneath the rounded, rear end of the burrow, which has a funnel-shaped anterior mouth.

The Hemichordate genus Balanoglossus, which inhabits the ocean, is of significant zoological importance as it represents a "evolutionary link" between invertebrates and vertebrates. As a deuterostome, Balanoglossus shares similarities with Ascidians and sea squirts due to the presence of branchial apertures, sometimes known as "gill slits".Its notochord is located in the upper part.

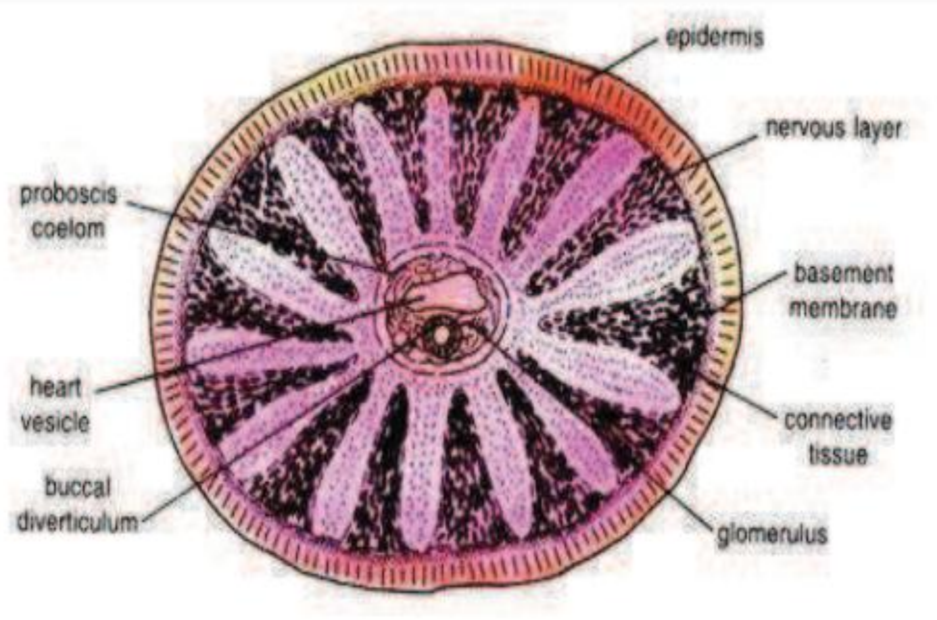


Fig. 2.6 TS of Balanoglossus through proboscis

2.4.2 Proboscis

It is the most anterior portion of the body, tapering anteriorly and shaped like a cone. It continues posteriorly into a short proboscis stalk that blends in with the collar's inner surface and is primarily hidden beneath the collar. The preoral ciliary organ, a chaemoreceptor, is a "U" shaped cilialed depression located below the stalk base of the proboscis. Coelom of proboscis is enclosed by proboboscis.It exits through the mid-dorsally located proboscis pore close to its base.

2.4.3 Collor

It is a thick, middle-sized belt-like organ that rests behind the proboscis. Its surface is frequently characterized by hills or circular grooves. The front portion of the collar, which encircles

Collarette refers to the stalk of the proboscis. The mouth is a broad opening that is enclosed by the collarette ventral to the proboscis stalk. A circular constriction clearly separates the collar from the trunk behind it. The collar encloses the collar coelom and is made of thick muscles.

Dorsal and ventral mesenteries can occasionally separate the left and right portions of the collar coelom. A pair of collar pores allow the collar coelom to enter into the initial pair of branchial sacs.

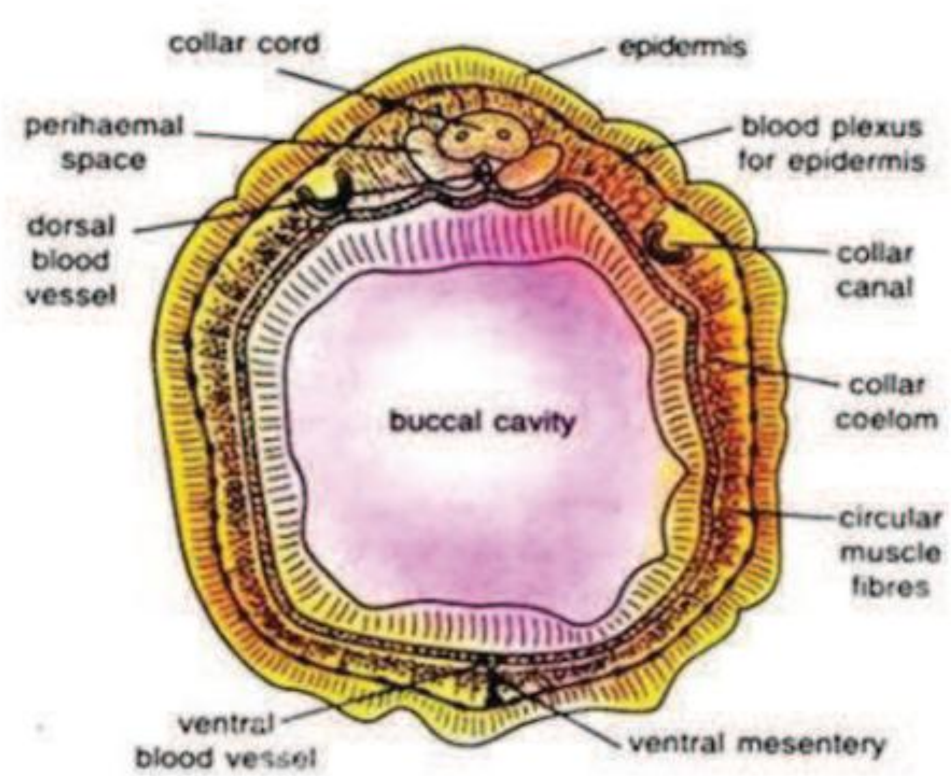


Fig. 2.6 TS of Balanoglossus through collor

2.4.4Trunk

It is the largest and most posterior portion of the body. It usually has superficial annulations and is slightly flattened. Mid-dorsal and mid-ventral longitudinal ridges, as well as divided into three areas: the middle hepatic region, the posterior abdominal region, and the anterior branchio-genital region. A longitudinal row of gill pores on either side of the mid-dorsal ridge characterizes the branchio-genital area. Every row of gill holes is positioned on a prominent elevation resembling a ridge. The branchio-genital region's sides are narrow andcalled genital wings, and they resemble leaves and house the gonads. Gonopores are tiny holes that allow the gonads to open up. In order to hide the gillpores, the genital wings are typically curled and bent when the dorsal side approaches the median line.

(f) Region of the Hepatic Heart

The hepatic area is identified by several numerous small, paired, transverse folds.The hepatic caeca are tiny, paired transverse folds located on the dorsal side. Its color is either greenish or dark brown. The abdomen or post-hepatic area has a terminal anus and taper gradually at the back. The longest and most posterior portion of the trunk is known as the posthepatic area.

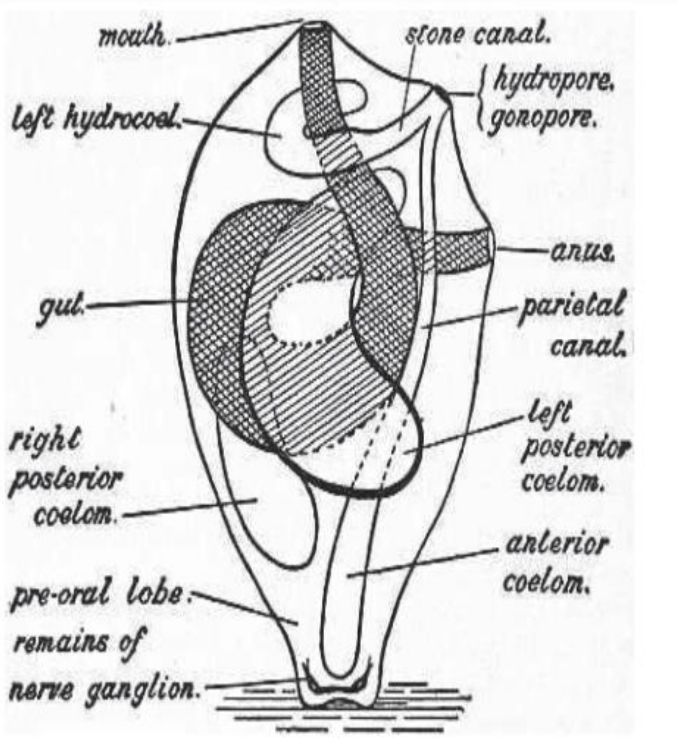


Fig. 2.7 Hepatic Region

(g) Body wall.

The musculature, peritoneum, and epidermis make up the body wall. The outermost layer, or epidermis, is made up of a single layer that is primarily composed of tall, slender, columnar, and ciliated cells. There is no dermis. The majority of the muscles are longitudinal, smooth,and feeble. There are solely longitudinal muscle fibers in the trunk area.

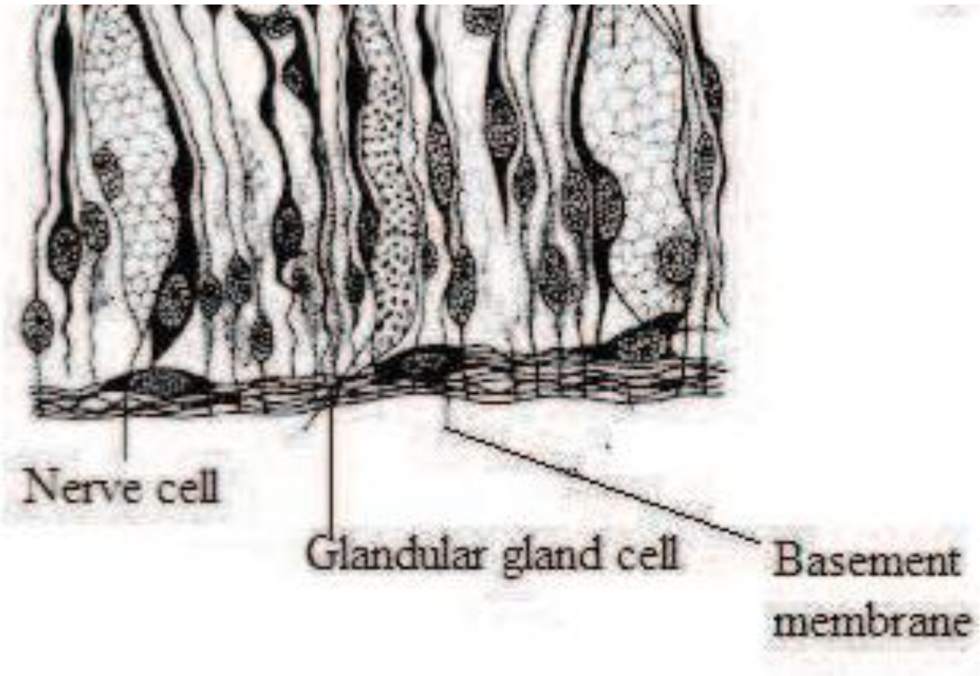


Fig. 2.8 V.S. of Balanoglossus body wall

(h) Coelom

Balanoglossus in its early developmental phases has a large coelom that is peritoneum lined. Its genesis is enterocoelous. Muscle fibers and connective tissue develop from the coelomic epithelium after adulthood is reached. The coelomic cavity is thus completely destroyed. Three sections make up the entire coelom.

Proboscic coelom (Protocoel) A number of organs, including the central sinus, heart vesicle,glomerulus, buccal diverticulum, and others, protrude from the base of proboscis into the coelom, a small, unpaired hollow in the proboscis. At the base of the proboscis, there is a dorsal orifice through which the proboscis coelom opens.

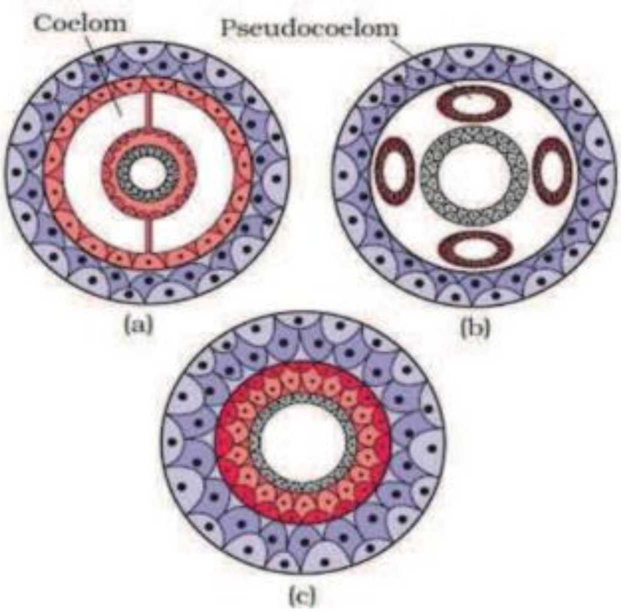


Fig. 2.9 Diagrammatic representation of coelome

Mesococl collar coelom

The coelom in the collar is divided into two distinct sac-like cavities on the left and right sides because dorsal and ventral mesenteries are present. They converse with the initial two gill-sacs connected by two collar pores.

Trunk coelom (Metacoel): The coelom in the trunk is made up of two chambers that are divided by complete ventral mesentries and incomplete mid-dorsal mesentries. Coelomic fluid, which contains amoeboid corpuscles known as coelomocytes, fills the trunk coelom. They came from the epithelium of coelomic rock. Spengel (1893) claimed that coelomocytes behave like leucocytes by secreting a barrier around any foreign particle that enters the animal.

Skeletal structure

Balanoglossus lacks a distinct endoskeletal structure, but its basement membrane thickens and lamellates remarkably to operate as a skeleton. Here are the components of the skeleton:

(i) Buccal diverticulum

It is a short, rigid, hollow projection that resembles a tube that extends through the proboscis stalk and into the proboscis coelom. It is referred to a claimed notochord by Bateson (1885). Dawydoff (1948) and Willy (1899) referred to it as a stomochord. It was referred to as the buccal diverticulum by Hyman. One layer of tall, thin, vacuolated endodermal cells makes up its wall. According to Silen (1950), it is an extension of the digestive tracts preoral area.

(ii) A hollow, short, stiff projection that goes through the proboscis stalk and into the proboscis coelom. It resembles a tube. It was related to a notochord that Bateson (1885) claimed to have. While Dawydoff (1948) and Willy (1899) called it a stomochord. It was referred to as the buccal diverticulum by Hyman. One layer of tall, thin, vacuolated endodermal cells makes up its wall. According to Silen (1950), it is an outgrowth of the single layer of tall, slender, vacuolated endodermal cells that line the preoral portion of the digestive system. According to Silen (1950), it is an extension of the digestive tract's preoral area.

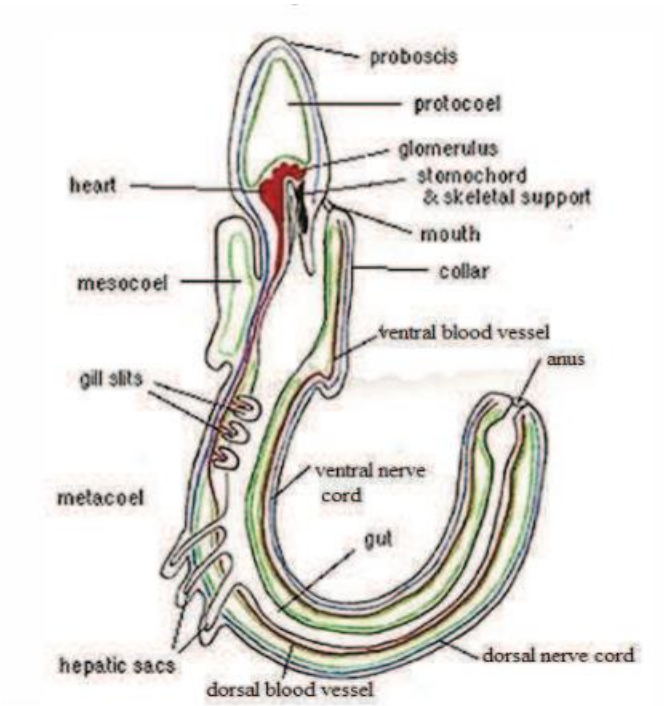


Fig. 2.10Endoskeleton of Balanoglossus

(iii) Proboscis skeleton

It is a Y-shaped structure that is partially secreted by coelomic tissue and partially by the epithelium. In general, its look is similar to a hyoid apparatus. It starts with a median plate in the proboscis stalk and continues into two slender horns that reach into the buccal cavity's roof from behind.Ventrallv produces the middle plate ventral to the keel. The buccal diverticulum is situated beneath the median plate.

(iv) Skeletal branches As the foundation membrane gets thicker, it is formed. It consists of several U-shaped gill slits that pierce the wall of the pharynx, supported by numerous M-shaped chitinous skeletal rods.

(j) Pygochord A rod-like thickening known as a phygochord forms mid-ventrally between the intestine and body wall in the post-hepatic area of the trunk.It has vacuolated cells.

(k) The digestive tract It is divided into the following sections:

(i) **Mouth**: A broad, circular mouth with a collarette covering it is located ventrally at the base of the proboscis stalk. It is composed of 2 sets of muscle fibers and the concentric fibers that close it and the radial fibers that open it. Mouth opens onto the buccal area.

ii) **Buccal cavity-** It is located in the collar area and have glandular goblat cells in its epithelial wall. It develops a hollow buccal diverticulum anteriorly, passes into the pharynx, and extends posteriorly up to the collar trunk septum.

(iii) **Pharynx:** Located in the trunk's branchial area. Parabranchial ridges are lateral constrictions on its wall that protrude into the lumen.The pharynx is partially divided by these ridges into a ventral digesting section and a dorsal respiratory or branchial portion. lined section of the ventral digestive tract

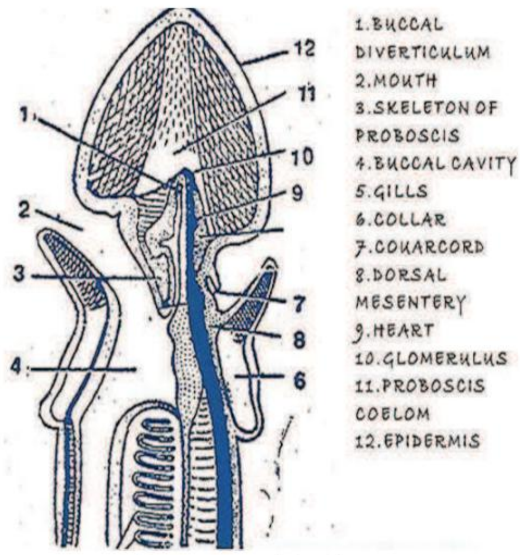


Fig. 2.11 Digestive system of Balanoglossus

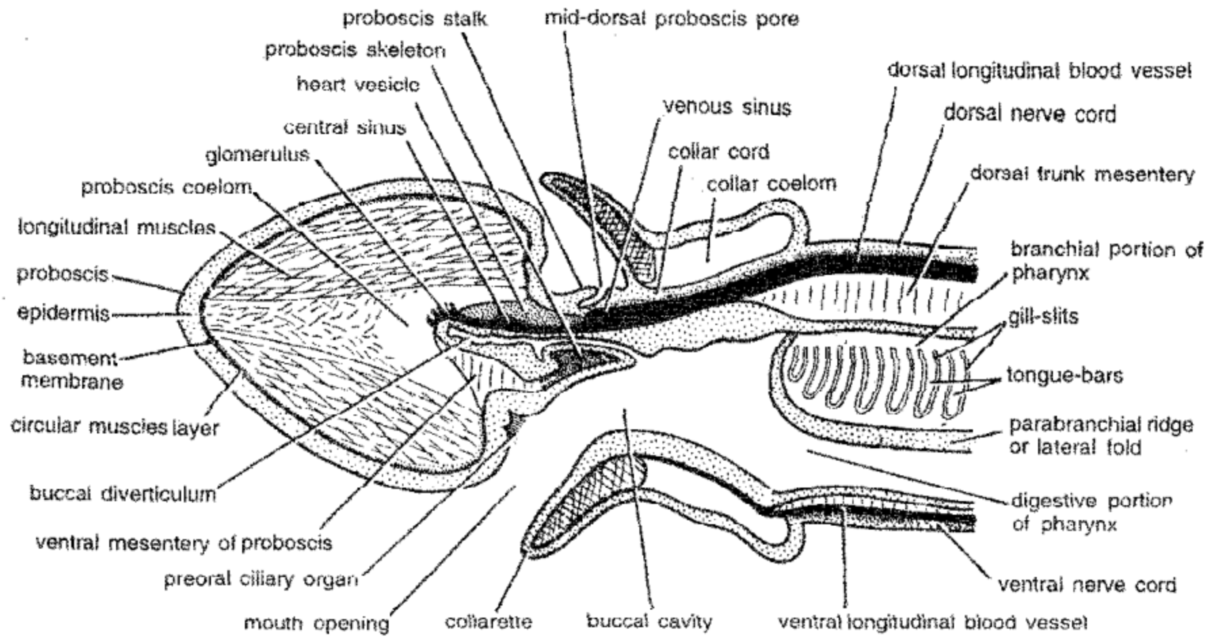
(iv) **Oesophagus:** The pharynx extends into the small oesophagus behind the final set of gill slits. The post branchial canal, which is located dorsally in the oesophagus, has thick, foldedand the epithelium glandular. The epithelium in the posterior region of the oesophagus is highly wrinkled and its diameter decreases.

(v) **Intestine:** It is located in the trunk's hepatic and post-hepatic regions. Additionally, the intestinal caecum extends to match this region's hepatic caeca. The pygochord connects the post-hepatic section of the intestine to the ventral body wall.

(vi) **Anus:** At the extremity of the trunk, the anus is the terminal circular aperture through which the intestines open to the outside world. It frequently has a sphincter muscle surrounding it.

(I) Food, feeding, and digestion:

Balanoglossus eats microscopic creatures and organic particles found in water and the bottom sand and serve as its food sources. Lateral gill slits provide a respiratory cum food water current. It enters the mouth and travels through the pharynx, gill slits, branchial sacs, and buccal cavity.



Balanoglossus. V.L.S. Anterior region to show the alimentary canal.

Fig. 2.12 Digestive system of Balanoglossus

The mucus, which is released by the proboscis gland cells as a mucus string, gathers the food that is present in the water stream. The cilia covering the proboscis drive this mucus string in the direction of the pre-oral ciliary organ, which is situated at the proboscis' base. After then, it returns it to the oral cavity. The preoral ciliary organ, which is U shape, evaluates the quality of food and water that enter the mouth. The ciliated lining of the alimentary canal's walls prevents food from moving backward through it. Enzymes released by gland cells in the pharynx, oesophagus, and hepatic area of the intestine facilitate digestion.It is unknown how exactly Balanoglossus digests food. Sand and silt, as well as undigested materials, escape throughthe anus as “castings.

(m) The breathing apparatus.

The respiratory system consists of the branchial section of the throat with gill-slits and the branchial sacs of Balanoglossus that open out through gillpores.

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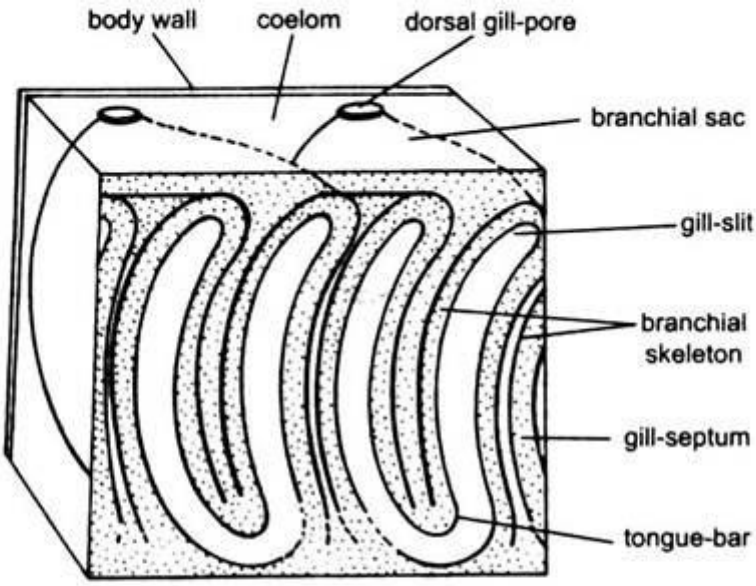

Fig. 2.13 Respiratory system of Balanoglossus

(n) Branchial pharynx:

The pharyngeal canal is divided into a dorsal respiratory or branchial section and a ventral digestive portion by two lateral longitudinal parabranchial ridges. Dorso-laterally, the branchial part on either side is pierced by a row of long, several U-shaped openings called gill slits.

The animal becomes older and produces a greater variety of them. When a gill slit first forms, it is a wide, oval slit. Later, it develops a U-shaped hollow projection known as the tongue bar from the dorsal pharyngeal wall. The synapticula, which are brief transverse or horizontal connections, link a tongue bar to neighboring gill septa. Gill-slit development and arraying are exactly the same as in Brassiostoma.Lateral cilia, which line the gill slits, are abundant.

(o) Mechanism of respiration:

The gill slit lateral cilia initiate a food-cum-respiratory stream of water. It enters the pharynx by the mouth, moves into the branchial sacs, and exits the body by the gill pores. The tongue bars take involved in gas exchange and have a rich vascular structure. Their capillary networks' blood absorbs oxygen from the water and releases carbon dioxide back into it.

(p) Neural system:

Echinoderms and coelenterates share a primitive neural system with us. Two distinct strands of thicker nerve layer are formed.

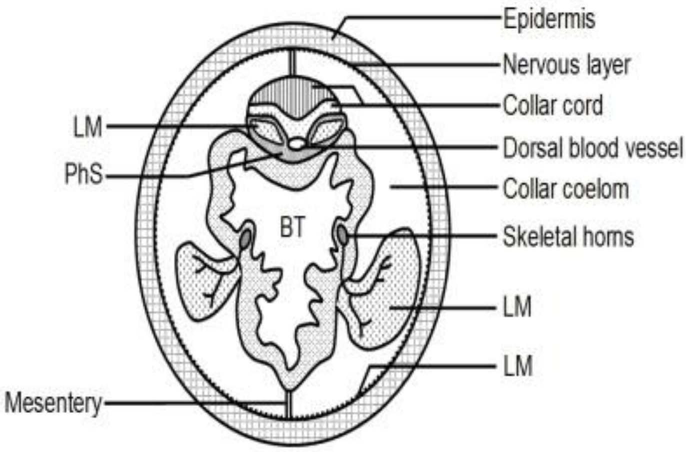

Fig. 2.13 Nervous system of Balanoglossus

(q) Reproductive System:

Asexual and sexual reproductions are carried out by Balanoglossus.In Balanoglossus capsensis, asexual reproduction was described by Gilchrist. Its back will split into several sections over the summer. Everybit grows into distinct individuals.There is no sexual dimorphism and the sexes are distinct. The gonads are basic organs of the reproductive system.

In the branchio genital region, can be found in one or more rows and fertilized zygote undergo holoblastic cleavage. The development in Balanoglossus kowaiowsley is linear. Its life history shows no evidence of a larval stage. A larval phase known as "**Tonaria**" is observed in several Balanoglossus species. It will change into adult after metamorphosis

SELF ASSESSMENT QUESTION

Q1. Balanoglossus belongs to the group:

(i) Annelida

(ii) Platyhelminthes

(iii) Hemichordata

(iv) Cephalochordata

Q2. Balanoglossus is generally called as:

(i) Acorn (worm)

(ii) Snake (worm)

(iii) Corn (worm)

(iv) Earth(worm)

Q3. HemichordatLarval forms :

(i)Crinoidia

(ii) Tornaria

(iii) Caterpillar

(iv) Nauplius

Q4. Chordates originated from:

(i) Tachoglossus

(ii) Amphioxus

(iii) Starfish

(iv) Balanoglossus

Q5. In a Balanoglossus, - Musculature is a:

(i) Transverse

(ii)Smooth

(iii) Striated

(iv) Cardiac

Q6. In BalanoglossusCoelom is:

(i) Scizocoel

(ii) Entercoel

(iii) Holocentric

(iv) Metacentric

Q7. Balanoglossus is:

(i) Bottom (feeder)

(ii) Surface (feeder)

(iii) Column (feeder)

(iv) Ciliary (feeder)

Q8. The true blood vascular system of Balanoglossus?

(i) Absence of central sinus

(ii) Closed system

(iii) Arteries and veins are absent

(iv) Blood is colourless

Q9. In hemichordate body is:

(i) Radially symmetrical

(ii) Segmented

(iii) Triploblastic

(iv) Diploblastic

Q10. Fertilization in Hemichordata is:

(i) External in freshwater

(ii) Internal

(iii) External in air

(iv) External in sea water

Answers

1(ii) 2 (i) 3 (ii) 4(iv) 5 (ii) 6(ii) 7 (iv) 8 (iv) 9(iii) 10 (iv)

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UNIT-3
UROCHORDATA AND CEPHALOCHORDATA;
STUDY OF LARVAL FORMS IN PROTOCHORDATES;
RETROGRESSIVE METAMORPHOSIS IN UROCHORDATA

Learning Objectives

- Recognize the fundamental traits and divisions of Cephalochordates (lancelets) and Urochordates (tunicates).
- Describe the stages of larval and adult life in the life cycle of Urochordates.
- Understand the Retrogressive Metamorphosis process.
- To study the different larval forms of Protochordates

3. 1 Urochordata and Cephalochordata:

Urochordata and Cephalochordata are the closest living relatives of the basal chordates. Together, with the vertebrates, they constitute the phylum Chordata, descended from a last common ancestor that lived around 550 million years ago. Fossils of the Middle Cambrian Burgess Shale such as Pikaia gracilens resemble extant cephalochordates, e.g., amphioxus (Branchiostoma spp.) and thus, place them around 505 Myr and older.

3.1.1 Urochordata

The Tunicata, frequently referred to as the Urochordata, are commonly called "sea squirts." Adult tunicates have very basic bodies that are essentially sacks with two siphons that allow water to enter and escape. Within the body structured like a sack, water is filtered. On the other hand, the larvae of many tunicates swim freely and have all the traits of chordates.

A hard secreted tunic containing cellulose, a glucose polymer not often seen in animals, is typically embedded in adult members. Benthic organisms are sessile and bottom-dwelling, but pelagic organisms are highly evolved and can swim and float in open water. During the life cycle, a distinctive tadpole larva forms. In one group of organisms, called appendicularians or larvaceans, the adult closely resembles this larva, which has many characteristics with other chordates.

Fig 3.1 Tunicates

Source: https://ucmp.berkeley.edu/chordata/urochordata.html

Certain families of tunicates produce minute spicules that have the potential to be preserved as microfossils.

3.1.1.1 Features of Urochordata

A branchial aperture allows water to enter the body, while an atrial aperture allows waste products, gametes, and water to exit. These two siphons are the two main surface apertures on a single tunicate that face away from the place of attachment.

The animal's pharynx's ciliary action generates water circulation. The thick tunic covering the animal is made up of blood vessels, a few cells, and a secretion of proteins and carbohydrates, including cellulose—a substance that is uncommon in animals but plentiful in plants.

3.1.1.1.1 Diversity and Size range:

Ascidiacea (ascidians, or sea squirts), Appendicularia (Larvacea), and Thaliacea are the three classes into which tunicates are classified. Most ascidians are benthic organisms. They frequently create colonies made up of a few to many individuals, or "zooids," which can grow to a length of two meters. The length of solitary (noncolonial) forms varies from one millimeter to more than 20 centimeters. The tadpole larvae of other tunicates resemble the adult appendicularian. The animal uses its "house" to trap food around its body. Simple and small, appendicularians typically measure five millimeters in length (including the tail) and do not establish colonies. They live out their whole lives at sea. Moreover, salps, dolioloids, and pyrosomes are thaliaceans that live in the ocean. Their structure implies that they are adapted ascidians meant to withstand circumstances in an open environment.

Fig 3.2 Sea Squirt

Source: https://www.britannica.com/animal/tunicate/Locomotion

3.1.1.1.2 Life cycle:

Although unicates are hermaphrodites, they can reproduce asexually (by budding) or sexually. Hermaphrodite animals generally avoid self-fertilization (i.e., producing both male and female gametes). In rudimentary forms, fertilization occurs in the surrounding water, where development also occurs. However, embryos are frequently held in the female's atrium or another location until the larvae are fully mature.

Instead of feeding, the larva focuses on locating a suitable location for the adult to reside. Two thirds of the larval body is made up of the muscular tail, which is supported by a notochord and possesses a nerve cord, in accordance with this motile phase. The larva's orientation during swimming is determined by gravity and light-sensitive sensory vesicles located on the dorsal surface of the body. The larva will settle and use its three anterior adhesive papillae to adhere to a surface after a few days or so. The tail resorbs as the larva transforms into an adult, supplying food reserves for the growing animal. Free-swimming tunicates change their form without becoming attached.

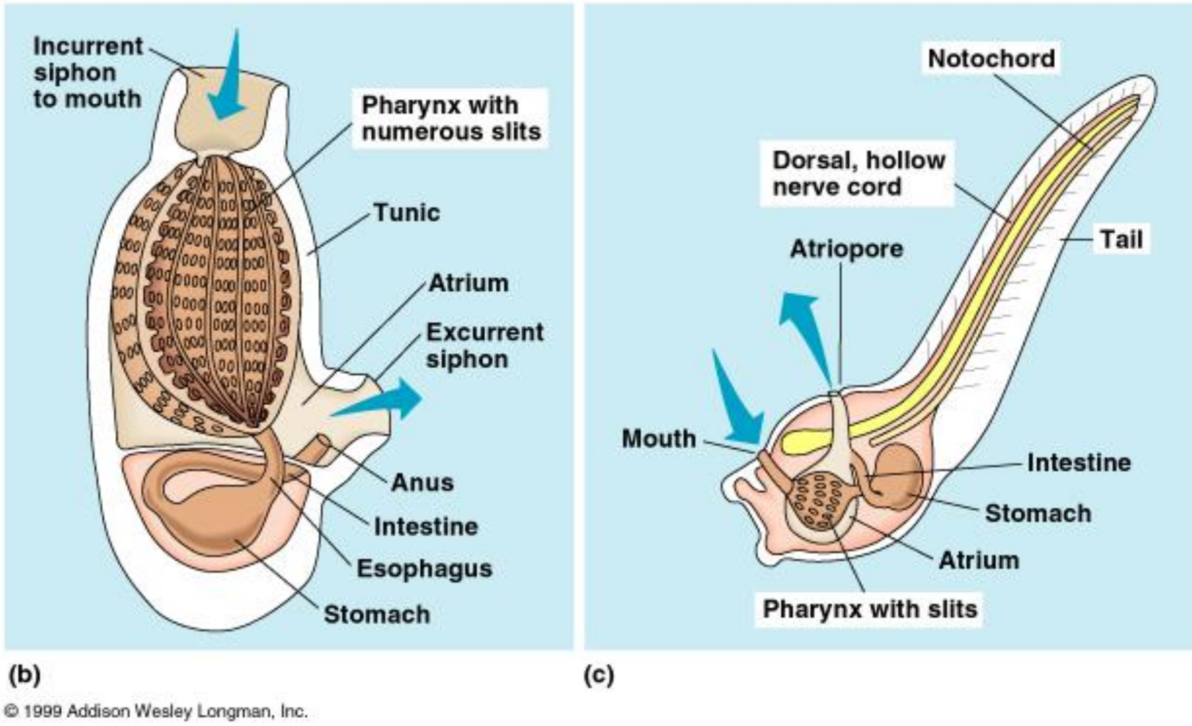

Fig 3.3 metamorphosed adult (b) and free-swimming larvae (c)

Source: https://www.mun.ca/biology/scarr/Urochordata.html

3.1.1.1.3 Locomation:

Appendicularians and tadpole larvae swim by swishing their tails, which have a rigid notochord. Even though they live sessile lives, certain adult ascidians are able to move by grasping onto one part of their body and releasing it from another. It has been observed that colonies can move up to 1.5 centimeters every day. In thaliaceans, an exhalant water current, when coupled with a powerful muscular contraction in dolioloids and salps, produces a jet stream that drives the animal forward.

3.1.1.1.4 Metabolic activities:

Pharyngeal cilia beat, producing a water stream in ascidians and thaliaceans. A film of mucus released by the endostyle captures a variety of extremely small creatures suspended in the water current as the water is forced from the branchial sac into the atrial cavity, especially small plantlike protists (phytoplankton).

After being wrapped into a cord, the mucus is transported to the intestine for digestion and absorption. There might be glands and a stomach. Beneath the atrial hole in the atrium, the intestine terminates as an anus. Through this opening, wastes are released as a stream of water.

Tunicates lack the fully formed coelom found in other chordates; nonetheless, there may be indications of one in the form of cavities surrounding the heart and the epicardium, an extension of the gut that surrounds several internal organs. The circulatory system is said to include the body cavities. There are no tiny capillaries, but there is a heart and a few major blood vessels.

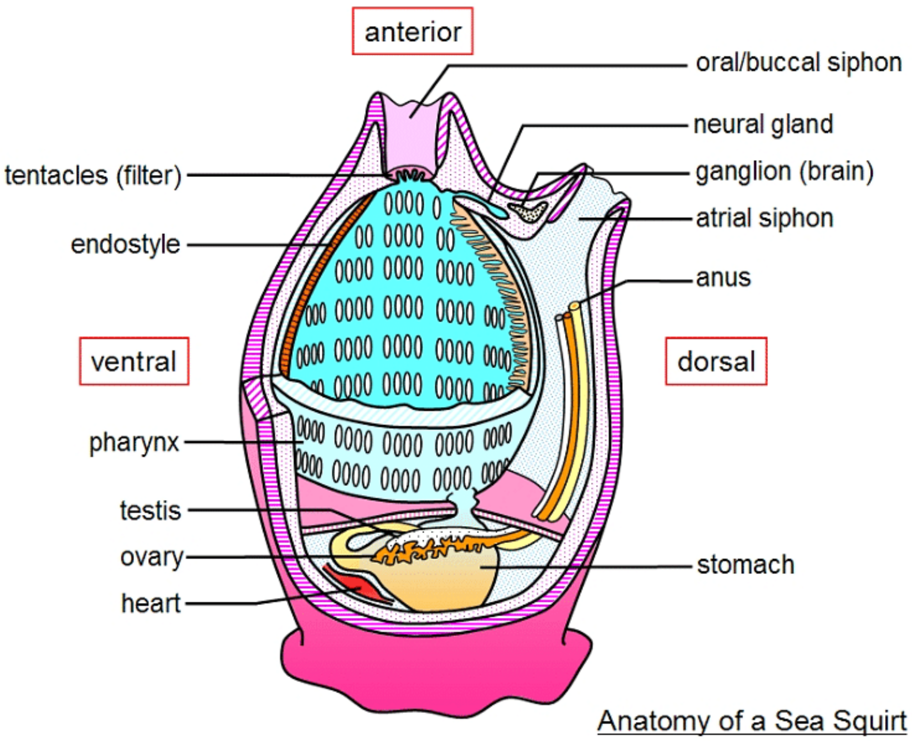

Fig: 3.4 Urochordata Diagram

https://collegedunia.com/exams/urochordata-biology-articleid-7626

3.1.2 Cephalochordata:

More than two dozen species that make up the phylum Chordata's subphylum Cephalochordata are referred to as cephalochordates. They are likely the closest extant cousins of vertebrates, being little, fish-like sea invertebrates. Vertebrates and cephalochordates have pharyngeal gill slits, a notochord, and a hollow dorsal nerve cord.

In two families, there are roughly 20 species, each having a single genus. Amphioxus was the previous name for Branchiostoma; it is still used informally. Asymmetron, commonly known as Epigonichthys, is the other genus. There are species that are occasionally kept in the genus Asymmetron.

Fig 3.5 Cephalochordata

Source: https://miller.biology.utah.edu/courses/3315/handouts/01_slides.pdf

3.1.2.1 Features ofCephalochordata:

Cephalochordates have pharyngeal gill slits, a notochord, and a hollow dorsal nerve cord. The notochord is preserved until adulthood and is never replaced by vertebrae in cephalochordates, in contrast to most vertebrates where the notochord is eventually replaced by bony vertebrae or cartilaginous tissue.

They are found on temperate and tropical shores all over the world. They live in shallow coastal water on soft substrates that range from sand to coarse shelly sand or gravel. Lancelets are buried in this substrate, frequently with their mouths sticking out so they can drink food-filled water.

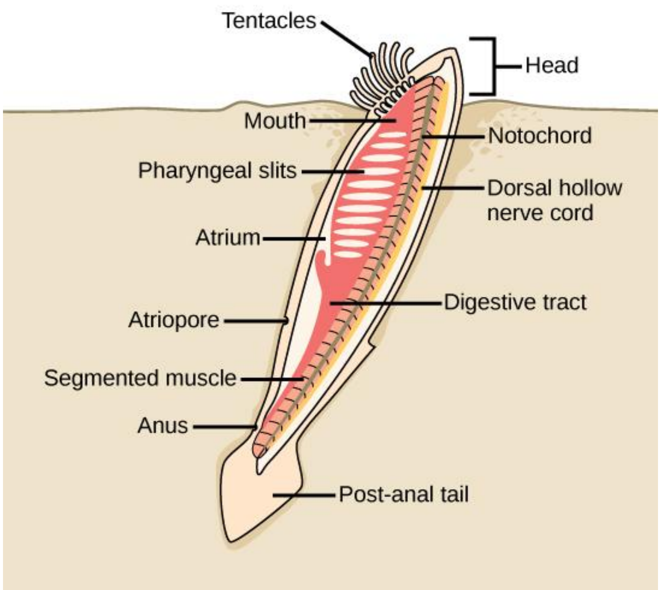

Fig 3.6 Ultrastructure of Cephalochordata

3.1.2.1.1 Life cycle:

There is no asexual reproduction in Cephalochordata, and the sexes are distinct. Fertilization takes place when sperm and eggs are released straight into the water. Early developmental phases are remarkably similar to those of vertebrates and tunicates.

It produces a larva that resembles the adult in form but is smaller, simpler, and asymmetrical (one side's gill slits develop first). It also lacks an atrium. Although they are on the bottom, the larvae spend much of their time feeding in open water. They grow and mature, then change into adults and live out their entire lives in the substrate.

3.1.2.1.2 Metabolic activities:

The wheel organ, a series of ridges inside the mouth, has cilia that beat to pull in water when it is swallowed. The oral cirri, which are thin projections that encircle the mouth opening and then filter the water.

It then goes via the openings in the gills. The body chamber known as the atrium is formed by folds in the body wall called the metapleural folds, which enclose these gill slits. Mucus traps food particles in the water, allowing water to flow through the slits and exit the atrium through the atriopore, which is situated at the back. The remainder of the digestive system is somewhat straightforward: the hepatic caecum, a pouch that secretes digestive enzymes, and the iliocolonic ring, a specialized section of the intestine, are where actual digestion occurs. Moreover, cephalochordates have a basic excretory system made up of paired nephridia and a well-developed circulatory system.

Cephalochordates and vertebrates share a surprisingly similar basic pattern of blood circulation through veins and tissues, despite the latter being more complex. The absence of a heart is the most obvious distinction among cephalochordates. Blood is pushed through the closed system by gill blood vessels and contractile blood vessels, particularly the ventral aorta. The ventral aorta, which is situated beneath the endostyle, receives blood from the back of the animal and branches upward through gill vessels.Blood travels forward from the posterior end of the body and then veers back to the ventral aorta through capillaries in the caecum, much like it does through the liver of lower vertebrates. The blood does not include corpuscles.

3.2. Study of larval forms of Protochordates

Due to their possession of all the fundamental characteristics shared by chordates, the larval forms of Protochordata are important in phylogenetic studies of Chordata. On the dorsal side of these animals is a solid, unjointed, strong, yet flexible rod-like structure called the notochord.

Different larval forms of Protochordates:

A. Tornaria:- Larva of Balanoglossus

Structure:

- A tornaria is the planktonic larva of certain Hemichordata species, including acorn moths.
- Its look is remarkably similar to that of the bipinnaria larvae of Echinoderm (star fishes).
- It is a transparent larva with an oval form.
- The body has a diameter of roughly 3 mm.
- It possesses an apical plate, a thickened area made possible by two eyespots and a tuft of cilia.
- The larva's alimentary canal is fully developed.
- The cilliary band extends into the postoral area as well as the anterior and posterior regions.
- The sexes of tornaria are distinct and Gonads are found on the side of the alimentary canal in longitudinal rows.
- Gonads grow in the wall of coelomic rock where Germininal epithelium lines the gonad.
- Cells from the germinal epithelium proliferate to create sperm and ova and Ovum and mature sperm are expelled through the vaginal hole.

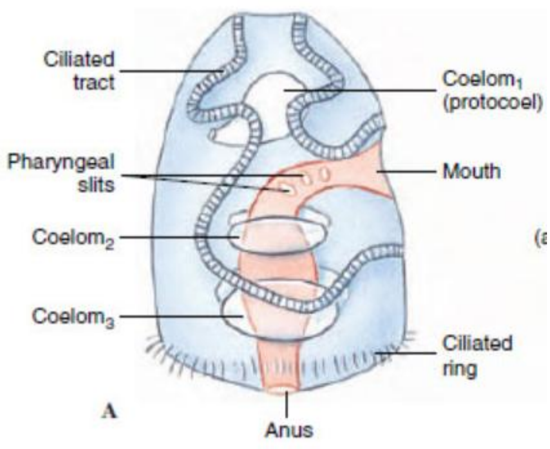

Fig 3.7:Tornaria- Larva of Balanoglossus

Source:https://www.gbri.org.au/SpeciesList/Balanoglossuscarnosus%7CPatriciaLoboDosReis.aspx?PageContentID=4849

- Two distinct events may result to development:

  Indirect (using a small-sized egg form known as a tornaria larva)

  Direct (big eggs do not contain larvae)

  Development of Larvae:
- The protocoel develops into the proboscis pore and coelom.
- Collar and trunk arise from the hindgut's in vagination.
- The stomach, intestine, and oesophagus all develop from the gut.
- The anus (next to the blastopore) is situated inside wheres the stomach opens.
- For the embryo to live as a free-swimming larva, cilia are developed.

B. Urochordata ascidian tadpole larvae

Structure:

- The body of the ascidian tadpole larva is ovoid in shape and has a long tail.
- Ectoderm secretes a thin test that covers the entire body.
- The test forms a caudal fin that fringes the tail.
- Three sticky papillae composed of ectodermal cells are located at the anterior end of the trunk.
- The brain, also known as the sensory vesicle, is the larger anterior portion of the nervous system.
- There is a hollow nerve cord that continues the brain.
- The nerve cord extends mid-dorsally into the tail.
- As sense organs, the pigmented 1statocyst and 2 ocelli are found in the sense vesicle.
- The notochord extends to the tail's tip.
- The gastrointestinal tract is finished.
- The pharynx features some stigmata in addition to an endostyle.
- The dorsal atrial opening allows the atrial cavity, which surrounds the pharynx, to open out to the outside world.
- The pericardium and heart have developed.

  Development is through Retrogressive Metamorphosis:
- The caudal fin larva's long tail shortens and eventually vanishes.
- The notochord, caudal muscles, and nerve cord decompose and are eaten by phagocytes.

- The ocellus and otolith, which are larval sense organs, disappear, and the sensory vesicle develops into an adult cerebral ganglia.
- The adhesive papillae completely vanish.
- Adhesive papillae, the point of attachment, and the anterior region between them exhibit rapid growth, whereas the original dorsal side with the atriopore stops growing. This results in a 90° shift in the mouth. Consequently, the original anterior and dorsal sides of the larva are represented by the adult's final branchial and atrial apertures.

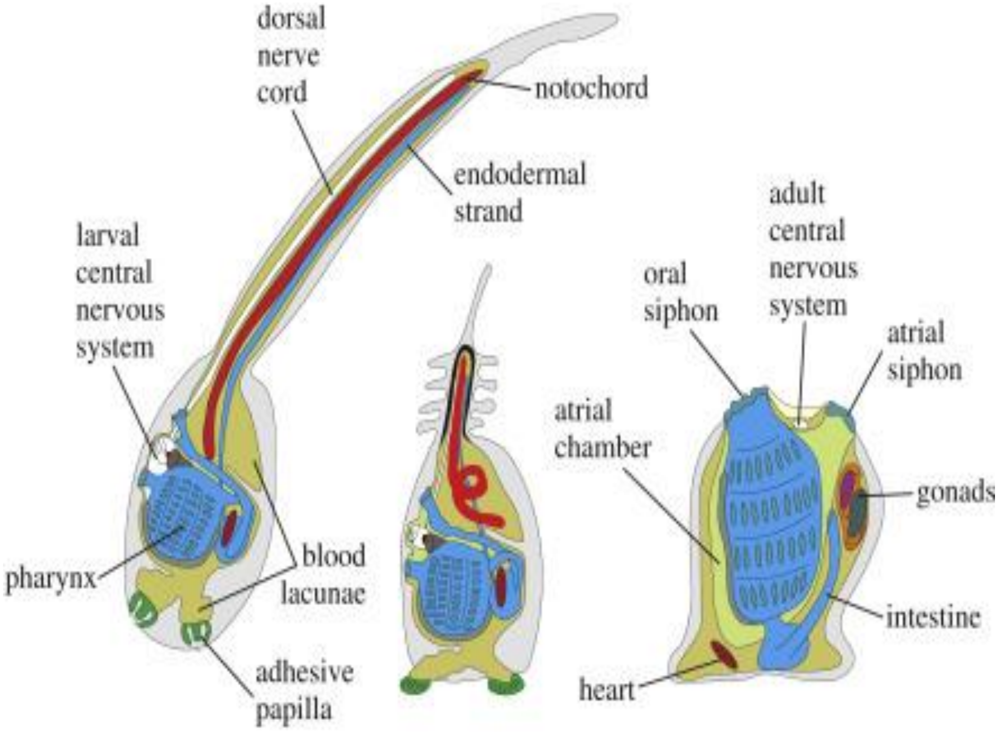

Fig 3.8 Different stages of metamorphosis in ascidian tadpole larvae

Source: https://www.sciencedirect.com/topics/immunology-and-microbiology/ascidiacea

C. Cephalochordata Larvae

Structure:

- Lancet, also known as Amphioxus, is a tiny, 3.5–6.0 cm long fish-like creature.
- The body is narrow, slightly transparent, compressed laterally, and pointed on both ends.
- The rostrum, or pointed anterior end, protrudes forward.
- There is an oral hood with at least twenty oral cirri, or tentacles, below the rostrum.
- The oral hood contained within a vestibule or buccal cavity shaped like a cup.
- The body is generally triangular in the anterior two thirds and oval in the last portion.

- The mid-dorsal caudal fin spans the entire body and the ventral fin extends midventrally, connecting the atriopore to the caudal fin.
- Rear and empty nerve cord.
- Other chordates, an adult's gill cleft opens to the atrium rather than the outside.
- Protonymph system excretory system.
- Men and women are distinct.
- They feed on suspended materials.
- According to recent research, they are a sister group of vertebrates based on ribosomal and mitochondrial evidence.

Developmental stages:

1. Ectodermal cilia and the club-shaped gland disappear during this procedure.
2. The mouth moves from the body's left side to its other. Its edges develop into a velum, skin folds create an oral hood, and an oral cirri houses the developing ciliated wheelorgan.
3. The larva develops the filter-feeding habit.
4. The emergence of tongue bars causes gill-slits to split, and additional gill-slits emerge behind the initial sets.
5. The coelomic chamber in the pharynx, myocoel, and gonocoel is reduced as a result of atrial development.
6. Gonads grow from the anterior lower angles of myotomes and become gonocoels when they project into myocoelic areas.
7. The tail area lengthens and, upon reaching adulthood, adopts a significant degree of symmetry in both directions.

3.3 Retrogressive Metamorphosis

At the time of metamorphosis the larva will remove all chordate characteristics during metamorphosis and acquire an invertebrate-like shape.This kind of transformation, in which

the highly developed larval form terminates in a poorly organized adult is referred to as regressive transformation.

1. Larval fixation: (Various transformation during metamorphosis)
   - The larva swims for some time without eating.

- It gets attached to a substratum with the adhesive papillae's assistance. Its tail is pointed upward as it stands erect.
  After that, it has a retrogressive change.
- There will be lesser of a notochord, nerve cord, muscles, and tail.
- The alimentary canal develops intricate.
- The throat becomes longer. Gill slit count will rise as a result of divisions and the the intestine and stomach will expand.
- The nervous system is shrunk, and a little neural ganglion develops from the anterior portion of the nervous system.
- It has a neural gland linked to it.
- The atrial cavity expands to resemble a sac.
- The statocyst and eyespot will totally vanish. Mesenchyme gives rise to gonads.
- The area between the adhesive papillae and the mouth expands quickly during these alterations, and the growth of the dorsal region is halted at the same time. As a result, the mouth rises to the top and the body rotates 180 degrees.

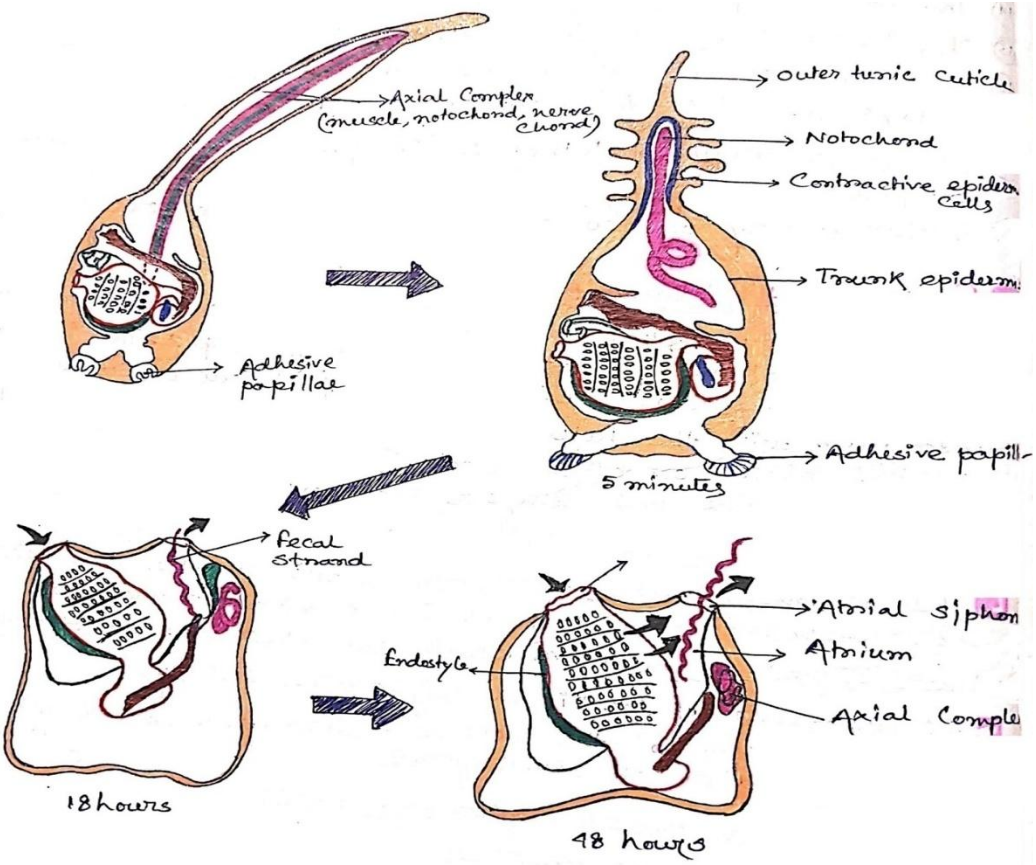

Fig 3.9 Mechanism of Retrogressive Metamorphosis

Source:https://everyething.com/Retrogressive-metamorphosis-of-Ascidia-sp

Questions:

1. What are the main characteristics that define Urochordata?
2. How does the notochord in Urochordata differ from that in other chordates?
3. Write a short note on life cycle of Urochordata.
4. What are the key differences and similarities between Urochordata and Cephalochordata?
5. What are the primary anatomical features of Cephalochordata?
6. Elaborate the mechanism of Larva of Balanoglossus
7. Write a detailed note on Retrogressive Metamorphosis and its mechanism.
8. Draw a detailed structure of Urochordata.

UNIT-4

AGNATHA : GENERAL CHARACTERISTICS AND CLASSIFICATION OF CYCLOSTOMES UP TO CLASS

LEARNING OBJECTIVES

After studying this unit you should be able to:

.Outline the distinctive features and connections of Agnatha

• Detail the traits of cartilaginous and bony fishes, highlighting their contrasts.

• Classify cartilaginous and bony fishes into specific subclasses.

• Explore the reasons behind and methods of transition for amphibians from water to land.

• Enumerate the general characteristics of Amphibia as well as those specific to its three orders.

• Examine the adaptations of fishes and amphibians to their respective environments.

4.1 SUPERCLASS AGNATHA

- The superclass Agnatha comprises two categories of jawless fishes: hagfishes and lampreys, totaling approximately 60 species.
- Primary distinctions of Agnatha from other fish groups include the absence of jaws and paired fins. Internal ossification and scales are also lacking.
- Unlike typical fishes, jawless varieties possess an eel-like body shape and gill openings resembling pores.
- Agnathans are alternatively referred to as cyclostomes or ring-mouthed fishes.

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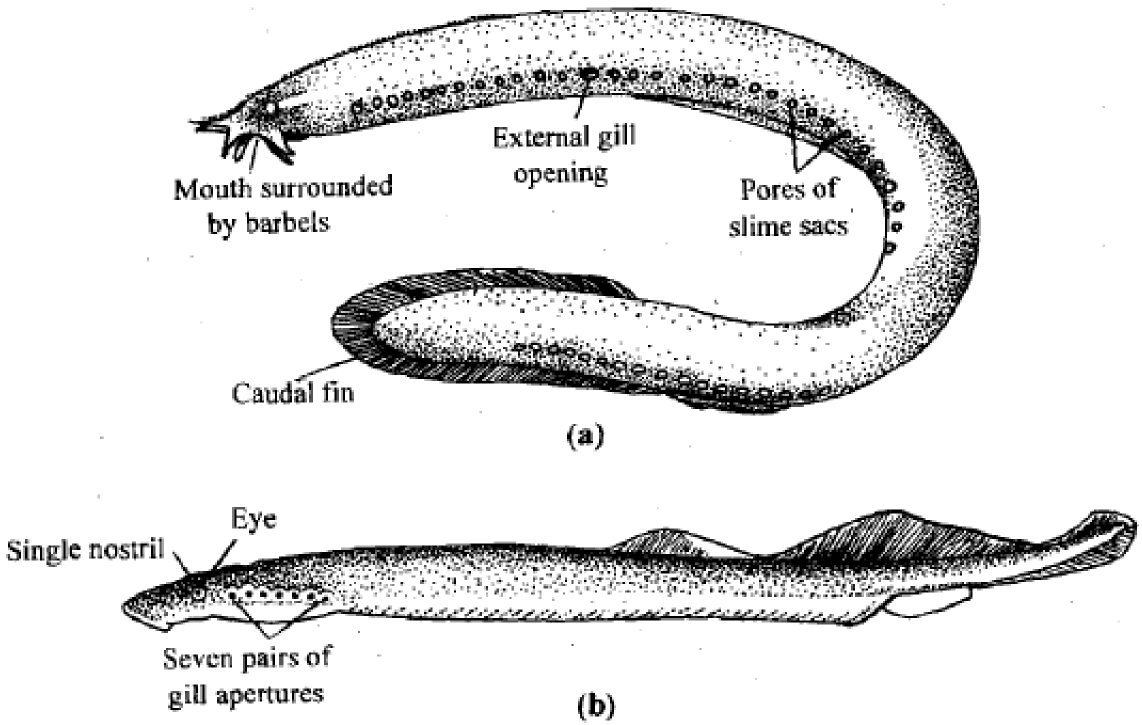


Fig 4.1 : (a) Hagfish (b) Lamprey.

4.2 GENERAL CHARACTERS

- Both hagfishes and lampreys boast a rounded body structure.
- Scales are nonexistent, and their skin remains soft due to the presence of mucus glands.
- Agnatha exhibit a lack of paired appendages, although they do possess median fins supported by cartilaginous fin rays.
- Their skeleton, instead of being ossified, is fibrous and cartilaginous.
- Lampreys sport a sucker-like oral disc equipped with well-developed teeth, while hagfishes feature a biting mouth armed with two rows of eversible teeth.
- The absence of a stomach characterizes their digestive system.
- In lampreys, the intestine boasts a spiral fold with cilia, whereas in hagfishes, the fold is present without cilia.
- A two-chambered heart, comprised of an auricle and a ventricle, pumps blood through aortic arches to supply the gills.
- Both lampreys and hagfishes possess erythrocytes and leukocytes, along with a differentiated brain and a dorsal nerve cord.

- Approximately eight to ten pairs of cranial nerves exist, alongside sensory organs for locating, tasting, and hearing.
- Lampreys possess moderately developed eyes, whereas hagfishes' eyes are degenerate.
- The internal ear includes one pair of semicircular canals in hagfishes and two pairs in lampreys.
- Agnatha exhibit separate sexes, with unpaired gonads and absent gonad ducts.
- Fertilization occurs externally, with hagfishes skipping a larval stage in their development, while lampreys undergo an ammocoete larval stage.

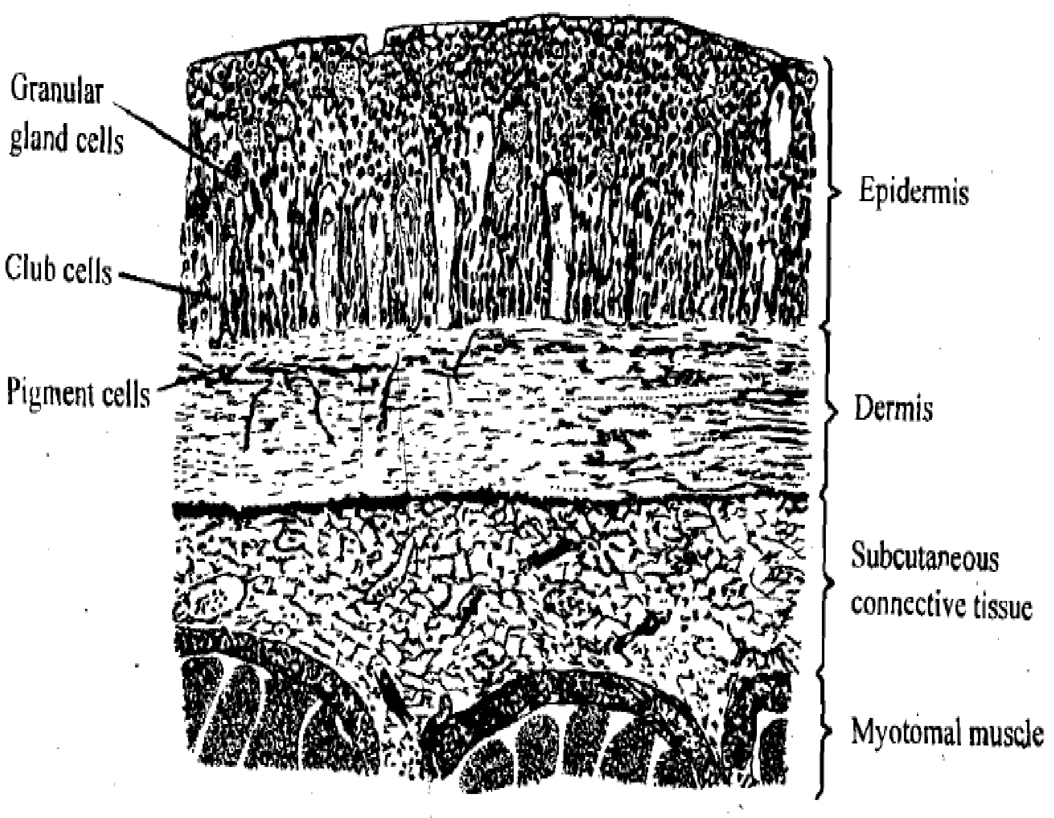


Fig 4.2 Section of skin of Lemprey.

- Previously, hagfishes and lampreys were occasionally classified as separate clades within Agnatha, mainly due to the perception of lampreys as true vertebrates, unlike hagfishes.

- However, recent molecular and embryological data, including studies on rRNA and mtDNA, strongly support the hypothesis that living agnathans, formerly termed cyclostomes, are monophyletic, indicating a shared recent common ancestry.
- The distinguishing characteristics of living in which jaw is absent fishes
- Interior ossification and gauges are also absent, though un-exclusive structures of the clade.
- Certain ostracoderms, contrasting present-day jawless fishes, shows presence of paired fins.

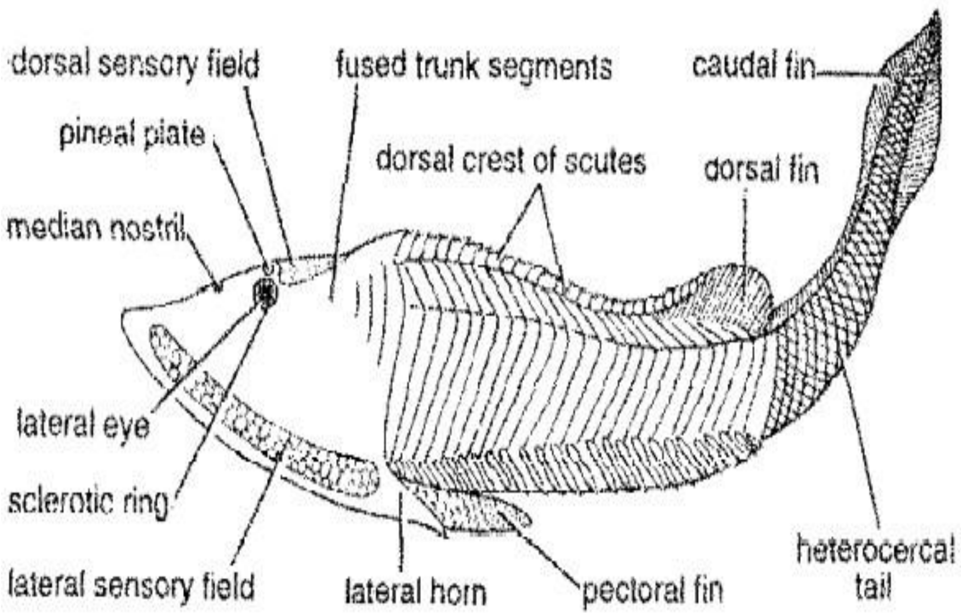


Fig 4.3 Cephalaspius restoration

- Ostracoderms" denote a collection of profoundly armored inexistent jawless fishes that may not constitute a regular evolutionary cluster.

4.3 ARRANGEMENT AND FUNCTION:

- The extended bodies are variations for a burrowing lifestyle, persisting throughout life in hagfishes but only during the larval stage in lampreys.
- Extinct agnathans display considerable variation in body form.
- Certain Osteostraci, for instance, have a compressed head shield and, despite having a influential swimming tail, seem to have primarily inhabited the bottom.
- Their mouth size and shape suggest a filter-feeding behaviour.

- The edgewise flattened, fish-like shape of anaspids, such as Pharyngolepis, indicates a propensity for free-swimming.
- Non-existent heterostracans encompass clear bottom-dwelling species like Drepanaspis and others like Pteraspis, which seemingly modified to mid-water or nektonic lifestyles.
- heterostracans featured mobile enamel plates exclusive to their lower lip, likely serving a biting or grazing function.
- Osteostracans, anaspids, hagfishes, and lampreys possess a single median nostril, whereas heterostracans appear to have had 2, positioned at each angle of the mouth.

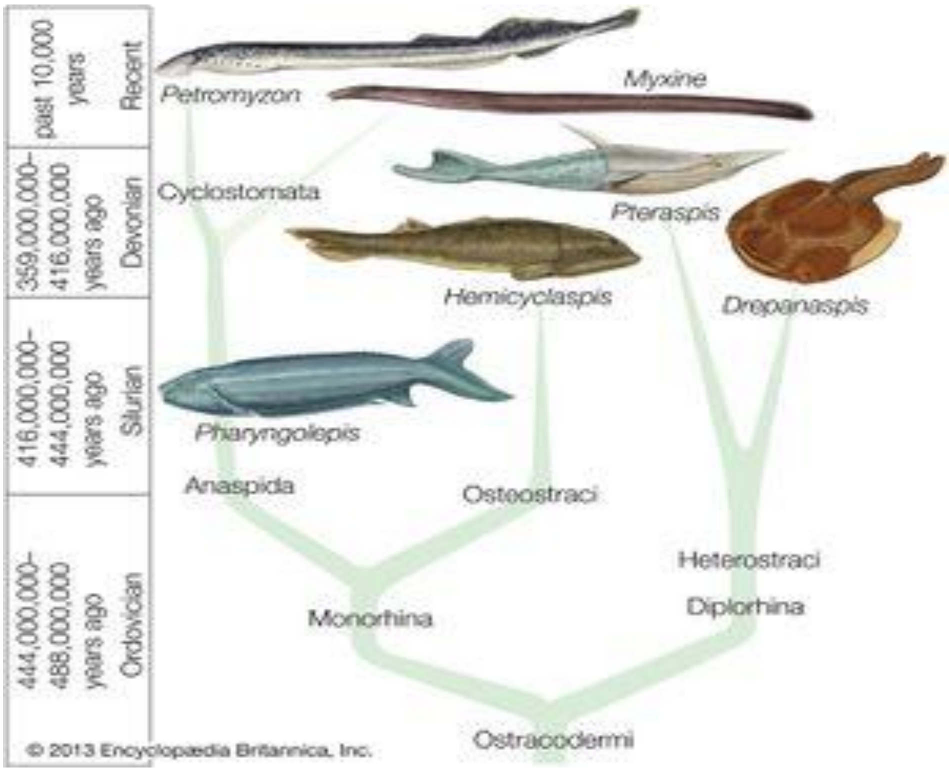


Fig 4.4 Systematic division of Agnatha

4.4 EVOLUTION AND TAXONOMY EVOLUTION:

- When indication from fossils and existing forms is amalgamated, Agnatha can be distinguished from other craniates (Gnathostomata) by their absence of jaws, lateral fins supported by fin rays, vertebrae, a horizontal semicircular canal in the ear, and genital ducts.
- While the nervous, sensory, endocrine, circulatory, excretory, and muscular systems of Agnatha share a basic structure with gnathostomes, they tend to be simpler overall.

- Unlike the slit-like gills of gnathostomes, Agnatha's gills are pouch-like and open through pores.

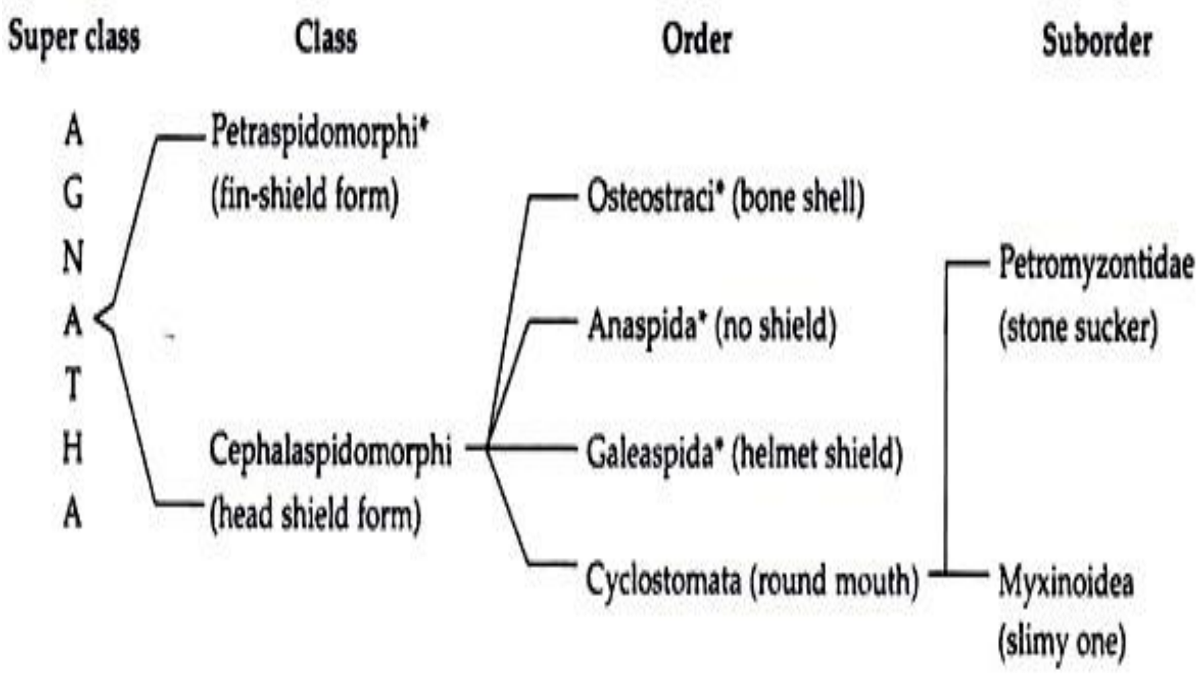


Fig 4.5 Evolution chart

4.5 CLASSIFICATION

Cyclostomata – Characteristics and Classifications:

- Cyclostomatas, unique jawless fishes classified within the class Agnatha, encompass lampreys and hagfishes with soft bodies.
- Their designation stems from their circular mouth shape.
- These creatures inhabit various aquatic environments.
- Termed jawless fishes due to their underdeveloped jaws.
- Cyclostomatas possess 6-14 pairs of gills and a cartilaginous skeleton.
- They thrive in both marine and freshwater habitats, displaying adaptability to diverse conditions.
- Cyclostomatas differ from fishes notably in their lack of paired fins or true jaws.

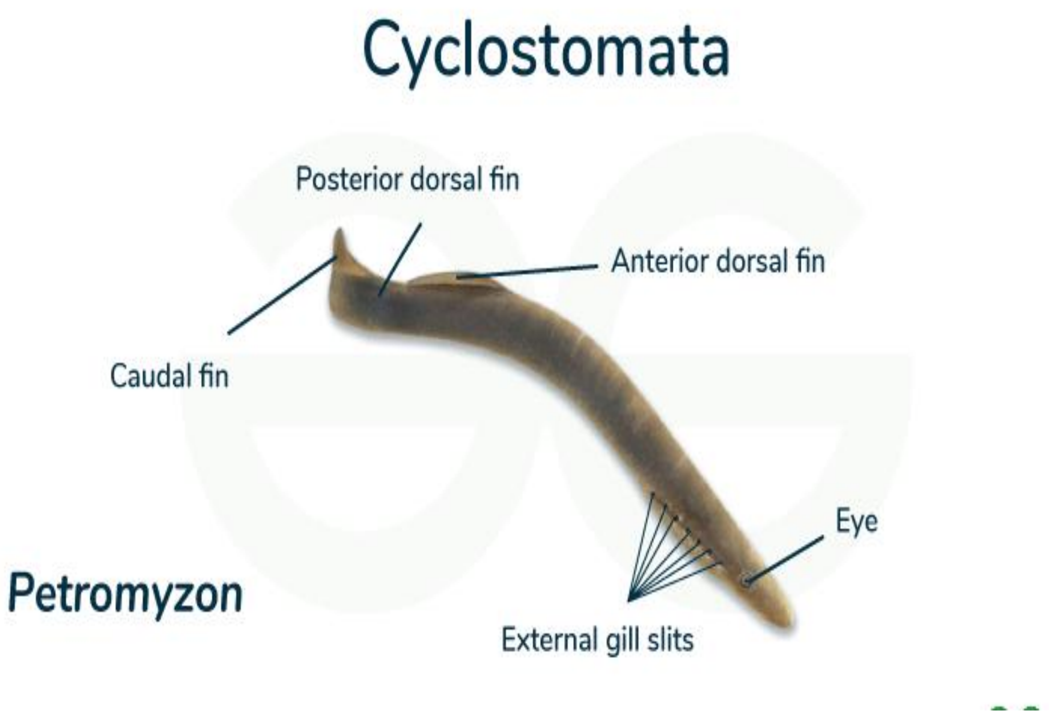


Fig 4.6 Anatomy of Cyclostomata

Examples

- Japanese Lamprey
- European River Lamprey
- Pacific Lamprey

4.6 CHARACTERISTICS:

- The body exhibits a round and elongated form reminiscent of an eel.
- Paired fins not present, with median fins supported by cartilaginous fin rays.
- Lack of corresponding appendages is notable.
- Skin texture is soft and smooth, devoid of scales.
- Sexual dimorphism is evident, with some hagfish species believed to be hermaphrodites.
- The spleen is notably absent.
- Exoskeletons are non-existent, with a cartilaginous endoskeleton devoid of bones.
- The notochord persists throughout their lifespan.
- A single median nostril is present.
- Gills range from 5 to16 pairs.

- The heart comprises two chambers, while the brain is visible. The lateral line serves as a sensory organ.
- Approximately eleven pairs of cranial nerves are present.
- Two mesonephric kidneys contribute to the excretory system.
- The digestive system lacks a stomach.
- Examples include Maxine and Petromyzon.

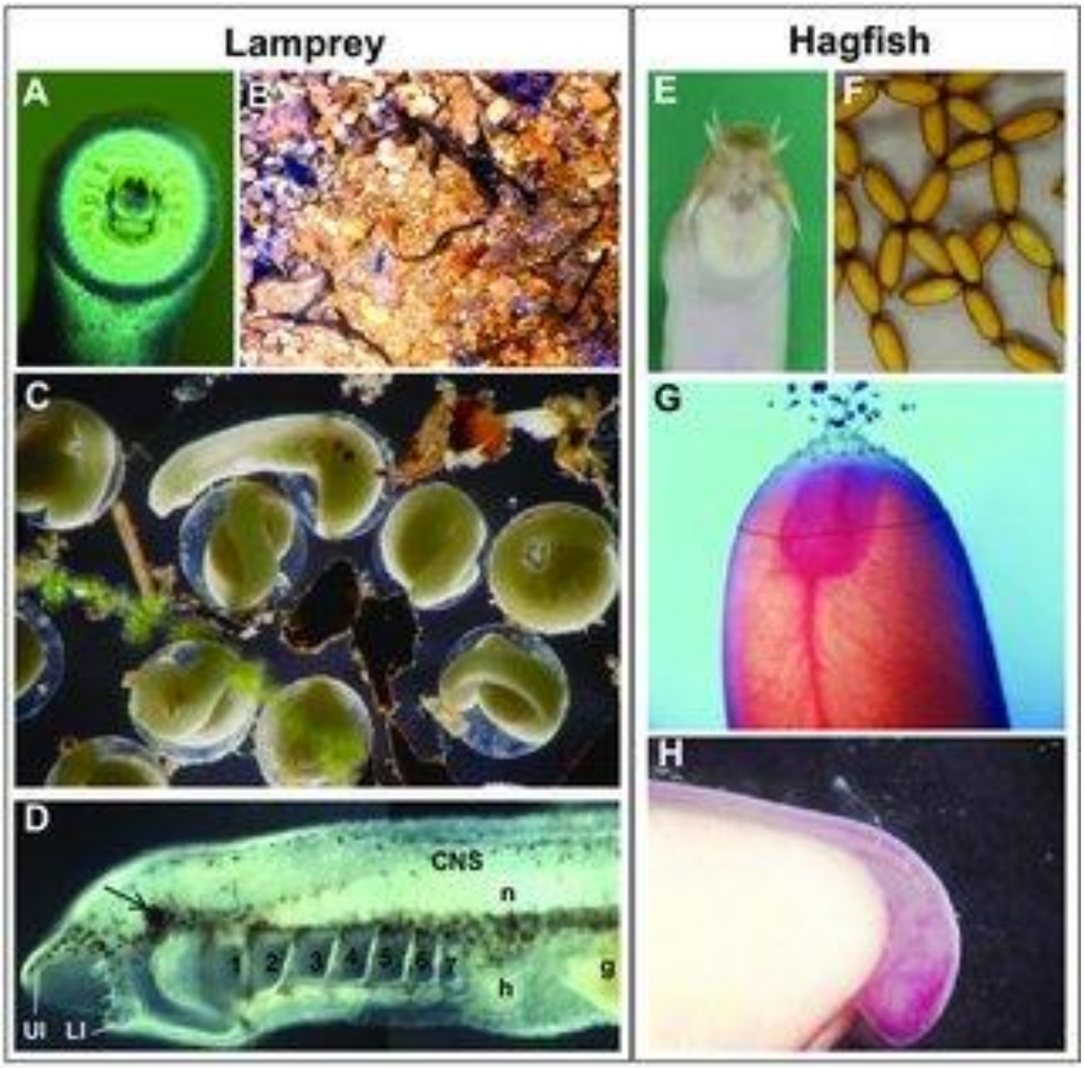


Fig 4.7 Lamprey and hagfish adults and embryos.

4.7 FUNCTION:

- These creatures play a crucial role in the nutrient cycle, essential for maintaining ecosystem balance.
- They serve as indicators of environmental health.
- Additionally, they help regulate aquatic systems by controlling fish populations.

SUB-DIVISIONS:

PETROMYZONTIFORMES:

- This category encompasses eels or Lampreys.
- They inhabit both marine and freshwater environments.
- Exhibiting indirect development.

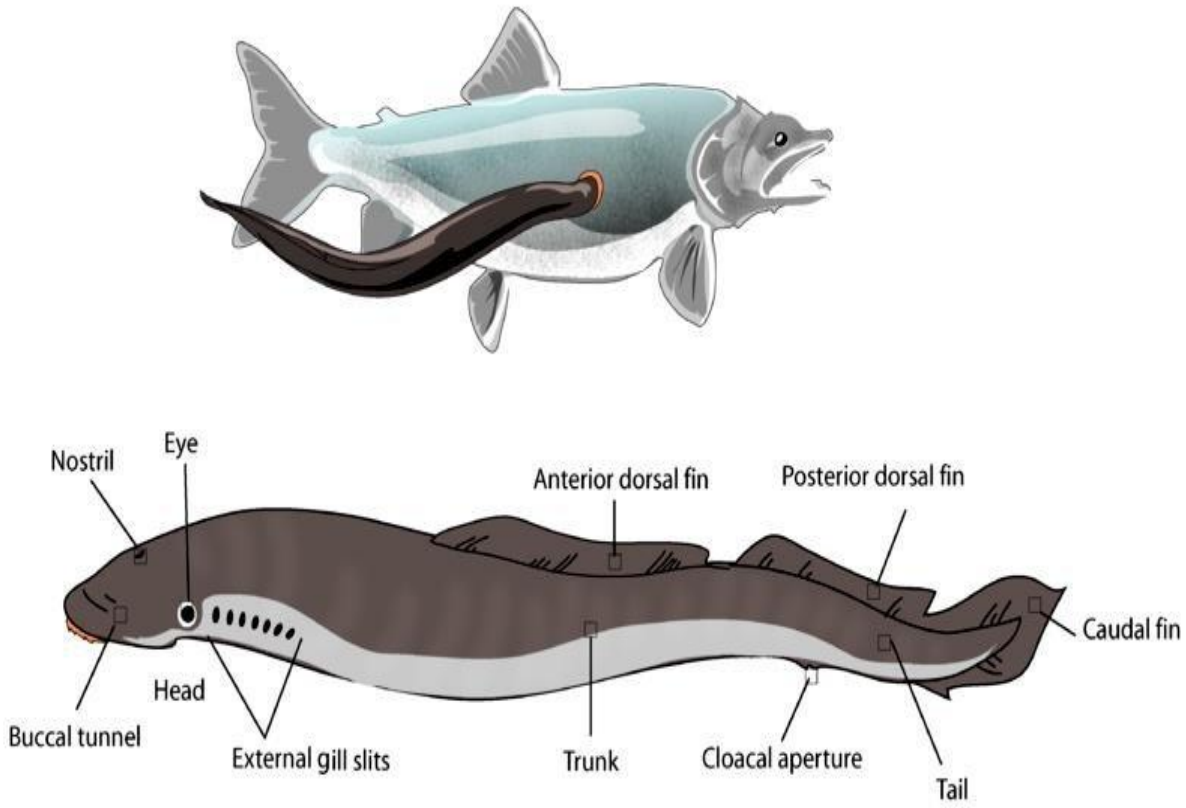


Fig 4.8 Diagram showing the external morphology of sea lamprey (lower panel).

Characterized by a ventral mouth and dorsal nostrils.

- Typically possess a well-developed dorsal fin.
- Examples include Lampetra and Petromyzon.

- Lampreys predominantly inhabit coastal and freshwater regions, boasting a global distribution.
- While few species dwell in aquatic environments, all species undertake spawning in freshwater.

- Intriguingly, northern lampreys within the Petromyzontidae family possess the highest chromosome count (ranging from 164 to 174) among vertebrates.
- Fertilization of eggs occurs externally, and the resulting larvae, known as ammocoetes,.

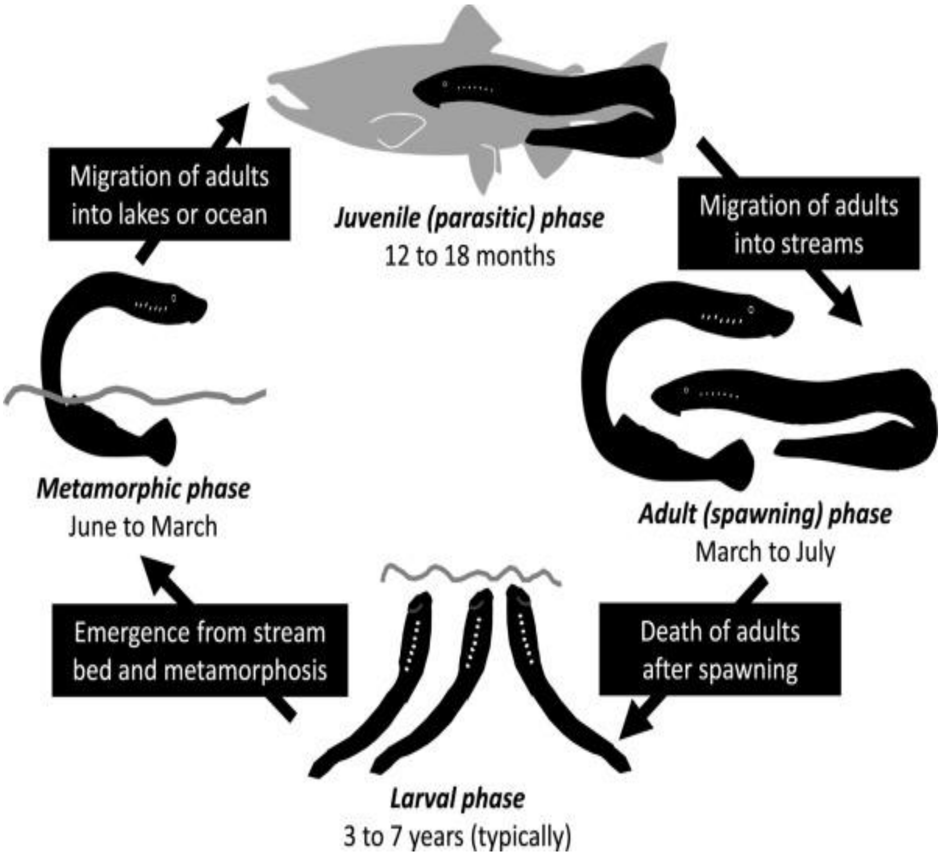


Fig 4.9 Life cycle

ORDER 2: MYXINOIDEA

1. This order comprises hagfishes or slime eels.
2. The buccal funnel is absent.
3. The nasal sac opens into the pharynx via a canal.
4. Vestigial organs represent the eyes.
5. The dorsal fin is either absent or very small.
6. The branchial basket is poorly developed.
7. The brain displays primitive characteristics.
8. The pineal eye is reduced.
9. Only one semicircular canal is present in the ear.
10. All hagfishes within this order are marine species.

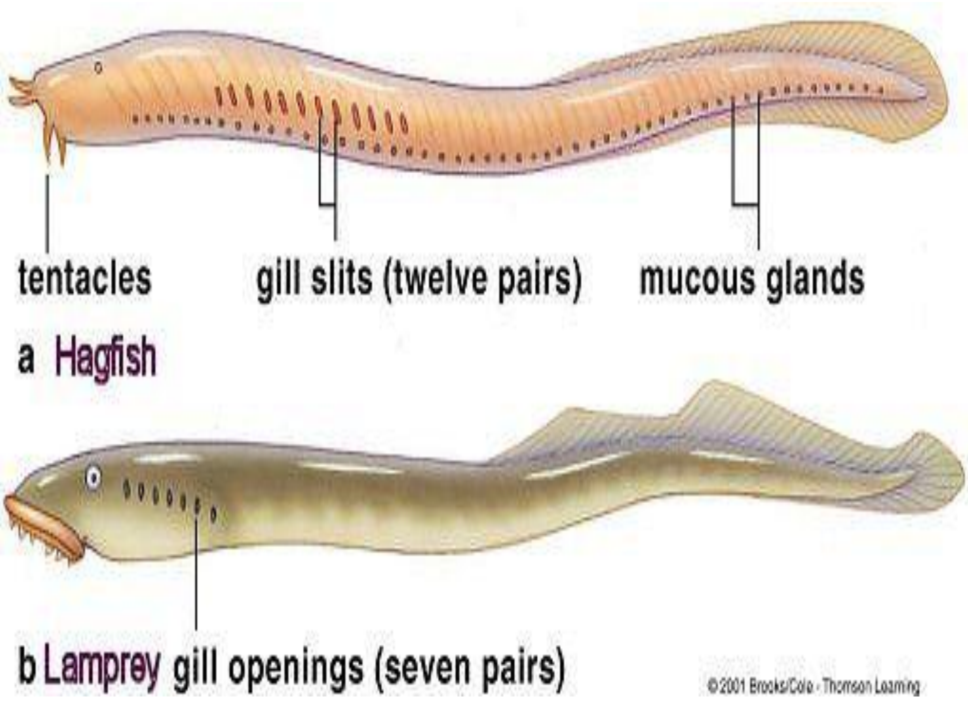


Fig 4.10 hagfishes

- Hagfishes possess a cartilaginous skull and a fibrous, cartilaginous skeleton, with the primary supportive structure being the notochord extending along the body's length.
- Unlike in true vertebrates, the notochord in hagfishes remains intact and is not replaced by the vertebral column.

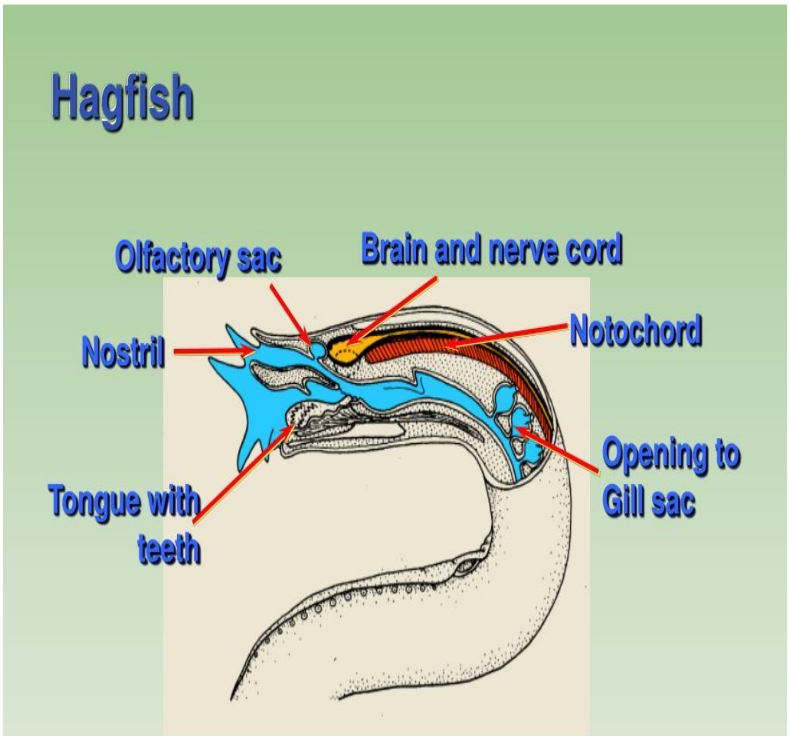


Fig 4.11 hagfishes anatomy

UNIT-5

PISCES : GENERAL CHARACTERISTICS OF CHONDRICHTHYES AND OSTEICHTHYES, CLASSIFICATION UP TO ORDER MIGRATION, OSMOREGULATION AND PARENTAL CARE IN FISHES

LEARNING OUTCOMES

- Investigate the migration patterns observed in different fish species, taking into account factors like seasonal variations, temperature fluctuations, and the availability of food.
- Explain the processes through which fish manage their internal levels of salt and water, especially in accordance with their habitat, be it freshwater or saltwater.
- Examine the adaptations that facilitate fish in maintaining a balanced osmotic environment, highlighting specialized mechanisms like ion transport in their gills and kidneys.
- Gain insight into the wide array of reproductive strategies utilized by various fish species, covering aspects such as mating behaviors, egg-laying methods, and the extent of parental care provided.

5.1 INTRODUCTION

- Fish are primarily aquatic vertebrates characterized by their jaw-bearing structure.
- They originated during the Silurian period and experienced significant proliferation during the Devonian period, often referred to as the golden age of fishes.
- This period marked the emergence of biting jaws among vertebrates, with the earliest jawed vertebrates known as gnathostomes, exemplified by species like Climatius.
- Subsequently, placoderms, another group of jawed vertebrates, appeared shortly after the acanthodians.
- Acanthodians eventually gave rise to bony fishes, while placoderms contributed to the ancestry of cartilaginous fishes.
- Notable among fish species, the smallest is Paedocypris progenetica, while the largest is Rhinodon typus.

Fig 5.1 Smallest fish Paedocypris progenetica

Fig 5.2 Largest fish –Rhinodon typus

5.2 GENERAL CHARACTERS

- Vertebrates dwelling in aquatic habitats, ranging from freshwater to marine environments, exhibiting herbivorous or carnivorous diets, and characterized by being cold-blooded and either oviparous or ovoviviparous.
- Typically possessing a streamlined, spindle-shaped body structure, although some species may be elongated resembling snakes, while others are dorsoventrally compressed.
- The body is divided into distinct regions: head, trunk, and tail.
- Movement is facilitated by paired pectoral and pelvic fins, in addition to median dorsal and caudal fins, all of which are supported by true dermal fin-rays.

- Propulsion is primarily achieved through the muscular action of the tail.
- The external body surface is covered by an exoskeleton composed of dermal scales, denticles, or bony plates (found in Placodermi). Chondrichthyes possess placoid scales, while Osteichthyes may have ganoid, cycloid, or ctenoid scales.
- The internal skeleton may be either cartilaginous or bony.
- The notochord is typically replaced by vertebrae, which can be composed of either bone or cartilage.
- These vertebrates exhibit a well-developed skull and a system of visceral arches, with the first pair forming the upper and lower jaws, the latter being movable and articulated with the skull.\
- Muscles are organized into segmented units known as myotomes, comprising distinct dorsal and ventral sections.
- The digestive system consists of a well-defined stomach and pancreas, culminating in either a cloaca or anus.
- Respiration occurs through gills, typically characterized by 5 to 7 pairs of gill slits, which may be exposed or covered by an operculum.
- The circulatory system features a venous heart with two chambers—a single auricle and ventricle.

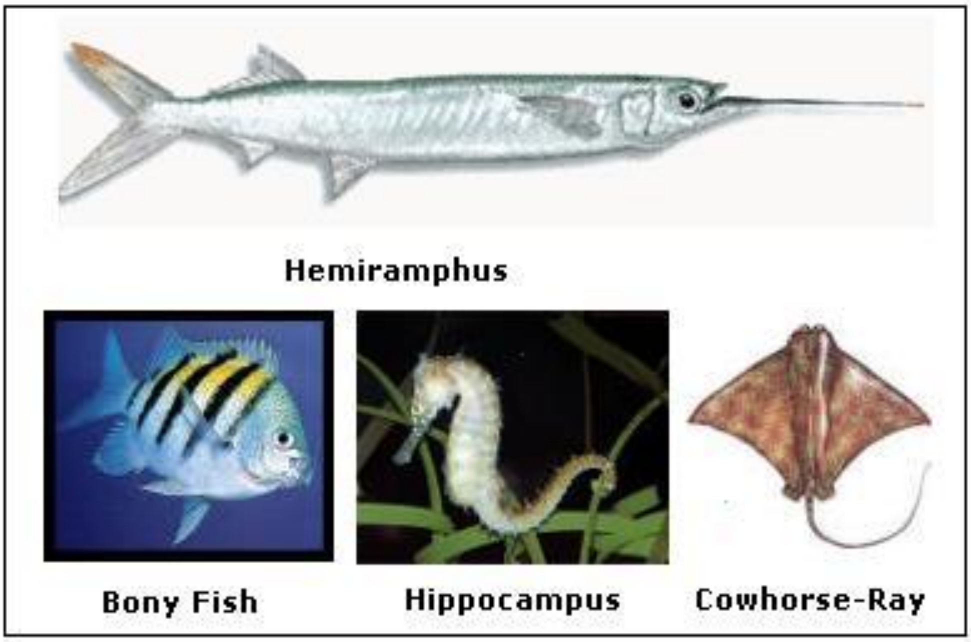


Fig 5.3 types of fishes

- Components such as the sinus venosus, renal, and portal systems are present. Erythrocytes possess nuclei.
- These organisms are poikilothermic.
- The kidneys are mesonephric, and excretions are ureotelic.
- The brain exhibits the typical five-part structure, with a total of ten pairs of cranial nerves.

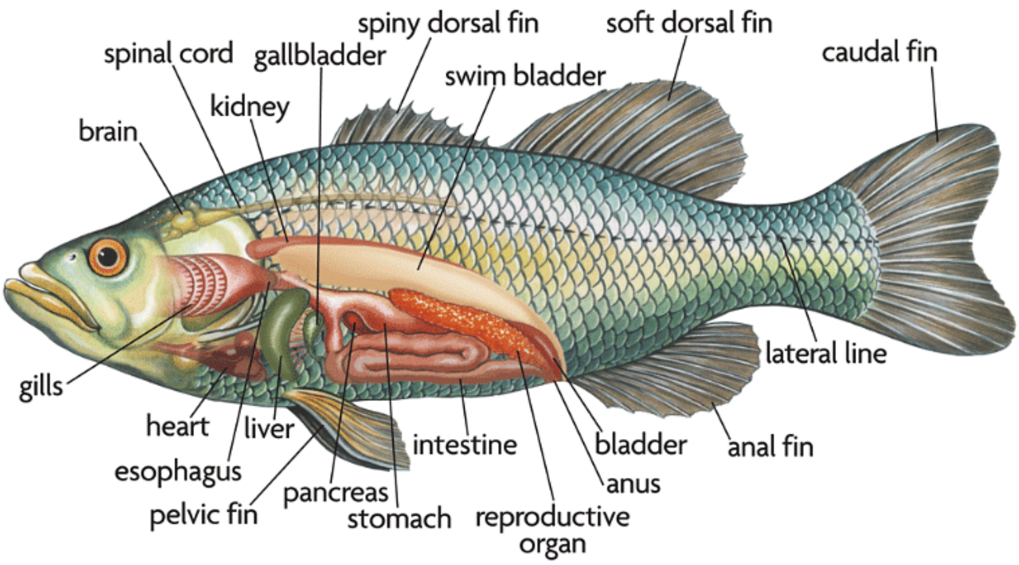


Fig 5.4 anatomy of fishes

- Nostrils occur in pairs but do not connect to the pharynx except in Dipnoi. In Chondrichthyes, nasal capsules are partially separate, while in Osteichthyes, they are entirely distinct.
- There is no presence of a tympanic cavity or ear ossicles.
- The internal ear consists of three semicircular canals.
- The lateral line system is highly developed.
- Fish exhibit separate sexes, with typically paired gonads. Gonoducts may open into the cloaca or independently.
- Fertilization can occur internally or externally. Female Chondrichthyes are typically oviparous or ovoviviparous, while those of Osteichthyes are primarily oviparous, with rare instances of ovoviviparity or viviparity.
- Eggs contain a significant amount of yolk, and cleavage is meroblastic.
- There are no extra-embryonic membranes present.
- Development usually proceeds directly, with minimal or no metamorphosis occurring

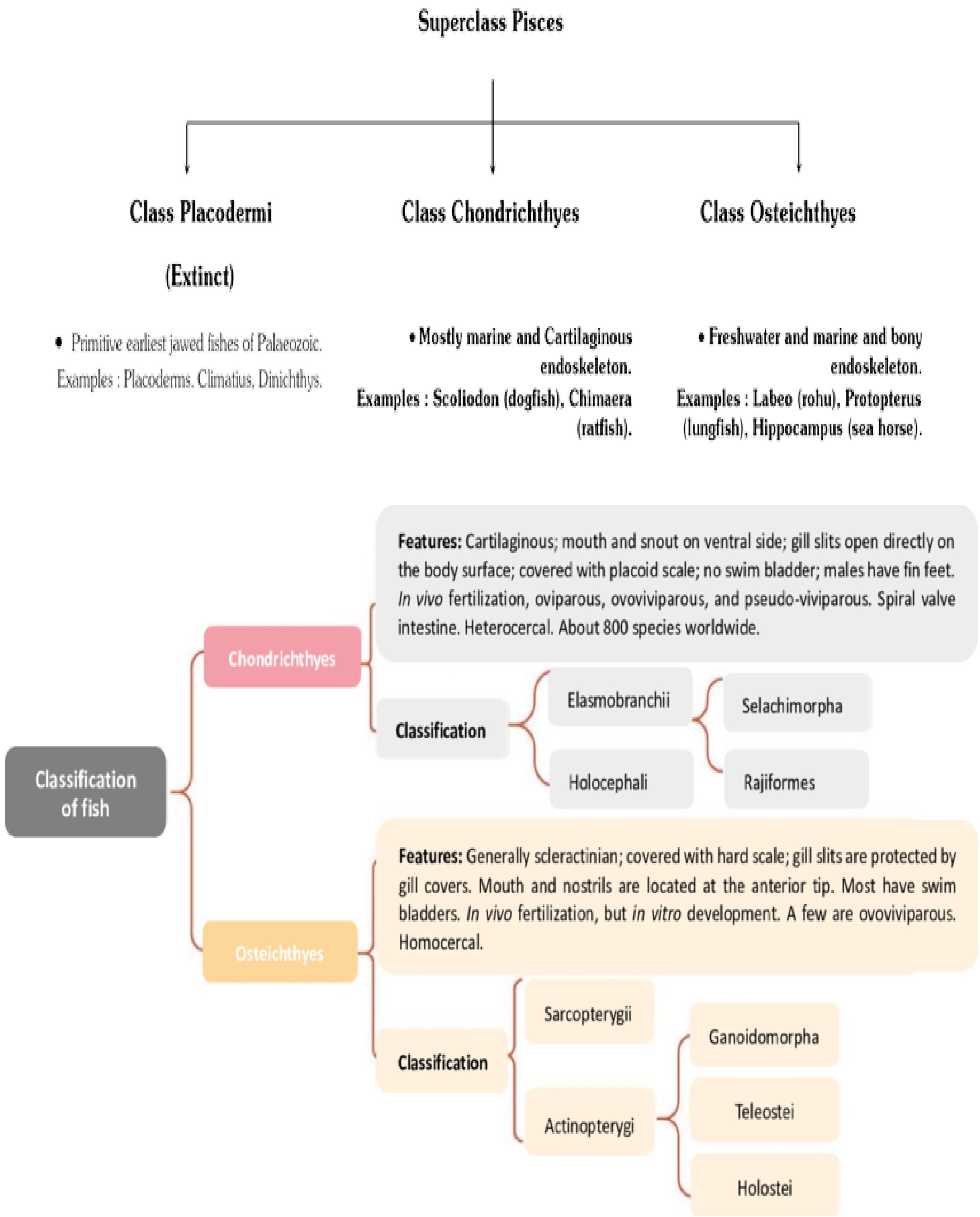


Fig 5.5 a and b Classification

5.3 CLASSIFICATION OF PISCES:

- There are approximately 25,000 species of extant jawed fishes known.
- Pisces are categorized into three main groups: Placodermi (extinct), Chondrichthyes, and Osteichthyes (living).

I. CLASS PLACODERMI (PLATE SKIN):

a) Originating from ostracoderms during the Silurian period, Placoderms became extinct by the beginning of the Mesozoic era.

b) Placoderms are considered the ancestors of modern fishes, particularly Chondrichthyes.

c) Their bodies are shielded by heavy bony armor, which is the characteristic feature giving them their name, 'Placodermi'.

d) The spiracle is represented as a gill.

e) Examples include Bothryolepis and Dunkelosteus.

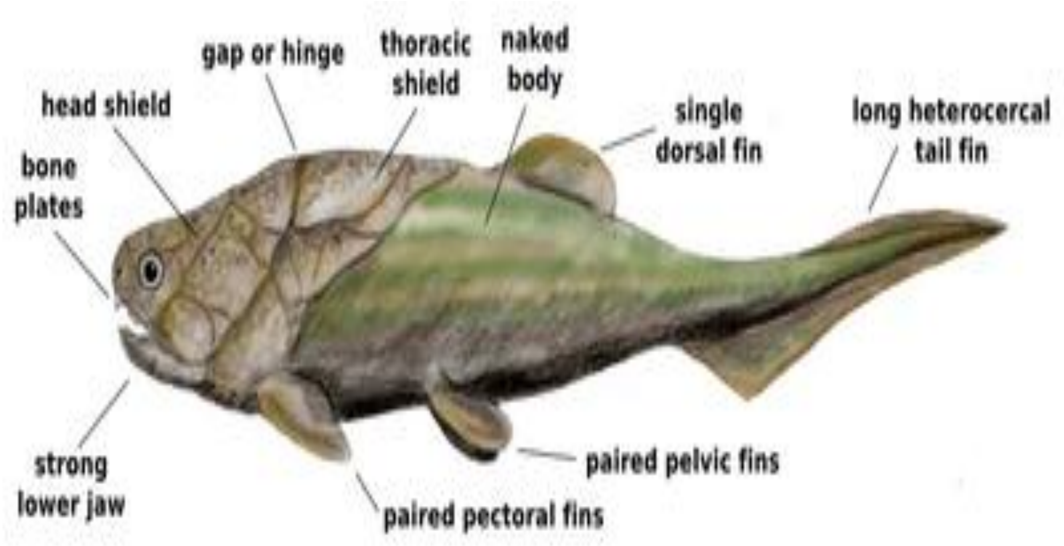


Fig 5.6 Placoderms

II. CLASS: CHONDRICHTHYES

a) Predominantly inhabiting marine environments and exhibiting predatory behavior.

b) The endoskeleton consists entirely of cartilage, lacking true bones

c) The exoskeleton is composed of placoid scales.

d) The caudal fin is heterocercal in shape.

e) The mouth is elongated, crescent-shaped, and positioned ventrally.

f) Gill slits typically range from 4 to 7 pairs and lack an operculum.

g) The gills are lamelliform in structure.

h) The intestine features a spiral valve or scroll valve.

i) Absence of an air bladder

j) The cloaca is situated between the two pelvic fins.

k) These animals are ureotelic. Males possess claspers on their pelvic fins.

l) Fertilization occurs internally.

m) Most sharks and all rays are viviparous and possess a yolk sac placenta. Subclasses of Chondrichthyes include Elasmobranchii and Holocephali.

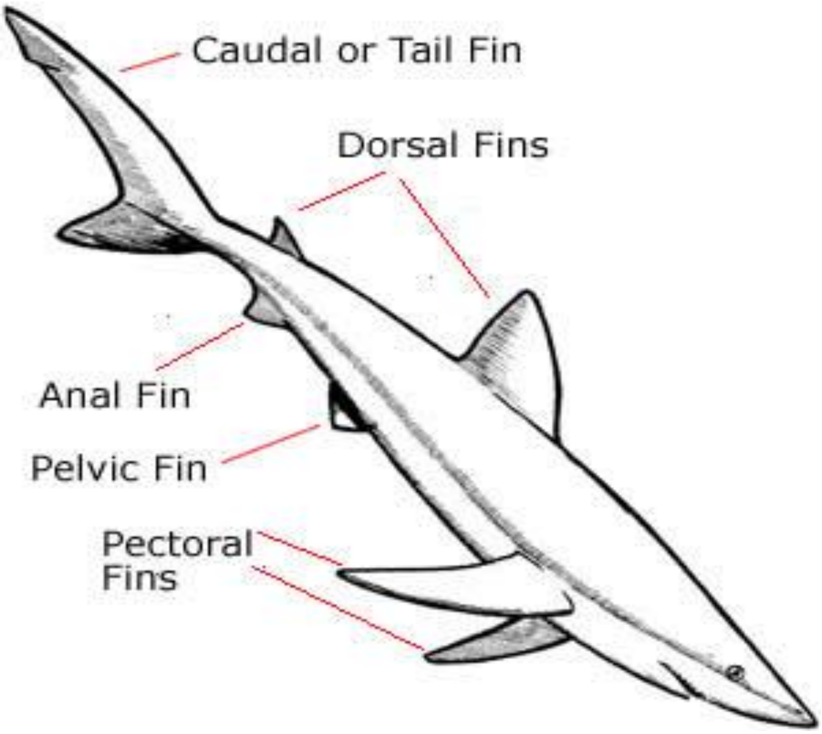


Fig 5.7 Chondrichthyes

III CLASS: OSTEICHTHYES

- These are osteichthyan fishes, inhabiting both freshwater and marine environments.
- Scales come in three varieties: ganoid, cycloid, and ctenoid
- The caudal fin may be either homocercal or diphycercal in structure.
- The endoskeleton primarily consists of bone.
- The mouth is positioned terminally.
- Respiration is facilitated by four pairs of filamentous gills, each covered by an operculum on both sides.
- An air bladder or swim bladder is present in some species, either connected or disconnected from the pharynx. In certain cases, it may resemble a lung.
- The air bladder functions as a hydrostatic organ.

i) Class Osteichthyes is divided into Acanthodii,sarcopterygii and actinopterygii

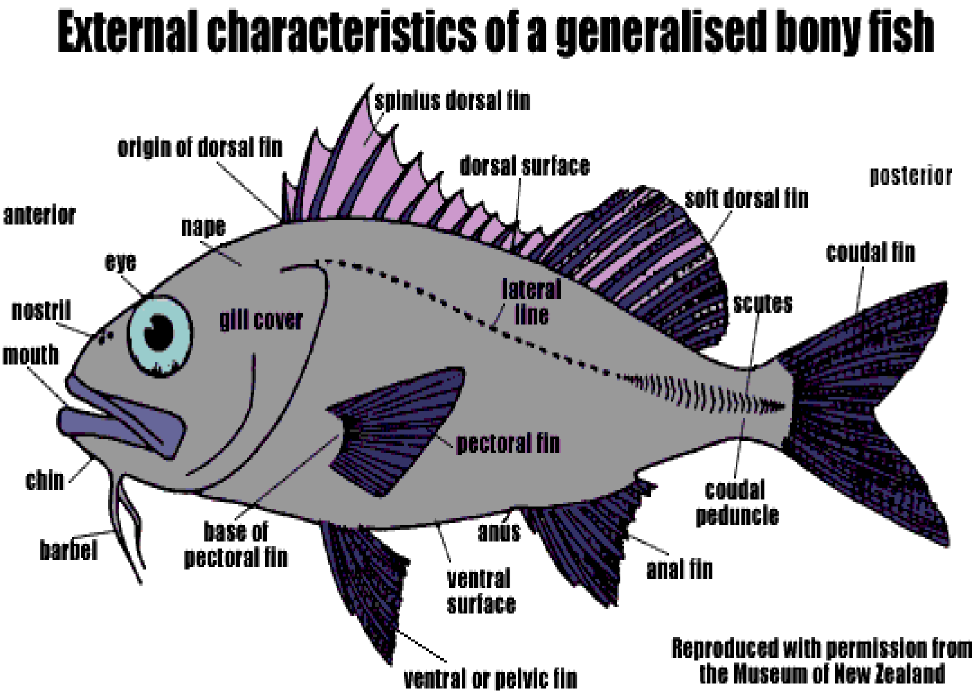


Fig 5.8 anatomy of bony fishes

5.4 ECONOMIC IMPORTANCE OF FISH

- Fish holds immense significance for human nutrition, being a readily available source of highly nutritious protein. In India, a variety of edible fish can be found abundantly in seas, rivers, lakes, ponds, and marshes.
- Apart from food, the fishing industry yields various valuable products and by-products.
- Oil: Extracted from the fatty tissues of fish, two main types are obtained: body oil and liver oil.
- Fish Meal: Derived from fish oil waste, it contains protein, minerals, calcium, phospholipids, and vitamins A, D, K, serving as feed for domestic animals.
- Fish Protein: Obtained by removing fat from fish waste, it finds applications in creams, paints, varnishes, textiles, and cosmetics.
- Fish Flour: Rich in nutrients, it can be utilized in biscuits, bread, cakes, sweets, and soups.

- Fish Fertilizer: Fish and fish waste contribute to fertilizer production, beneficial for tea, coffee, and tobacco cultivation.
- Fish Fins: Fins from large sharks are used in soup preparation.
- Fish Skin: Shark skin, favored by carpenters for smoothing and polishing, is also employed in crafting shoes, handbags, wallets, and tobacco pouches. Dried shark skin, known as shagreen, is utilized for ornamental purposes such as covering card cases and jewel boxes. The skin of large fish serves as leather.
- Fish Glue: A by-product obtained from cod skins, trimmings, and bones.
- Poultry Feed: Residue left after glue extraction is dried and used as feed or fertilizer for poultry.
- Medicinal Uses: Sharks are employed in the treatment of duodenal ulcers. By-products are utilized in treating conditions like night blindness, skin diseases, colds, cough, bronchitis, asthma, and tuberculosis.
- Fancy Articles: The scales of garpike fish find application in jewelry and novelties.
- Scientific Research: Fish serve as valuable experimental animals in genetic studies, embryology, animal behavior, and pharmacology for research purposes.

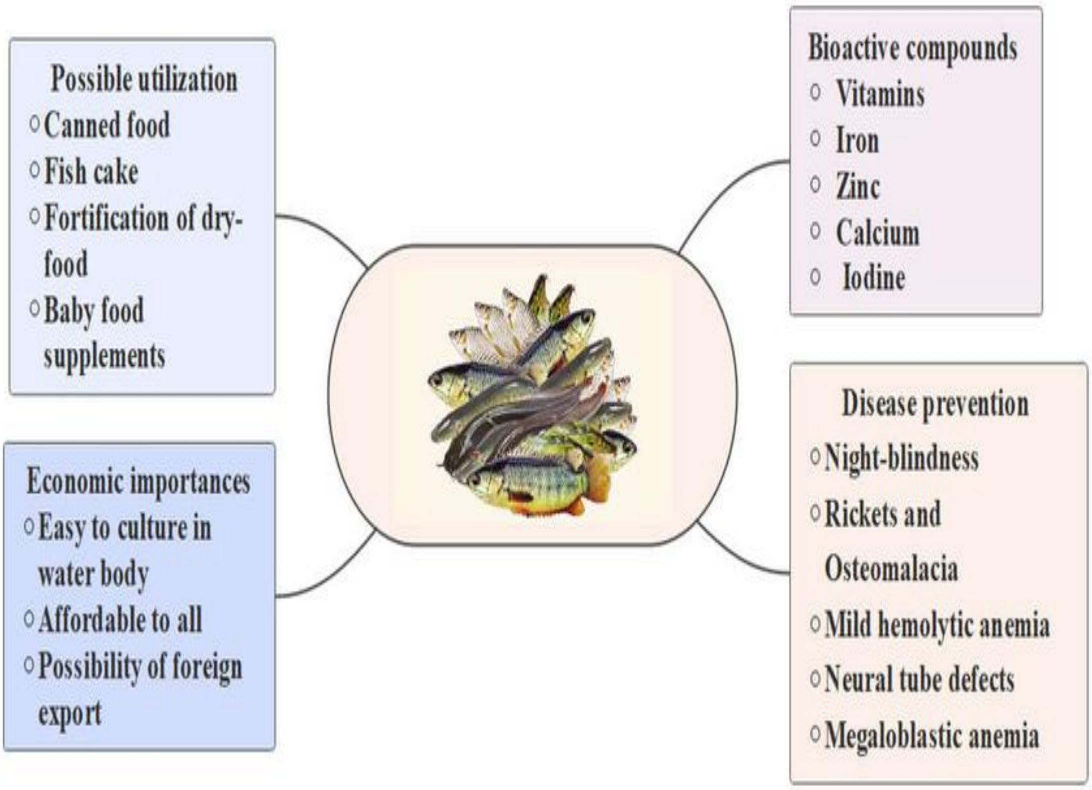


Fig 5.9 Importance of fishes

MIGRATION IN FISH

In ecology, migration refers to the mass movement of animals from one location to another. The reasons for migration vary among different species of animals

Fish exhibit migratory behavior as a regular occurrence, primarily driven by the needs of feeding and reproduction.

5.6 TYPES OF FISH MIGRATION BASED ON NEEDS:

1. **Alimentary or Feeding Migration**

   This type of migration occurs when fish seek new feeding grounds due to the depletion of food resources in their current habitat.

2. **Gametic or Spawning Migration:**

   Fish undertake spawning migration during the breeding season to find suitable spawning grounds for reproduction.

3. Climatic or Seasonal Migration: Fish migrate in search of favorable climatic conditions, especially to avoid extremes of temperature or other environmental factors.

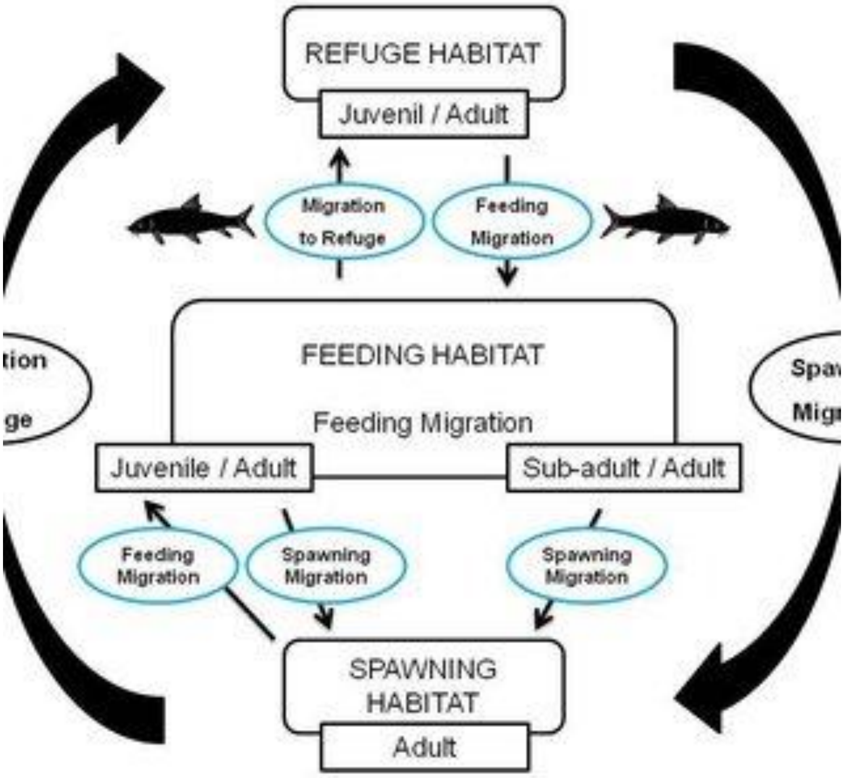


Fig 5.10 Migration

4. Osmo-regulatory Migration: Some fish migrate to maintain water and electrolyte balance, moving between saltwater and freshwater environments as needed.
5. Juvenile Migration: Young fish migrate from their spawning grounds to feeding habitats to ensure their survival and growth.

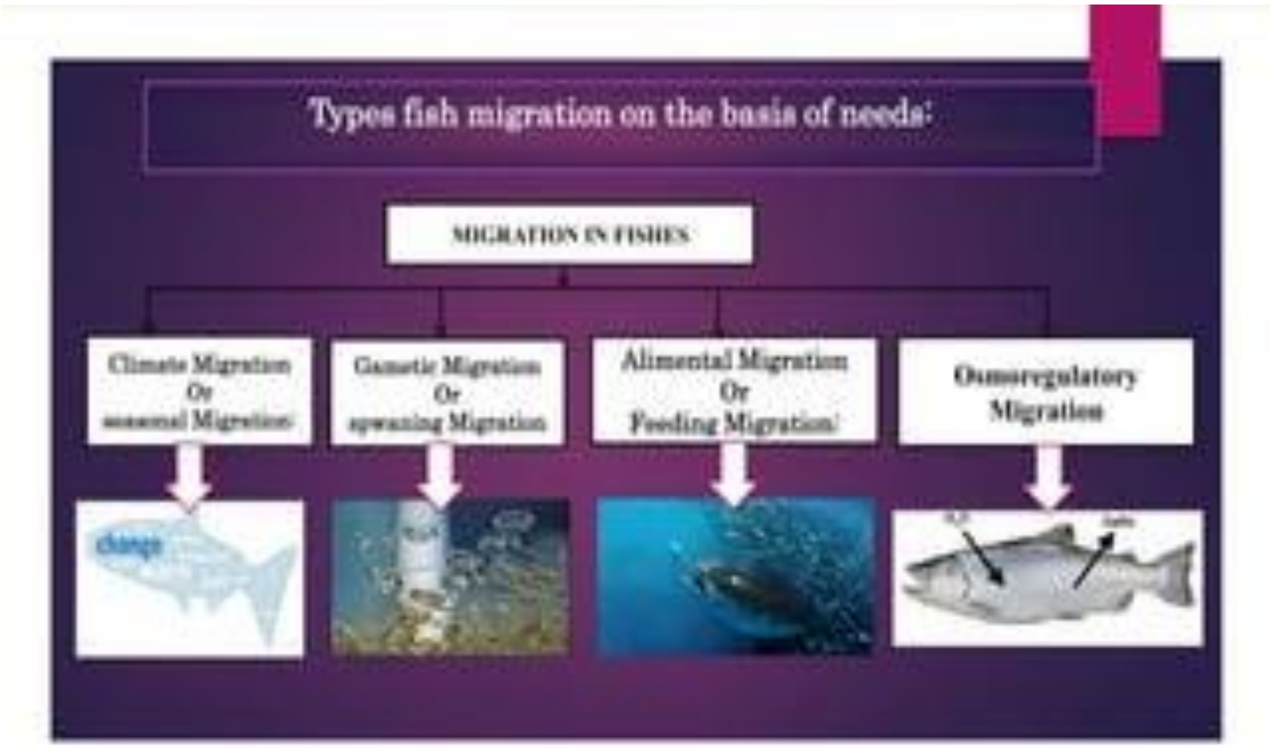


Fig 1.11 types of migration

5.7 MOVEMENT OF FISHES DURING MIGRATION:

1. **Drifting Movement**: Fish passively move along with water currents.
2. **Dispersal Movement**: Fish exhibit random locomotion, dispersing from one habitat to various directions.
3. **Swimming Movement**: Fish display oriented movement towards or away from a stimulus source.
4. **Denatant and Contranatant Movement**: This involves active swimming, with denatant movement occurring with the water current and contranatant movement against it.

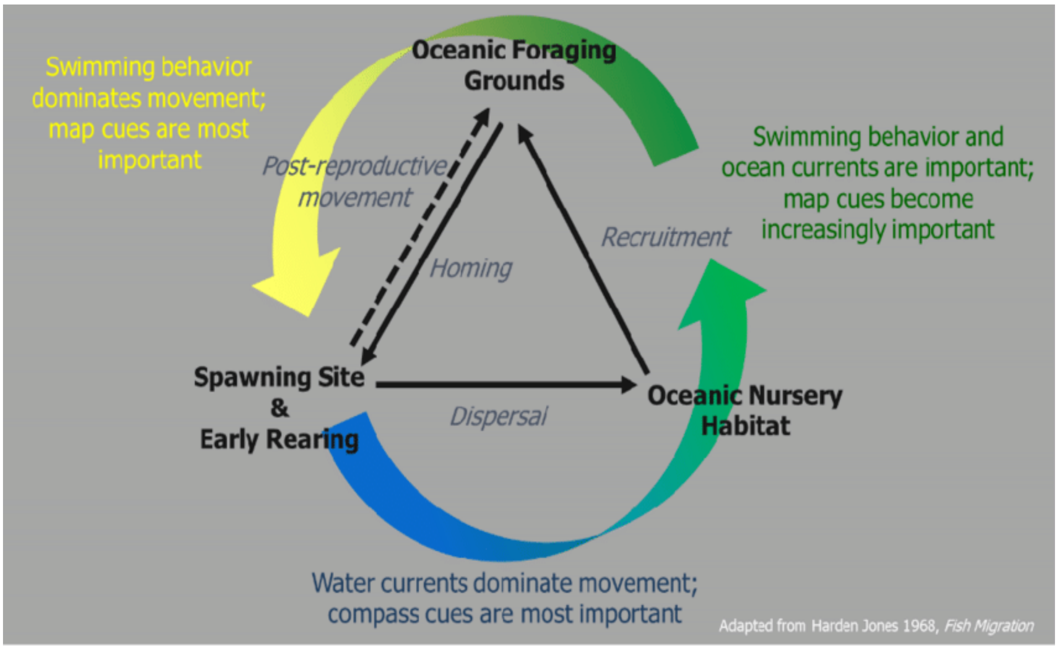


Fig 1.12 movement in migration

5.8 TYPES OF FISH MIGRATION:

1. **Diadromous Migration:**
    - Anadromous Migration: Fish migrate from the sea to freshwater for spawning, such as salmon.
    - Catadromous Migration: Freshwater fish migrate to the sea for spawning, exemplified by eels.
2. **Potamodromous Migration**: Freshwater fish migrate within freshwater habitats for feeding or spawning, like carps and catfish.
3. **Oceanodromous Migration**: Fish migrate within the sea in search of suitable feeding and spawning grounds, including species like herring and tuna.
4. **Latitudinal Migration**: Fish migrate between north and south latitudes based on seasonal changes.
5. **Vertical Migration**: Fish move between deep and surface waters daily for feeding, protection, and spawning.
6. **Shoreward Migration**: Fish temporarily migrate from water to land, although this phenomenon is rare.

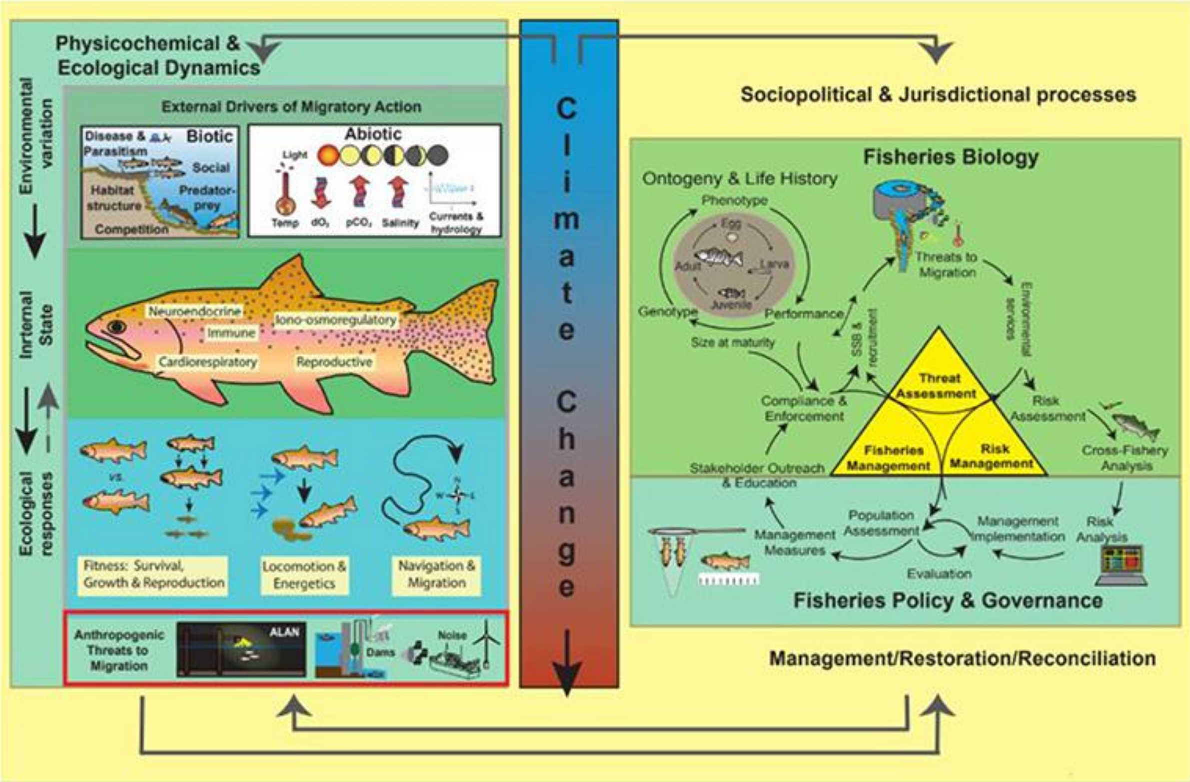


Fig 1.13 **Latitudinal Migration**

SIGNIFICANCE OF FISH MIGRATION:

- Finding suitable feeding and spawning grounds.
- Protection from predators.
- Survival in extreme climatic conditions.
- Enhancement of genetic diversity.
- Adaptational characters for survival and existence.

5.9 PARENTAL CARE IN FISHES

Parental care behavior refers to any behavior exhibited by one or both parents after breeding, contributing to the survival of their offspring.

While fishes as a group generally provide little parental care, there are notable exceptions where eggs and young are guarded diligently, primarily by the male parent.

Various mechanisms have evolved among fishes to ensure the proper development of eggs into adults:

- Scattering Eggs over Aquatic Plants: Eggs are dispersed over aquatic plants, providing attachment surfaces for embryos.

- Deposition of Eggs in Masses: Eggs are laid in masses with special sticky coverings, as seen in some carps.

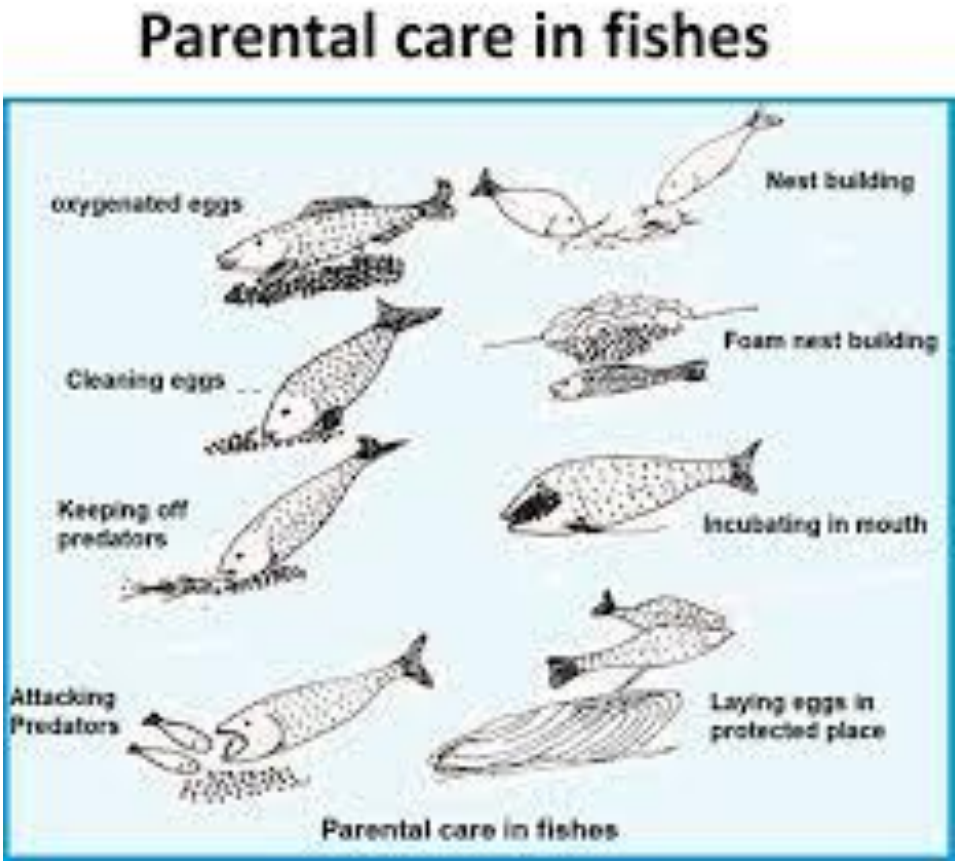


Fig 1.14 parental care in fishes

- Nest Building: Nests are constructed using materials like stones and aquatic vegetation, providing safe environments for egg development.
- Floating Nests: Some fish, like catfish, build floating nests using bubbles and mucus, suspending the eggs within.
- Egg Brooding in Mouth and Intestine: Females of some species, like Tilapia mossambica, brood fertilized eggs in their mouths or intestines, providing protection until hatching.
- Coiling around Eggs: Certain fish, such as the butterfish, roll eggs into a ball and curl around them for protection.
- Attachment of Eggs to Body: Males of nursery fish carry eggs attached to their bodies, aiding in their development.

Fig 1.15 egg deposition by fishes

- Formation of Integument Cups: The skin of some female catfish becomes spongy, allowing eggs to be lodged in small depressions until hatching.
- Deposition of Eggs by Ovipositor: Bitterling females deposit eggs in the mantle cavity of freshwater mussels using an elongated oviduct.
- Viviparity: Some fish exhibit true internal incubation, with embryos obtaining nutrition through yolk sac placentas. This is most common in species like sharks and certain teleosts, enhancing parental care and offspring survival.

Self-Assessment

- **Explain significance of fish migration**
- **Describe Parental care in fishes**
- **What are the General characteristics of chondrichthyes**

UNIT-6

AMPHIBIA ; GENERAL CHARACTERISTICS AND CLASSIFICATION UP TO ORDER; PARENTAL CARE IN AMPHIBIANS

Learning Objectives:

1. Understand the general characteristics of amphibians and their importance in ecological systems.
2. Explore the classification of amphibians up to the order level, emphasizing distinguishing features of each group.
3. Examine the various forms of parental care exhibited by amphibians and their significance in offspring survival.

6.1 GENERAL CHARACTERISTICS:

- Amphibians, the pioneers of terrestrial and aquatic life, exhibit a unique blend of features that enable them to thrive in both environments.
- With a name derived from the Greek roots "amphi" meaning dual or double, and "bios" meaning life, amphibians symbolize their transitional nature between aquatic and terrestrial realms.
- Structurally, they bridge the evolutionary gap between fish and reptiles.
- Amphibians are cold-blooded vertebrates known for their ability to inhabit both water and land.
- They undergo metamorphosis, transitioning from aquatic larvae with gills to terrestrial adults with lungs.
- Found across diverse habitats such as deserts, rainforests, mountains, and woodlands, amphibians play a crucial role as insect predators, contributing to ecosystem balance.

Fig 6.1 Types of Amphibia

Class Amphibia encompasses a group of vertebrates characterized by:

- **Moist Skin:** Thin and moist, facilitating gas exchange through the skin.
- **Metamorphosis**: Transition from aquatic tadpoles to terrestrial adults.
- **Dual Respiration**: Utilization of both lungs and cutaneous skin for respiration.
- **Ectothermy**: Dependence on external sources for temperature regulation.

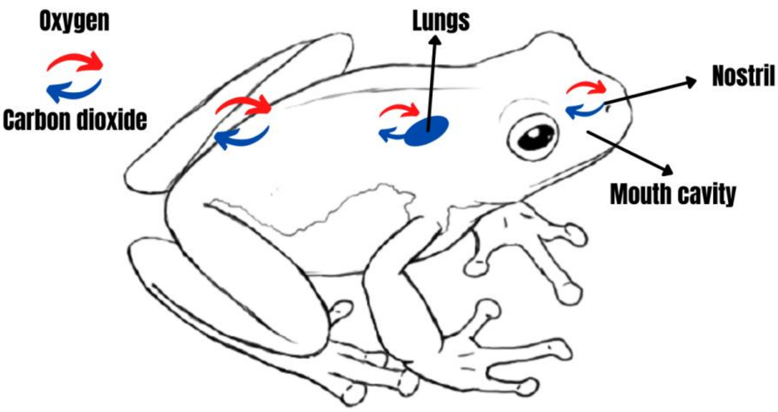


Fig 5.2 respiration

- **Heart**: Possession of a three-chambered heart, distinguishing them from mammals.
- **Larval Stage**: Passage through a larval stage before becoming terrestrial adults.
- **Amphibious Nature**: Ability to survive in water and on land, with a requirement for water during the reproductive cycle.
- **External Fertilization**: Deposition of eggs outside the female's body, fertilized externally by male sperm.

- **Estivation and Hibernation**: Adaptations to survive extreme weather conditions.
- **Carnivorous Diet:** Predatory feeding behavior, primarily targeting insects.

6.2 ANATOMY AND PHYSIOLOGY:

Amphibians possess unique anatomical and physiological adaptations for their dual lifestyle:

- **Skin**: Soft, moist, and glandular, facilitating respiration and gas exchange.
- **Skeleton**: Vertebrates with bone structures and limbs for locomotion.
- **Muscular System**: Powerful hind limbs enabling jumping.
- **Respiratory System**: Combination of lungs and gills, with tadpoles possessing gills and adults utilizing lungs and skin.
- **Cardiac System**: Three-chambered heart with two atria and one ventricle.
- **Digestive System**: Simple digestive tract with a two-chambered stomach.
- **Excretory System**: Waste excretion through kidneys, primarily urea.
- **Reproduction**: External fertilization of eggs.
- **Thermoregulation**: Ectothermic nature, relying on external sources for temperature regulation.
- **Metamorphosis:** Transformation from aquatic larvae to terrestrial adults.
- **Circulatory System**: Three-chambered heart structure.
- **Nervous System**: Basic nervous system comprising a brain and spinal cord.
- **Sensory Organs**: Eyes and ears for environmental perception.
- **Defense Mechanisms**: Presence of poison glands for predator deterrence.

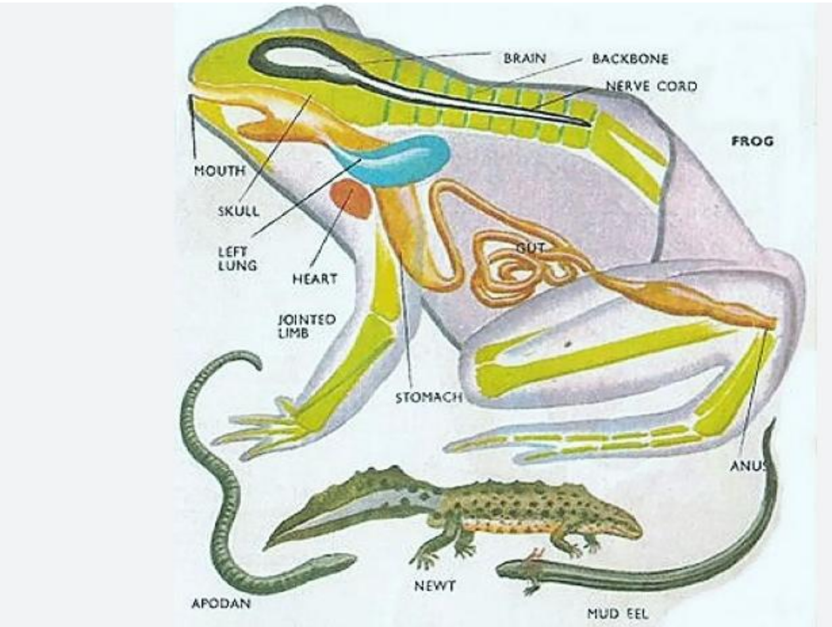


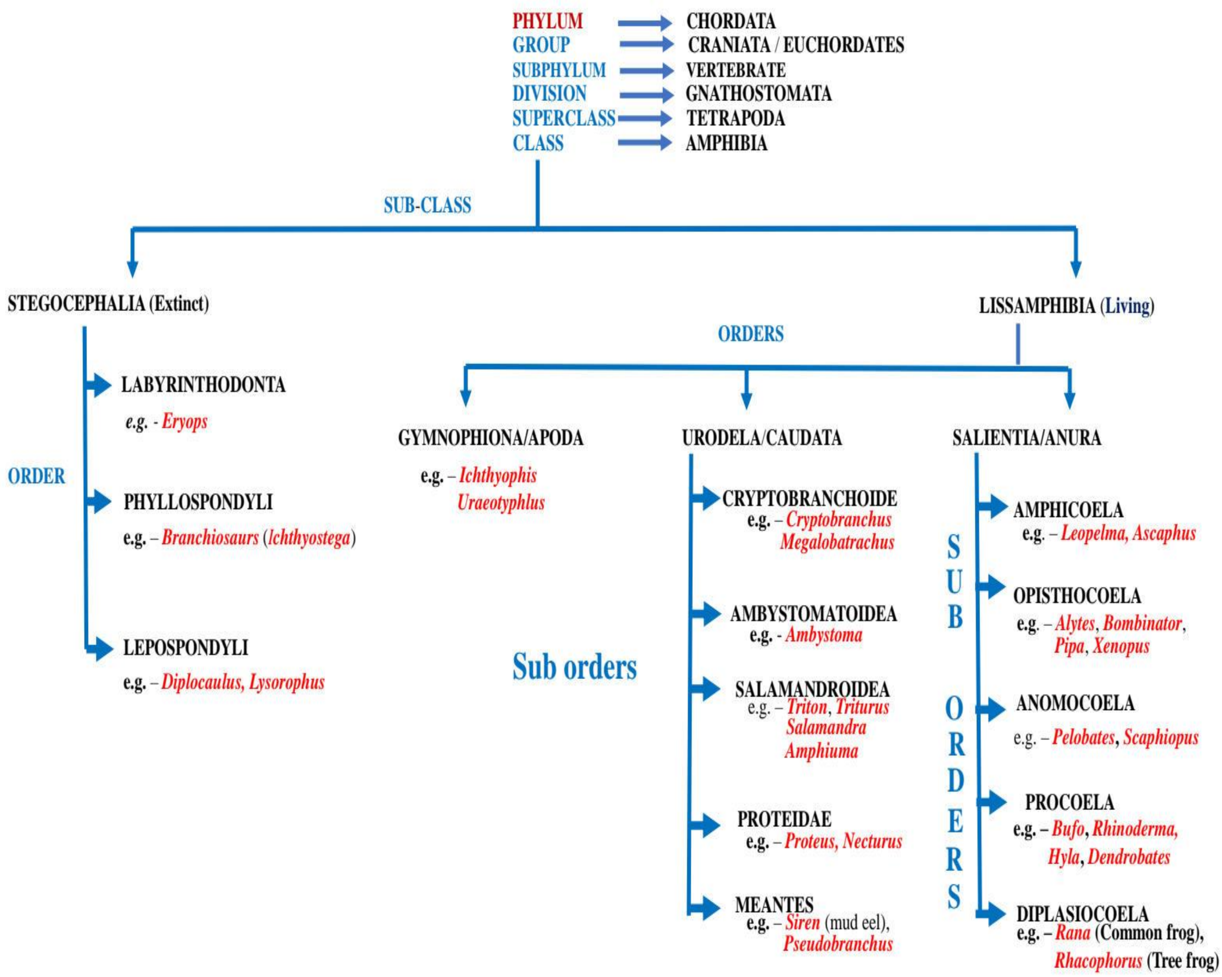
Fig 5.3 anatomy of frog

6.3 CLASSIFICATION:

Amphibians are classified into orders based on key anatomical and physiological characteristics. The main orders include:

- Gymnophiona (Caecilians): Legless, worm-like amphibians primarily found in tropical regions.
- Caudata (Salamanders and Newts): Long-bodied amphibians with tails and four limbs, known for their regenerative abilities.
- Anura (Frogs and Toads): Short-bodied amphibians with hind limbs adapted for jumping, comprising the largest order of amphibians.

Understanding the classification of amphibians up to the order level provides insights into their evolutionary history and ecological significance.



Sub-class: Lissamphibia (Smooth Amphibia)

6.4 GENERAL CHARACTERISTICS:

1. Wide Distribution: Found in tropical and temperate regions globally.
2. Skull Structure: Broad skull with enlarged orbits extending into cheek and temporal regions.
3. Teeth: Fang-like, pedicellate in structure.
4. Vertebrae: Monospondylics lacking separate intercentra.
5. Ear Features: Presence of auricular operculum and columella.
6. Skin Texture: Smooth, scale-less skin with numerous glands.
7. Respiration: Occurs through the skin.

Order-1: Anura (Salientia) General Characteristics:

1. Body Form: Short, stout, four-legged, and tailless.
2. Eye and Ear Features: Well-developed eyelids, distinct tympanum, and large eyes located anteriorly.
3. Mouth Structure: Wide mouth, presence or absence of tongue.
4. Limb Proportions: Posterior limbs longer than anterior limbs.
5. Skull Bones: Frontal and parietal bones fused into a single frontoparietal bone.
6. Dentition: Mandible devoid of teeth.
7. Vertebrae: Typically five to nine pre-sacral vertebrae.
8. Post-sacral Structure: Fusion of post-sacral vertebrae into a urostyle.
9. Fertilization: Generally external, with tadpole larva undergoing metamorphosis into adult form. Examples: Duttafrinus melanostictus, Hyla annectans, Rana tigrina, Rhacophorus malabaricus, Bufo melanostictus.

Order-2: Urodela (Caudata) General Characteristics:

1. Body Form: Lizard-like appearance with distinct head and developed tail.
2. Limb Structure: Two pairs of weak limbs in aquatic forms.
3. Sensory Organs: Small, lidless eyes; eyes may be lost in cave-dwelling species.
4. Circulatory System: Presence of four pairs of aortic arches.
5. Middle Ear Features: Absence of columella.
6. Skull Composition: Occipital region with cartilaginous elements.
7. Dentition: Teeth present on premaxilla, maxillopalatine, vomer, and dentaries.
8. Vertebrae: Amphicoelous or opisthocoelous with ribs.
9. Pectoral Girdle: Simple cartilaginous structure.
10. Reproduction: Generally internal fertilization. Examples: Tylototriton, Ambystoma, Triton, Necturus, Salamandra, Triturus.

Order-3: Apoda (Gymnophiona or Caecilia) General Characteristics:

1. Body Form: Worm-like, limbless burrowing creatures.
2. Skin Texture: Smooth, slimy, segmented by annular grooves with embedded dermal scales.
3. Sensory Organs: Lidless eyes reduced and covered by skin or maxillary bones.
4. Special Appendage: Conical, protrusible sensory tentacle between nostril and eye.
5. Ear Features: Absence of tympanum and tympanic cavity.
6. Tongue: Fused with floor of mouth cavity.
7. Tail Structure: Short and conical if present.
8. Skull Composition: Solid, compact skull with fused maxilla and palatine.
9. Dentition: Teeth on premaxilla, maxillopalatine, vomer, and dentaries.
10. Vertebrae: Amphicoelous with persistent notochord.
11. Pectoral and Pelvic Girdles: Absent, no sternum.
12. Intestine: Straight.
13. Reproduction: External or internal fertilization, large yolky eggs. Examples: Ichthyophis, Uraeotyphlus malabaricus, Gegenophis.

6.5 PARENTAL CARE IN AMPHIBIANS:

Introduction: Parental care in amphibians involves modifications in structure and behavior to ensure offspring survival. This adaptation is crucial for the continuation of the species.

Fig 5.4 parental care

6.6 TYPES OF PARENTAL CARE:

1. Site Selection: Some species protect eggs by choosing suitable nesting sites.
2. Frothing: Certain frogs create frothy water to protect eggs from desiccation and predators.
3. Nest Formation: Amphibians construct nests for egg deposition and development.
4. Egg Carrying: Females may carry eggs on their bodies or in pouches for protection.
5. Larvae Transport: Some species transport tadpole larvae to safer locations.
6. Egg Placement: Eggs may be placed in secure locations, such as inside the mouth or within body cavities.
7. Viviparity: In viviparous species, embryos develop internally, enhancing offspring survival. These forms of parental care are essential for amphibian reproductive success and demonstrate remarkable adaptations in the animal kingdom.

6.7 METAMORPHOSIS OF AMPHIBIA

DEFINITION OF METAMORPHOSIS:

Metamorphosis in amphibians can be defined as a process involving the rapid differentiation of adult characteristics following a prolonged period of slow or arrested development in the larval stage.

According to Duellman and Trueb (1986), it encompasses a radical transformation from larval to adult stage, involving structural, physiological, biochemical, and behavioral changes.

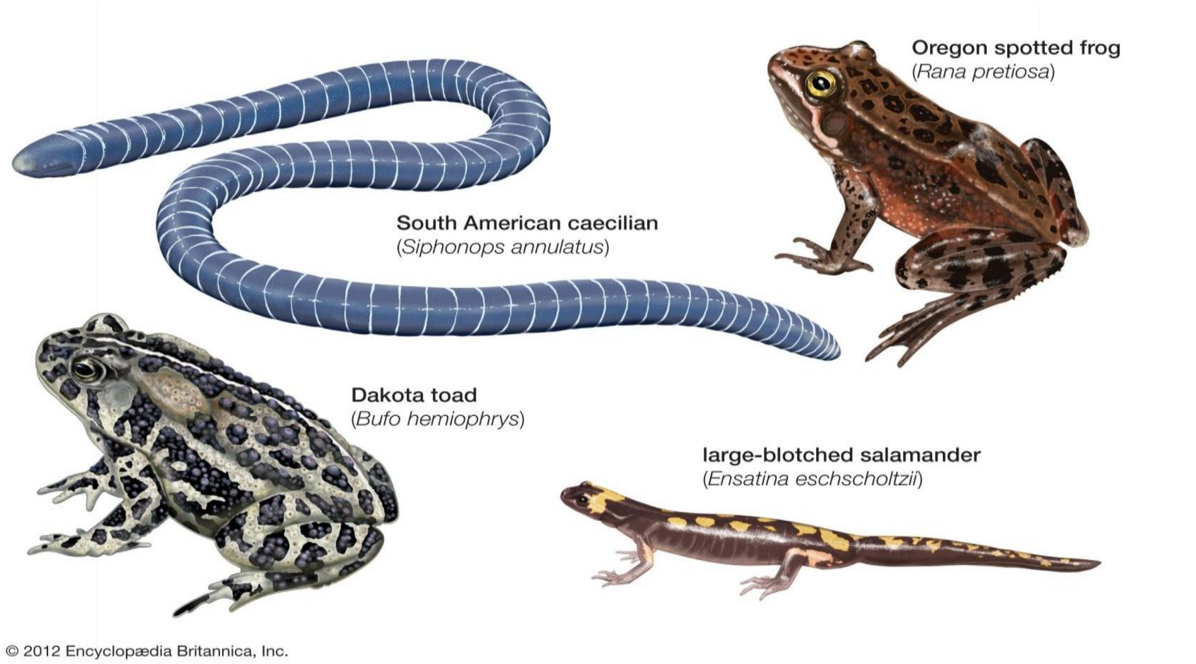


Fig 5.5 Metamorphosis Of Amphibia

6.8 TYPES OF AMPHIBIAN METAMORPHOSIS:

1. Progressive Metamorphosis: In progressive metamorphosis, the animal progresses in evolutionary grades during metamorphosis.
2. This type is commonly observed in most anurans of Amphibia.
3. Retrogressive Metamorphosis: Retrogressive metamorphosis involves a regression or indication of degeneration in the evolutionary scale during metamorphosis.
4. Examples include Ascidia in urochordates or neotenic forms like salamanders.

Metamorphic Changes of Amphibians: Etkin (1968) categorized metamorphosis into three stages: a. Premetamorphic Stage:
This stage is characterized by significant growth and development of larval structures without undergoing metamorphosis.

Prometamorphosis: During this stage, continuous growth occurs, particularly in limb development, initiating metamorphic changes.

Metamorphic Climax: The metamorphic climax stage is marked by radical changes in larval features, culminating in the loss of most larval characteristics.

UNIT-7

REPTILIA GENERAL CHARACTERISTICS AND CLASSIFICATION UP TO CLASSES; POISON APPARATUS AND BITING MECHANISM IN SNAKES

Objectives

At the end of chapter the Students will be have familiarized with

- The general characteristics and categorization of Reptilia
- The origin and evolution of reptiles, A
- quick overview of Seymouria by the end of the chapter.

Around 310 to 320 million years ago, when the planet was poised to enter a protracted dry era, amphibians gave rise to reptiles. Throughout the Mesozoic era, they ruled over animal life.

They can be found in a variety of environments, such as grasslands, marshes, forests, deserts, oceans, and mountains.

Reptiles' capacity to colonize land is aided by their well-developed lungs, which improve breathing in contrast to many amphibians those were using gills and moist skin.

Even while a large number of reptile species have persisted to this day, many others are only known from fossils. The flying pterosaurs, the terrestrial dinosaurs, and the marine ichthyosaurs and plesiosaurs are among the extinct groups.

We frequently come across reptiles, with lizards being the most prevalent kind. Among others is wall geckos, crocodiles, snakes and tortoise.

There are over 5,000 identified species of reptiles in the world today. Poikilothermic (cold-blooded) vertebrates are reptiles. These are the earliest known land vertebrates.

They belong to the first group of animals that have amniotic fluid. They have spread to all three types of habitats: air, water, and land.

It is now undeniably established that reptiles descended from amphibians, which in turn gave rise to mammals and birds. In actuality, the characteristics of reptiles are a blend of those of fish and amphibians on the one hand, and birds and mammals on the other. Reptiles have scales covering their bodies and use their lungs for breathing.

They hibernate in cracks during the winter when they go dormant. Reptile research is well-known as herpetology, For example: Snakes, lizards, turtles and crocodiles.

7.1 General Characterstic of snakes

1. Reptiles are cold-blooded, aquatic or terrestrial, burrowing or creeping creatures.
2. A covering of scales, horny scales, plates, shields, or scutes covers the body of a reptile.
3. The skin and glands of reptiles are dry.
4. Tetrapods, or reptiles.
5. With five fingers and clawed digits, they are pentadactyls.
6. Some snakes and lizards lack limbs.
7. The body is furnished with The head, neck, trunk, and tail are the four areas that make up the bilaterally symmetrical body.
8. The endoskeleton is bony.
9. One medianoccipital tendon connects the skull to the spinal column. (monocondylic).
10. Mandibles composed of numerous tiny parts that articulate via the quadrate bone with the cranium.
11. Invertebrates that are gastrocentrous.
12. Ribs arises fromtrue Sternum Reptiles.
13. There is a distinctive T-shaped interclavicle.
14. Reptiles are Carnivores.
15. Simple, conical teeth in the mouth terminal in position and located on the jaws. Turtles have horny beaks in place of teeth.
16. The gastrointestinal canal closes at a cloacalaperature.
17. Lungs continue to carry out respiration.
18. The heart has two chambers and an incompletely divided into ventricle; in a rare instance, crocodiles have four chambers.
19. The right and left aortic arches are fully formed.
20. Red blood corpuscles are oval and nucleated in reptiles.
21. The brain is more developed than in amphibians, with twelve pairs of cranial nerves present, no lateral line system, and Jacobson's organ located in the roof of the mouth.
22. The excretion is of the uricotelic type.
23. The kidneys in reptiles are metanephric, with separate ureters for each kidney.
24. Animals that are monogamous.
25. Males with hemipenis or a pair of copulatory sacs.

26. The body undergoes internal fertilization. On land, eggs are laid. development-oriented. Children look like adults.
27. The amnion, chorion, allantios, and yolk sac are additional embryonic membranes found in reptiles during the embryo's development.
28. No parental supervision for next generations.

Classification

The class Reptiles is subdivided into five sub-classes according to the existence or lack of specific holes in the temporal region of the reptile skull as shown in Figure 7.1. About 7000 extant species, grouped into 4 of the 16 orders that were active throughout the Mesozoic epoch, serve as its representative. The last orders exist no more.

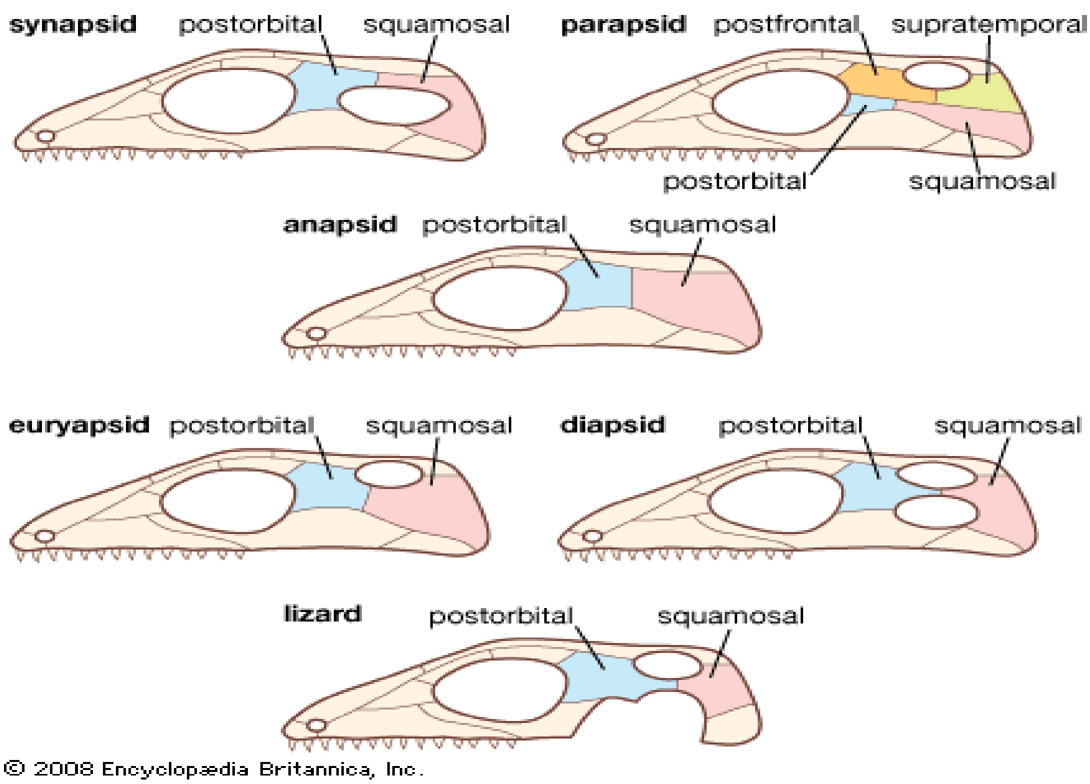


Figure 7.1: Skull and its types in Reptiles

The Class Reptilia is composed of four orders as in Fig 7.2

Order 1. Testudinata or Chelonia (turtles)

Order 2. Rhynchocephalia (Tuataras).

Order 3.Squamata (lizards and snakes).

Order 4. Crocodilia (crocodiles and alligators)

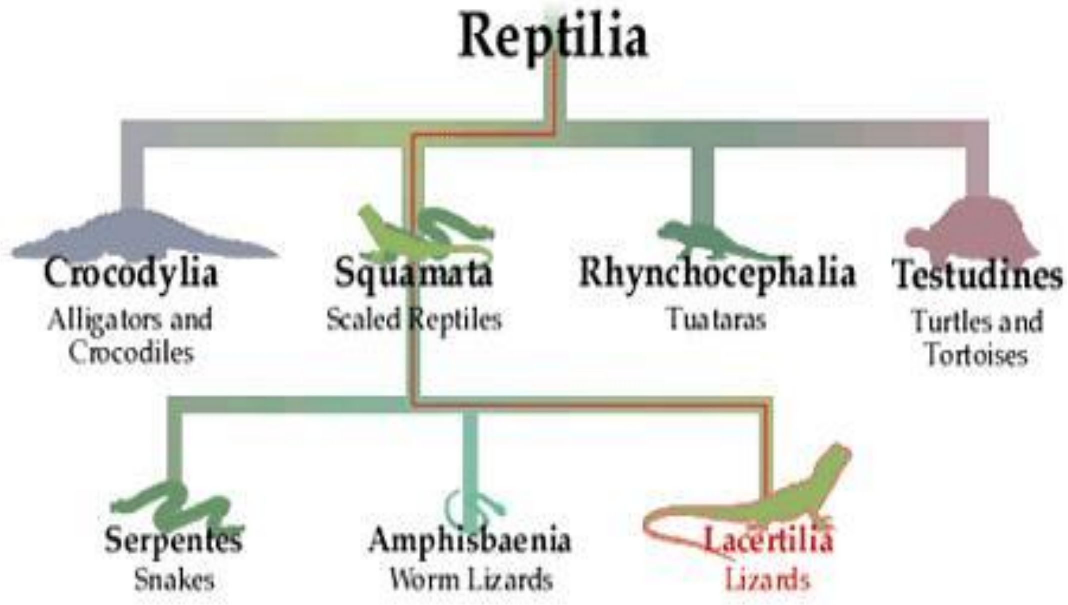


Figure 7.2:Taxonomic position of Reptiles

Subclass I: ANAPSIDA

The absence of temporal holes and the solidity of the skull's roof. Apsid skulls are found in two primary orders: the extinct Cotylosauria and the living Chelonia.

First Order: Cotylosauria

1. The order is extinct. It is believed that they existed from the Carboniferous to the Triassic.
2. They have similarities to Labyrinthodon frogs.
3. The limbs are weak and extend laterally.
4. Poorly formed jaws and teeth.

Examples are Camptorhinus and Seymouria.

Order 2: Testudinata (L., testudo, turtle) or Chelonia (Gr., chelone, turtle)

1. These animals have existed since the Pleistocene.
2. Short, broad, oval body covered in a flat ventral plastron and rounded dorsal carapace shell.
3. Limbs: pentadactyle with webbed, clasped, or paddle-like fingers.
4. Usually, the ribs and thoracic vertebrae merge with the carapace.
5. Absent sternum, quadrate immobile, skull solid.
6. A horny sheath covering a jaw without teeth.
7. There is a longitudinal cloacal aperture.
8. A solitary copulatory organism.

9. Turtles are marine animals, terrapins are freshwater animals, and tortoises are land animals.
Examples include Testudo, Dermachelys, Trionyx, Chrysemys, and Chelone.

Subclass II: EURYAPSIDA (Extinct)

A single dorso-lateral temporal aperture on either side of the skull, located above the eye, is surrounded by the parietal bone above and the supratemporal and postfrontal bones below.
They were alive throughout the Triassic era.

Subclass III: PARAPSIDA (Extinct)

1. A single dorso-lateral temporal aperture on each side of the skull.
2. The supratemporal and postfrontal bones encircle these holes below.
3. They were alive from the Mesozoic to the Cretaceous.
4. Ichthyosaurus, Mixosaurus, and so forth.

Sub-class IV: SYNAPSIDA (Extinct)

1. Gone.from Permian to Caroliferous.
2. A single lateral temporal aperture on either side of the skull.
3. The jugal portion of the squamosal bones below and the postorbital and squamosal bones above both encircle these holes.
4. A single lateral aperture on either side of the skull behind the eye, surrounded by the squamosal bones of the post-orbit above

Order 1. Pelycosauria (=Theromorpha)

Examples :Varanosaurus, Dimetrodon.
Order 2. Mesosauria
Example :Mesosaurus.

Sub-class V: DIAPSIDA

Skull with two temporal apertures on either side, divided by a bar made up of the squamosal and postorbital bones.
There are four orders in this category.
Order 1: Eosuchia is extinct (Eocene to Permian).
Prolacerta, Youngina are two examples

Order 2: Rhyncocephalia (Gr., kephale, head + L., rhynchos, snout).

1. Small, lengthy, elongated bodies resembling lizards that burrow.
2. Legs clawed and digging, pentadactyle.
3. Skin with a dorsal row of spines and covered with granular scales.
4. Vertebral oval, elongated, and cavernous.
5. Many abdominal ribs are visible.
6. Ribs are unruly, single-minded, and lack procedure.
7. The parietal foramen has vestiges of the spine.
8. Quadratebone inert.
9. The dental arch.
10. Diagonal slit in the cloacal aperture
11. Males do not have copulatory organs.

Representative organism Sphenodon punctatum

Order III: Squamata (L., squama, scale)

1. Contains snakes and lizards.
2. Land, burrowing, or forest animals.
3. A horny epidermal covering with scales and shields.
4. Some lizards and snakes have limping, missing limbs.
5. Girdles and limbs are often well-developed.
6. Moveable quadrate. Vertebroecollagenous. ribsingle-headed.
7. A single occipital tendon in the skull.Jugalbone is in attendance. Sternum at now 8
9. Removable eyelid. There is a tympanum, ear apertures, and nictitating membrane.
10. Pterygoids, palatines, and maxillae fixed. The mandible's two rami united in front. Teeth are held by premaxillae.
11. Aprodont or pleurodont teeth.
12. Displays regeneration and caudal autotomy.
13. The bladder is in place.
14. Transverse cloacal aperture.
15. Eversible and paired copulatory organ.

Gecko, Mabouia, Iguana are examples

Order IV: Crocodilian (Gr., krokodeilos, crocodile)

1. Large, aquatic, carnivorous reptiles with a long tail that is compressed laterally and a denticulated dorsal crest on top.

2. Short but strong limbs with four webbed and clawed digits on the hindlimbs and five on the forelimbs, adjusted for swimming.

3. Strong, lateral compression, and taillong.

4. Horny epidermal scales, bony plates, and scutes cover the body surface.

5. Parietal foramen missing, quadrate fixed. A pseudopalate is formed by the union of the maxillae, palatines, and pterygoid along the midline.

6. Several teeth of the codont.

7. Procoelous vertebrates. Sternum at now 8.

9. There are abdominal ribs.

10. Bilateral ribs.

11. Uncinate process in the thoracic ribs.

12. The heart is made up of two ventricles and two auricles, or four chambers.

13. Spacious and well-developed lungs.

14. An extended cloacal aperture.

15. Male with a single median, erection, and a penis groove**.**

   1. Crocodylus, Alligators (Fig 7.3)

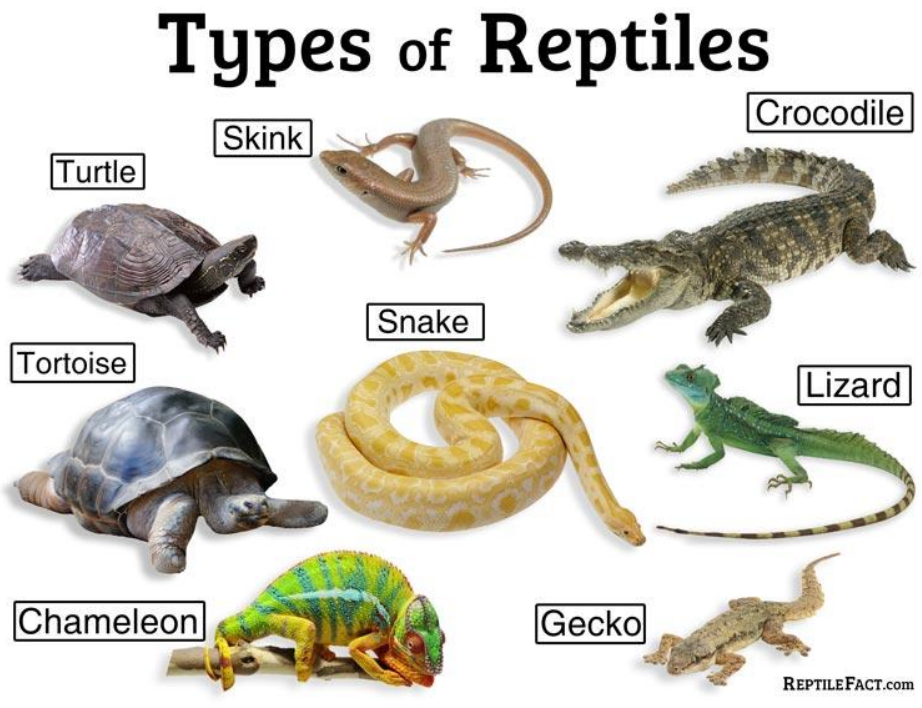


Fig 7.3: Types of Reptiles

7.2 SNAKES AND SNAKE BITES

Every continent, with the exception of Antarctica, has snakes. Snakes are amazing creatures that thrive in woods, meadows, lakes, seas, deserts, and forests. Without being provoked, most snakes do not behave aggressively toward people. As carnivores, snakes consume meat and their food can include insects, birds, small animals, and other reptiles, occasionally even other snakes. Out of the 3,000 snake species found globally, only about 400 are venomous. The number of species gradually decreases as one moves across the polar regions.

There are just 330 species in India, and only 69 of those are toxic. Many snakes use constriction to kill their prey. When a snake constricts its victim, it suffocates them by tightly grasping their chest and stopping their breathing or immediately causing cardiac arrest. It is not how snakes murder their prey. Certain snakes use their fangs to seize their meal and then finish it off. Snakes have a frigid heart. As a result, in cold weather, they are unable to stay active and raise their body temperature. Although the exact number of snake bite deaths is unknown, the World Health Organization reports that between 30,000 and 40,000 people worldwide may away from snake bites each year.

The prevalence of snakebite increases in tropical areas especially in agricultural lands.

Venom is injected by poisonous snakes through altered salivary glands. A snake bite that injects venom or poison into its victim is known as envenomation.

The venom enters the snake's mouth through a duct during envenomation, where it then enters the victim. Not every bite results in envenomation.

Snakes have the ability to control when and how much poison they discharge. A dry bite, which makes up between 25% and 50% of all snake bites, is one in which the snake does not inject venom.

This variation varies by species; up to 50% of bites from coral snakes and about 25% of bites from pit vipers are "dry" bites. Snake venom is a mixture of many chemicals with different properties.

Mechanism of biting

A pair of poison glands, their ducts, and a pair of fangs make up a snake's poison apparatus. Poison glands are located on either side of the upper jaw in snakes that are toxic.

The modified salivary glands that produce poison are thought to be parotid or superior labial glands. Every poison gland has a small duct at the front end and resembles a bag.

The duct opens at the base of the fang or at the base of the tunnel on the fang after passing ahead along the side of the upper jaw, looping over itself just in front of the fang.

These glands are located on either side of the skull and are encircled by muscle. When the glands contract, the venom, which can be clear or yellowish, is forced through the fangs and along venom channels before squirting out under pressure like it would from a pair of hypodermic syringes. Every potential set of successive bites could result in an injection of venom. Curiously, though, venom is not usually administered.

Ligaments keep the poison gland in place. The anterior end of the gland is attached to the maxilla by an anterior ligament. A ligament that runs posteriorly connects the gland to the quadrate.

Ligaments in the shape of a fan are located between the squamoso-quadrate junction and the side walls. The fangs are larger maxillary teeth with sharp tips. If a fang is gone, it grows back.

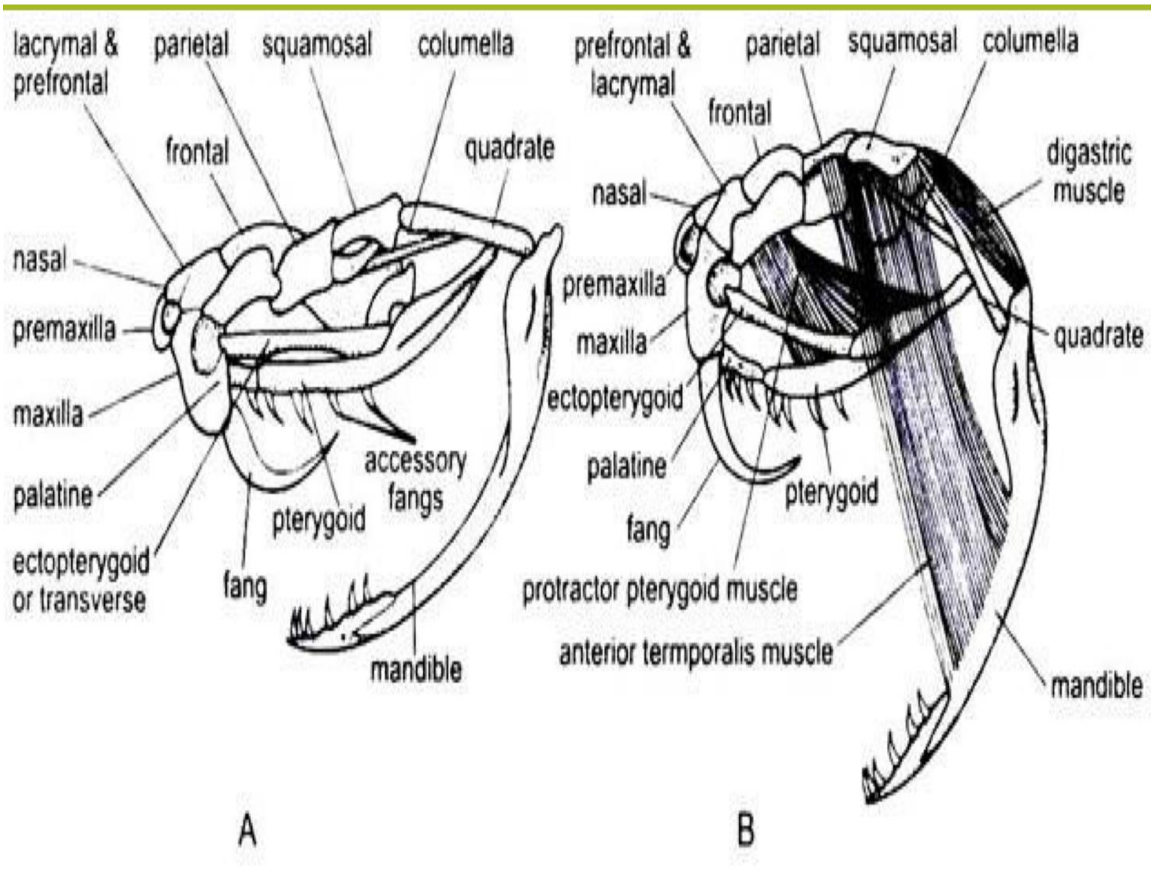


Figure 7.4 A. Snake's mouth in resting phase. B. Mouth of Snake while biting

The biting apparatus of a snake had following parts(Fig 7.4)

1. Poison glands
2. Poison ducts
3. Poison teeth or Fangs

Poison Glands

On either side of the upper jaw, there is a single pair of poison glands. Actually, the parotid glands are the poison glands. The look of each poison gland resembles a sac.

There are ligaments holding them in place. The gland and maxilla are linked by means of the anterior ligament. The quadrate and the gland are separated by the posterior ligament.

Fan-shaped ligaments are also located between the squamoso-quadrate junction and the side walls in addition to these.

Poison Duct

At the front part of each poison gland, there is a short duct that runs along the side of the upper jaw, loops over itself, and opens at the base of the fang.

Poison Fangs

Its front face has poison fangs. Examples include sea snakes, kraits, and cobras.The upper jaw has a single set of fangs. These are enormous, extremely pointed, and sharp maxillary teeth. When lost for any reason, there is a huge power of regeneration. The following categories can be applied to the fangs based on their arrangement and structure as shown in Fig

Proteroglyphous type:

Stenoglyphous type:

Opisthoglyphous type

Aglyphous type:

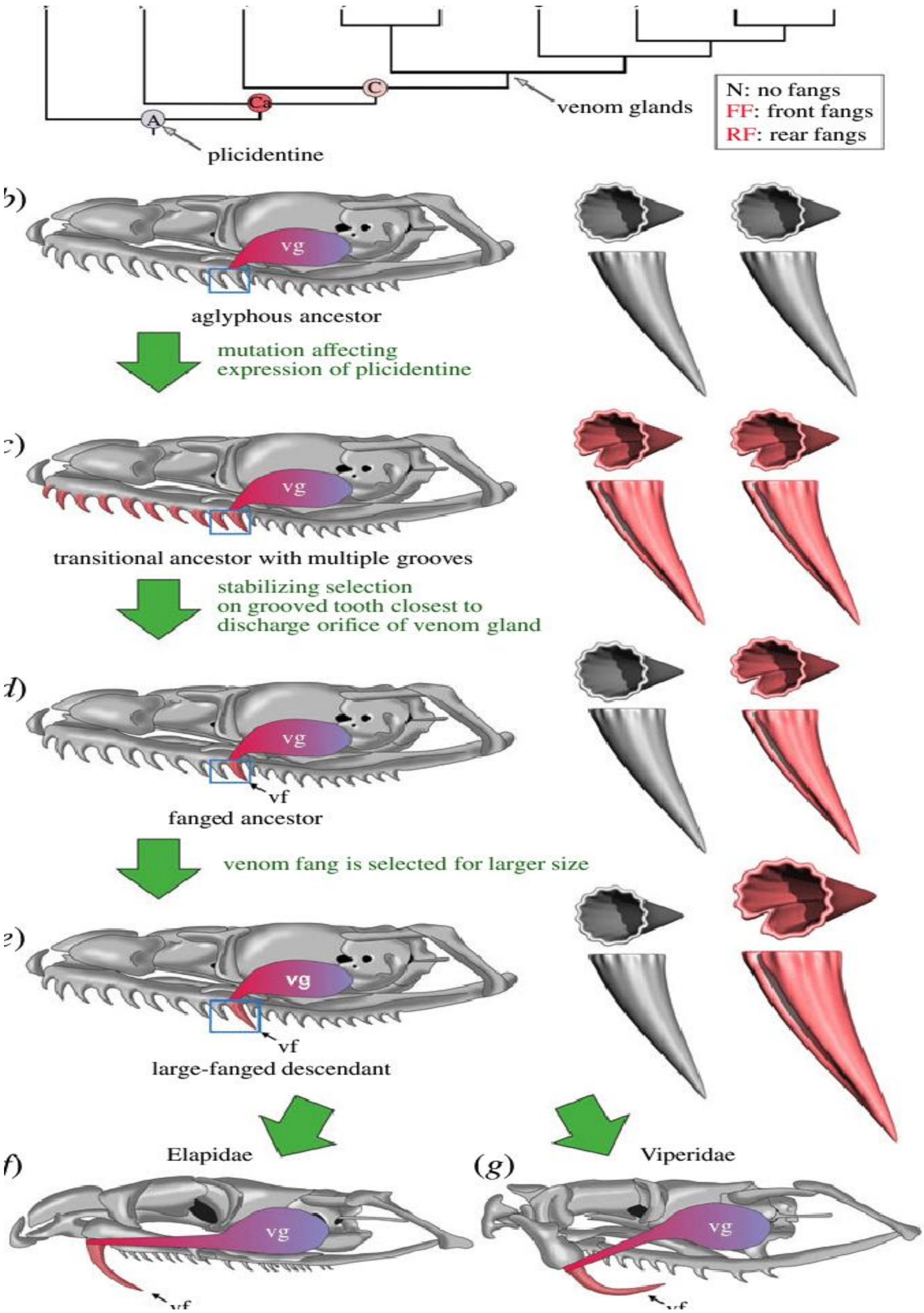


Fig 7.8 Types of Fangs in different snakes

Self-Assessment Question

1. Describe the traits that set Reptilia apart.
2. List the key characteristics together with instances from different Reptilia subclasses.
3. What are stem reptiles, in your opinion?
4. Describe the anatomy, physiology, and life cycle of pelagic and sessile tunicates, Doliolum
5. Sketch a diagram of a snake's poisonous gear.
6. Describe how reptiles came to be.
7. Explain the composition and mode of action of a snake bite.
8. Write about how to treat a snake bite.
9. Explain the safety measures used in case of a snake bite.
10. Compose a paper on venom from snakes.
11. Describe how anitsera is made.
12. Briefly describe the symptoms and indicators of a snake bite.
13. Compose a little essay about Seymouria.
14. List the different parts of snake venom.

UNIT-8

AVES GENERAL CHARACTERISTICS AND CLASSIFICATION UP TO CLASS. ARCHAEOPTERYX--A CONNECTING LINK

Objectives

By the end of the chapter, the learner with:

- The general characteristics and classification of aves,
- Their origin and evolution,
- A quick overview of the origin and evolution of birds from reptiles,
- The types and causes of avian migration.

Reptiles gave rise to birds during the Mesozoic era. It is believed that birds descended from a subclass of reptiles that belonged to the greater archosaur group of ancient diapsid reptiles. Although they appear to be very different from one another, closer inspection shows that birds and reptiles are actually very similar.

Given the close similarities between reptiles and birds, it is assumed that birds are descended from them. These two groups of vertebrates were combined into a single superclass, Sauropsida, by Huxley. Huxley said, "Birds are glorified reptiles," despite the fact that they are more advanced in terms of organization than reptiles.

Among vertebrates, birds are a specialized group. According to Young (1958), birds are "the masters of air." There are birds everywhere on Earth.

Currently, there are about 9700 different species of birds, with the majority having a high level of recognition. About 5000 of the 9700 species are members of the Passeriformes order, which includes songbirds and perching birds.

Modern birds are warm-blooded animals that belong to a class of vertebrates that includes bipedalism, feathery extremely high metabolic rates, and a forelimb that has been transformed into a wing that works in tandem with a long tail to facilitate flight.

The once toothed jaws of birds are altered into a lighter beak with horny rhamphotheca covering the top and lower jaws. Depending on the species of bird, this horny rhamphotheca may serve a variety of purposes depending on feeding patterns.

Only birds have feathers. Birds' feathers are filamentous, light adaptations of their skin with exceptional aerodynamic properties.

By producing lift and power, feathers serve as flight structures. They also function as a body cover that regulates body temperature. The pygostyle, a unique bone made up of several fused tail vertebrae, is where modern birds connect their tail feathers.

The uropygial gland, commonly known as the oil gland, is a crucial anatomical component that is housed in the pygostyle.

The modern bird joins its tail feathers to its pygostyle, a unique bone composed of multiple fused tail vertebrae. The pygostyle contains the uropygial gland, also referred to as the oil gland, which is an essential anatomical component. Birds have wishbones, or furcula, composed of joined clavicles, lightweight hollow bones, a hand with only three fingers, and a well-developed air sac and flow-through lungs.

Birds lay eggs that they either incubate themselves until they hatch or, in certain situations, enlist the help of another bird to do so. Certain species, like our songbirds, have helpless, naked young that need to be fed and looked for by a parent bird. They still rely on adult birds for safety.

Birds come in a variety of sizes; from ostriches the size of enormous to hummingbirds the size of thumbs. Birds are able to fly, cling, hop, swim, perch, and even burrow. They can be found in farms, open spaces, cities, woods, lakes, wetlands, and even the open sea.

They use a variety of habitats to raise their young, including holes in the ground, nest boxes made by humans, holes in trees, and different areas of structures. They also lay their eggs in these habitats and rear their young there.

Different foot adaptations are also seen in birds. Birds have highly developed auditory and visual senses. Although certain birds have a keen sense of smell, the sense of smell (olfaction) is not one of their strongest senses. The respiratory system of birds is highly developed.

8.1 General Characters of Aves

1. The feathers cover the spindle-shaped body, which is divided into four sections: the head, neck, trunk, and tail.
2. These are oviparous, warm-blooded, bipedal, flying vertebrates that breathe air.
3. The jaws are altered to resemble a toothless korbill.
4. There are two sets of limbs on the birds. For flying, the forelimbs are transformed into wings. Walking, running, perching, swimming, and other activities are all possible with the hind limbs. They have four clawed digits; the first, called the hallux, points backward, while the other three point forward.

5. The epidermal exoskeleton of the body takes the shape of scales on the legs, claws on the toes, horny sheath on the beak, and feathers covering the body.

6. Apart from the oil or preen gland at the base of the nose, the skin is dry and lacks skin glands.

7. The pneumatic bones that make up the endoskeleton are hollow and devoid of bone marrow. The body is light in weight as a result.

8. The cranium is smooth, with a single occipital condyle, diapsid-type sutures, and monocondylic structure.

9. The mandible, or lower jaw, articulates with the quadrate and is made up of five or six bones.

10. The heterocoelous centrum of vertebrae exists. Long neck means many cervical vertebrae.

11. The posterior thoracic, lumber, sacral, and anterior caudal vertebrae fuse to produce the bony structure known as the synsacrum, which is found in the spinal column. The pygostyle, or "ploughshare bone," is created by the fusion of the final three or four caudal vertebrae.

12. The big sternum has a keel on which the muscles used for flight are attached.

13. The ribs have two heads, or are bicephalous, and each one has an uncinate process that points backward.

14. A robust coracoids and a scapula with a sabre-like form make up the pectoral girdle. When the two sides' clavicles unite, a V-shaped bone known as furcula.

15. The synsacrum and the massive, robust pelvic girdle are fused together. The acetabulum has a hole in it.

16. The carpometacarpus, a fusion of three metacarpals, makes up the distal carpals. Carpals at the proximal end are free.

17. To produce the tibio-tarsus, the proximal tarsals fuse with the tibia. Tarso-metatarsus is formed when the distal tarsals unite with II, III, and IV metatarsals. One metatarsal is still free. Ankle joints are inter-tarsal joints.

There are four chambers in the heart.

19. There is no truncus arteriosus or sinus venosus. Only the right systemic arch endures; the left one vanishes. Red blood cells are formed by nucleation.

20. The lungs have thin-walled air sacs and are small, spongy, and non-distensible.

21. The larynx lacks vocal cords. There is a syrinx, or sound box.

22. There is no urine bladder and the kidneys are three-lobed and metanephric.

23.Birds are Uricotelic.

24. A well developed brain that includes the optic lobes, cerebellum, and brain stem.

25. The cranial nerves are divided into twelve pairs.

26. Vascular pectin is present in the sclerotic plates that round the eyes.

27. There is reduced development in the olfactory organs.

28. The cloaca of the birds have three chambers.

29. Female birds have a single ovary and oviduct; birds are unisexual and exhibit sexual dimorphism. Males lack copulatory organs, with the exception of ducks and ratitae.

30. Internal fertilization occurs.

31. Oviparous animals are birds.

32. Direct body development occurs.

33. The amniotic and cleidoic eggs need external incubation to develop.

34. The cleavage is meroblastic and discoidal.

35. Four extra-embryonic membranes that serve distinct purposes arise in the embryo.

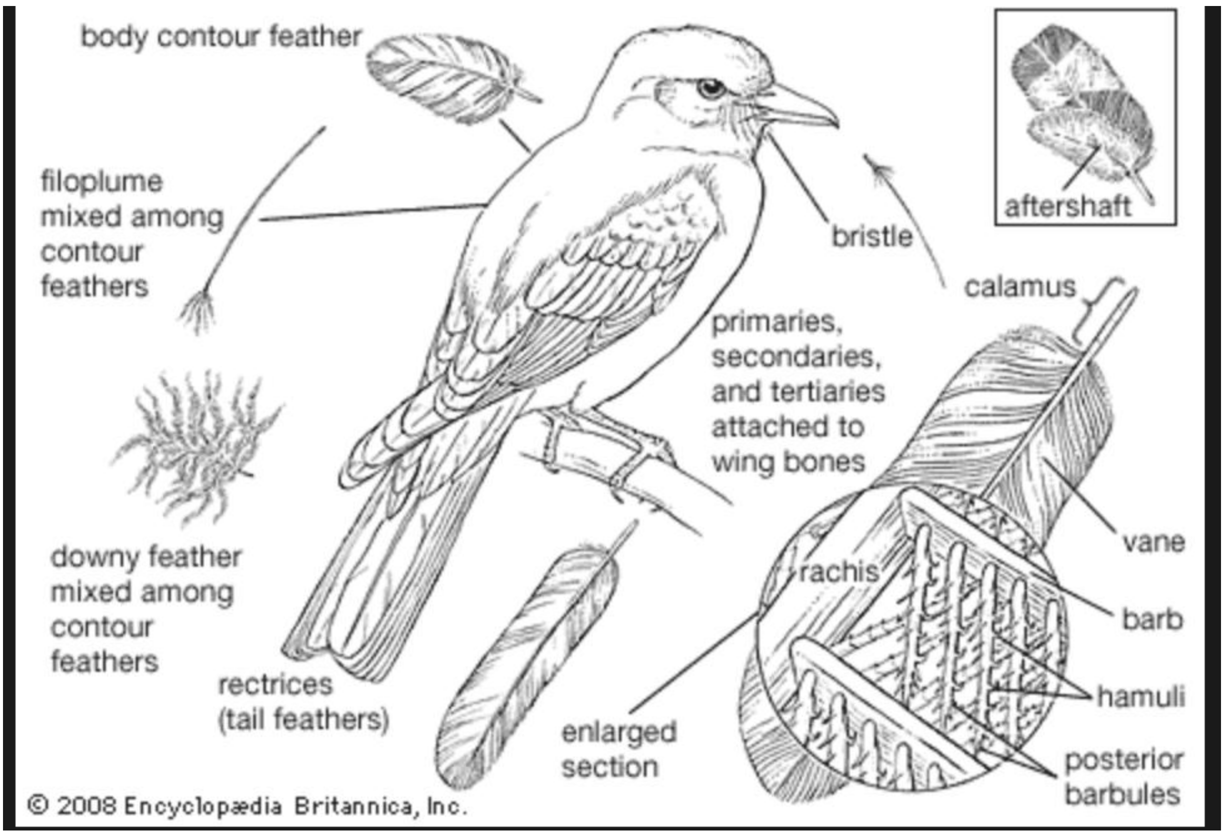


Fig 8.1

8.2 CLASSIFICATION

Birds are classified based on physiological similarities across species, and more recently, genetic makeup has also been taken into account. Carl Linnaeus is credited with creating the categorization system. The number of extant bird species is approximately 9000.

Archaeornithes and Neornithes are the two subclasses that make up the class Aves (Fig 8.2)

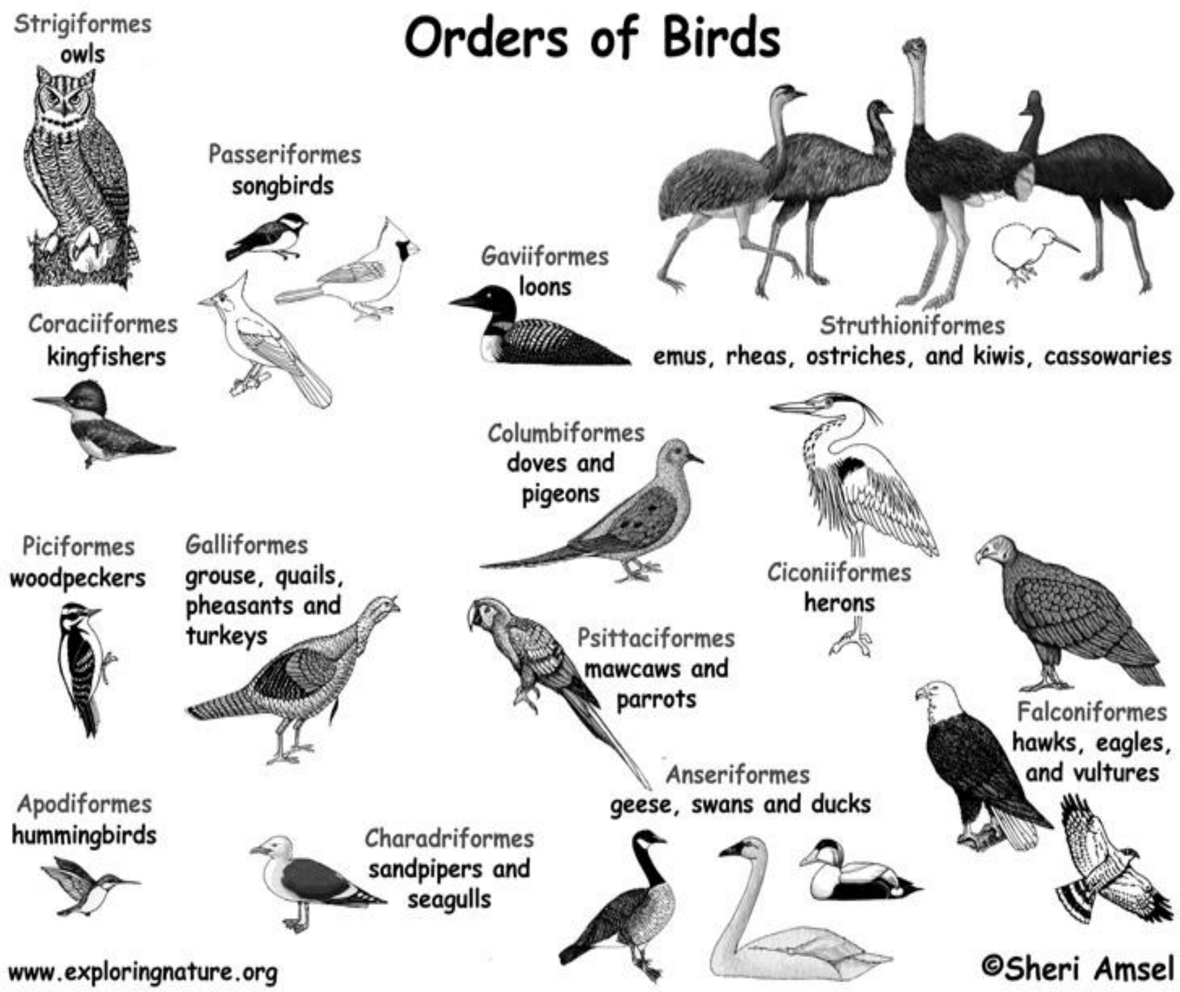
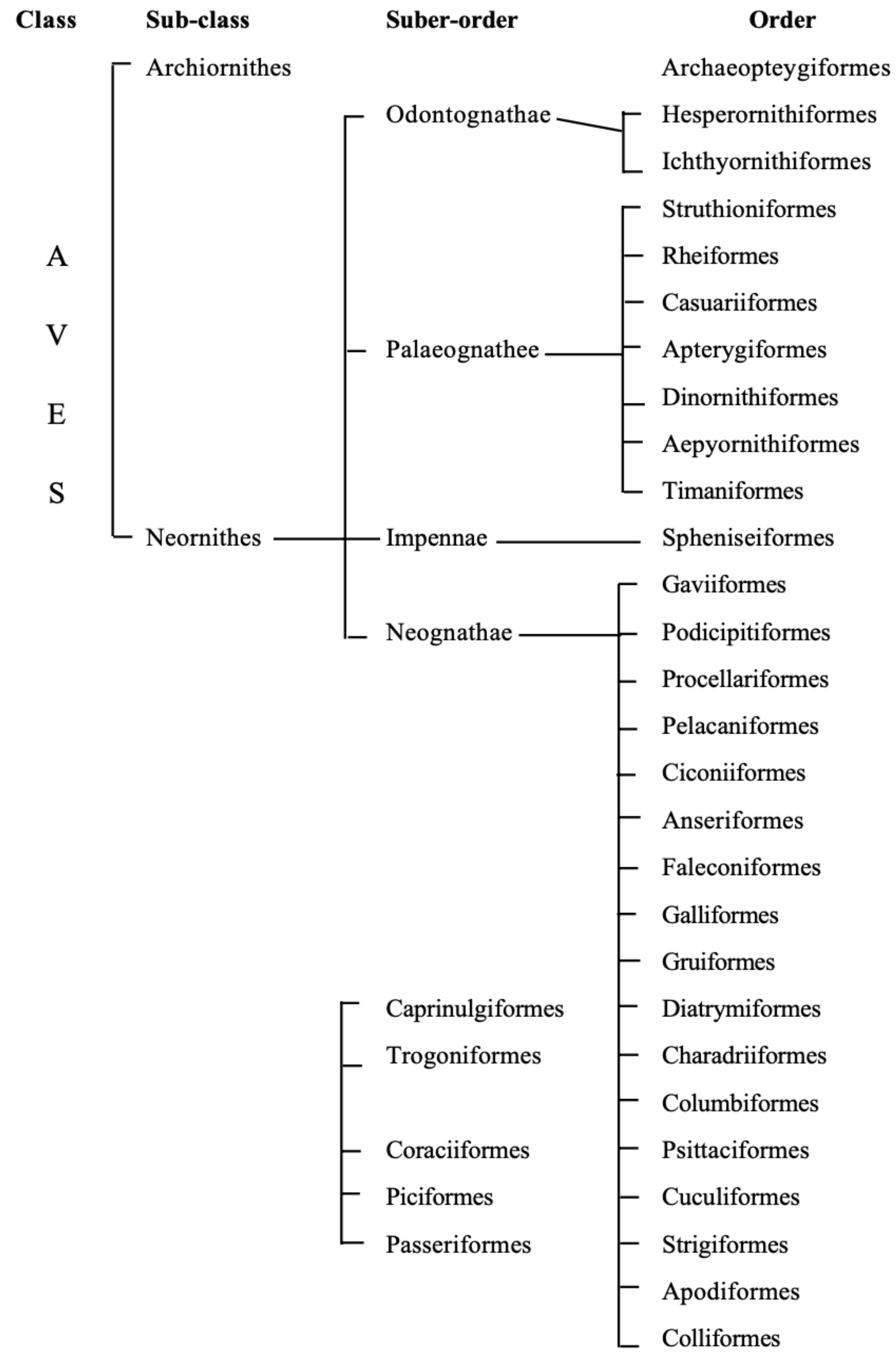


Fig 8.2:

8.3 Classification of Aves



Subclass-1: Archiornithes

Mesozoic ancestral or lizard birds with long tail and teeth in both the jaws.

Order: Archaeopterygiformes

1. First limbs have remiges.
2. A long tail that progressively tapers to the distal end and has numerous vertebrae. Each side of the caudal vertebrae has two lateral rows of rectrices.
3. The hand with three clawed digits is freed by the carpals and metacarpals.
4. There were big eyeballs.
5. Crowned teeth with enamel on both jaws.
6. There are only roughly six vertebrae in the sacrum.
7. On the ventral wall of the belly were thin abdominal ribs, also known as gastralia or so-called ventral ribs.
8. The cerebellum is tiny, and the cerebral hemispheres are smooth, long, and narrow.

Examples: Archaeornis siemensi, Archaeopteryx lithographica

Subclass-1: Neornithes

General Characterstics

1. Reticles are grouped in a semicircle around the drastically shortened tail, which typically ends in a pygostyle.
2. With the exception of a few extinct species, all are toothless.
3. The sternum is typically carinate or keeled and is well-developed.

Four superorders—Odontognathae, Palaeognathae, Impennae, and Neognathae—have been identified within the subclass Neognathae.

Superorder-1 : Odontognathae

General characters

1) Clavicle not fused. The sternum has no keel.

2) There are teeth in both jaws.

3) 150 cm long, flightless, and designed specifically for swimming.

Order-1: Hesperornithiformes

General characters

1) Not flight friends designed for swimming.

2) Forelimbs with only the vestigeal humerus.

3) The webbed feet and laterally oriented hind limbs.

4) There is no pygostyle.

5) Premaxilla lacking teeth; pointed teeth placed in grooves in both jaws. 6) There is no basipterygoid, quadrate, single process.

7) Sternum devoid of keel.

8) A long neck with vertebrae that are heterocoelous.

9) Massive reduction of pectoral girdle and non-fusion of clavicles.

Example: Baptornis, Enaliorni

Fig 8.3: Baptornis

Order- 2: Ichthyornithiformes

General characters:

1) The vertebrae in the neck are amphicoelous.

2) The wings are not like those of modern birds, and the sternum had a well-developed keel.

3) Fused clavicles.

E.g. Ichthyomis, Apatormiis

Order-1: Struthioniforms

General characters

1) Small-winged, flightless terrestrial omnivores that are typically folded when running but can spread out to serve as a steering mechanism.

2) Less feathers on the head, neck, and legs.

3) There is no aftershaft in feathers.

4) Tail coverts take the place of tail feathers.

5) Only the third and fourth toes of each foot are present, and the hind limbs are robustly constructed.

6) The sternum is keel-less.

7) There is a pubic symphysis.

8. Pygostyle is missing.

Fig 8.4: Struthio camelo

Order-2: Rheiformes

General characters:

1) Three front toes on each foot, webbed at the base.

2) Unkeeled sternum.

3) Upon nesting, a male protects three to seven females, excavates a nest, and every female lays roughly fifty lemon-yellow eggs in the same nest, which the male incubates for forty days.

Fig 8.5: Pteronemia pennata

Order-3: Casuariiformes

General characters:

1) Terrestrial, flightless, running herbivore birds supported on a single digit on rather short wings.

2) The body and neck were heavily feathered.

3) Feathers with an almost equal shaft after them.

4) Lacking a complete feather coating on the neck; the inside toe of the three is a clawed defense structure.

Fig 8.6: Dromaeus (Emu)

Order-4: Apterygiformes

General characters:

1) Small, nearly wingless, nocturnal, omnivorous running birds that resemble hens. 2) Long, thin bills with a nostril at the tip.

3) Wings lost their flight feathers, vestigeal humerus, and one digit. 4) There are four clasped toes on each leg.

5) The fluffy, hair-like body feathers lack aftershafts.

6) Unkeeled sternum. The eyes are not very big.

7) Only releases a single white egg at a time. Out of all the living birds, eggs are the largest.

Fig 8.6: Apteryx

Order- 5: Dinornithiformes

General characters:

1) Large aftershaft-free feathers devoid of barbicels.

2) Short beak.

3) Massive hindlimbs with four toes.

4) Unkeeled and decreased sternum. Reduced or missing wing bones, scapula, and coracoid.

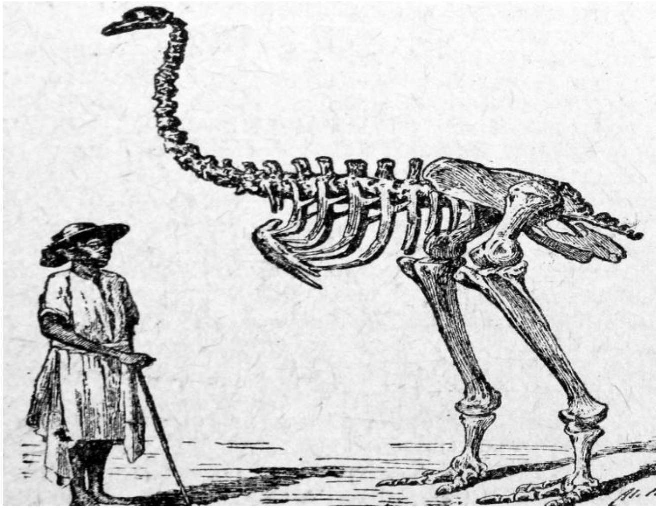


Fig 8.7 :Dinornis

Order-6: Aepyornithiformes

General characters:

1) Massive, flightless elephant birds from Madagascar.

2) The legs were strong, powerful, and had four toes, but the wings were comparatively small.

3) With a size of almost 10 liters, these eggs are the largest known animal eggs.

Order-7: Tinamiformes

General characters:

1) Partridges are essentially cursorial birds, herbivores that resemble quails and practically tailless.

2) The palate is palaeognathus, and the sternum is keeled.

3) A smaller Pygostyle.

4) The glossy white eggs that are raised by males.

Fig 8.8: Crypturellus

Superorder-3: Impennae

Eventually altered to form an efficient swimming paddle from ancestors that had wings for both swimming and flying. There is just one order in the superorder.

Order-1: Spheniseiformes

General characters:

1) The body is streamlined to provide the least amount of resistance to submerged activities including diving.

2) Dense, tiny, scale-like feathers covering the whole body without apteria; plumage closely packed.

3) Hind limbs altered for swimming; the webbed feet are particularly powerful.

4) The integument has a layer of fat that is dense and insulating.

5) The bones are solid, with the exception of some skull bones.

6) No air sacs present.

7) The featherless wings' bones flattened and fused to create a strong, resilient paddle or flipper that could only move at the shoulder joint.

8) Only lays one egg at a time and is monogamous. Consume seafood such as fish, crabs, and squid.

7) The featherless wings' bones flattened and fused to create a strong, resilient paddle or flipper that could only move at the shoulder joint.

8) Single egg laying at a time, Fishes and crustaceans are the main source of food.

Fig 8.9: Aptenodytes

Order-1: Gaviiformes

General characters:

1) Fish-eating birds developed swimming and diving abilities. They have the ability to fly.

2) There is a lengthy neck. The legs are positioned in the back and are fully covered with skin.

3) Short wings; webbed digits.

4) Nests among mounds of plants are where eggs are placed.

Fig 8.10: Gavia

Order-2: Podicipitiformes

General characters:

1) Compact-bodied creatures inhabiting freshwater environments.

2) Lobate toes.

3) The shortened tail has thinning tail feathers.

4) The lung is positioned far back.

Fig 8.10: Podiceps

Order-3: Procellariformes

General characters:

1) Long-winged seabirds: they only land during the breeding season to construct their nests in holes.

2) Arid, horny, tubular nose sheath with hooked bill made up of several plates.

3) Vestigeal hind toe or none at all (as in diving petrels).

4) Compact and oily plumage.

5) The wings may extend over three meters in length and width.

Fig 8.11: Diomedea

Order-4: Pelecaniformes

General characters:

1) Abundant consumers of fish.

2) Vestigeal or nonexistent nose.

3) A neck or gular pouch is visible, with the exception of tropical species.

4) A long, hefty pouch on the body of a pelican is used to scoop fish out of the water.

Fig 8.12: Pelecanus

Order-5: Ciconiiformes

General characters:

1) An extended neck.

2) They have either storks with naked patches on their heads or beautiful plumage, orflamingos with a bill that suddenly deforms in the middle.

3) The beak's design is distinct and features jagged edges.

4) The web between the toes is gone, save from flamingos.

5) Quick fliers with legs designed for brisk ambulation on mudflats.

Fig 8.13: Ardea

Order-6: Anseriformes

General characters:

1) They are all proficient flyers, with a nearly global reach.

2) Soft cornified epidermis covering the body with several sensory pits and a harder cap at the tip.

3) Short legs, fleshy tongue.

4. Webbed feet.

5) A short, heavily feathered tail is typical.

Fig 8.14:Coscoroba

Order-7: Falconiformes

General characters:

1) Strong, predatory birds are widely dispersed, with the exception of Antarctica.

2) A pointed mandible.

3. The feathers are rigid.

4) Laterally oriented eyes with exceptionally keen vision.

5) Primarily monogamous.

6) She bird incubate the eggs.

7) During incubation, the males feed the females.

Fig 8.15:Gymnogypes

Order-8: Galliformes

General characters:

1) Globally distributed, gregarious, non-migratory game birds that live on the ground. 2) The body is compact and the head is small.

3) The enormous, clawed legs are employed for digging through the ground in quest of food.

4) There are three toes pointing forward.

5) The bulk of wings are circular and short.

6) The arched, powerfully developed beaks are ideal for gathering up grains or seeds.

7) Male polygamy is hostile.

Fig 8.16: Opisthocomus

Order-9: Gruiformes

General characters:

1) Tiny size, poor or non-existent flying.

2) There is no webbed toe.

3) A ground nest could be constructed.

Fig 8.17: Fulica

Order-10: Diatrymiformes

General characters:

1) Big land birds without wings.

2) Huge neck, beak, and head.

For Example: Diatryma.

Order-11: Charadriiformes

General characters:

1) Firm and dense plumage.

2) Toes are typically webbed, at the very least.

In general, coastal birds have lengthy legs, while gulls have robust wings. Additionally, some birds have only three toes and have their legs positioned far back.

4) Highly spotted eggs.

Fig 1.18 Charadrius

Archaeopteryx-- a connecting link

The name Archaeopteryx, which means "old wing," refers to a genus of dinosaurs that resembled birds and stood in between non-avian feathered dinosaurs and contemporary birds. The name is derived from the Greek words "pteryx," which means "feather" or "wing," and "archalos," which means "ancient." The creature known as Archaeopteryx, which possesses both avian and reptilian traits, is the missing link or connecting connection between birds and reptiles. The following are the traits of Archaeopteryx's reptile and bird species:

Characters similar to Reptilian

1. Homogont teeth are present in the jaws
2. A long, lizard-like tail with twenty free caudal vertebrates.

3. Bones are not pneumatic
4. There are nine to nineteen cervical vertebrae
5. Amphicoelous vertebrae, similar to those found in Sphenodon
6. There are cervical and abdominal ribs. The ribs have a single head and no uninitiated process;
7. The sternum is either weak or nonexistent;
8. Sclerotic ossicles are present in the eyes
9. Scales are present
10. Carpels and metacarpals are free; there is no carpo-metacarpus
11. The pubis is oriented backward in the pelvic girdle.

Characters similar to Aves

1. Feathers are present; the forelimbs are altered to resemble wings
2. the tail has two rows of feathers; the brain case is rounded; the skull's bones are closely fused; beaks are present;
3. the limbs and girdles resemble those of a bird.
4. The sternum has a keel
5. The fibula and tibia are apart
6. The furcula is V-shaped.

8.4 Self-Assessment

i) List the general attributes of the aves class.

ii) Sort aves according to order using distinguishing traits and an appropriate example.

iii) Talk about "Archaeopteryx-a connecting link"

iv) Write a succinct description of the bird migration.

v) What is adaptation to flight?

vi) Write a little note on how birds have adapted to flight.

UNIT-9

FLIGHT ADAPTATIONS AND MIGRATION IN BIRDS

Learning Objectives:

- To explain the anatomical and physiological adaptations that enable birds to fly.
- To understand the pattern and types of migration.
- To understand the different types of flying adaptations in birds.
-

9.1 Flight Adaptations in Birds:

Adaptations to the particular atmosphere are the changes made by an animal to become more effective in moving through its surroundings, obtaining enough food, and finding a safe place to live.

Since birds have adapted to an airborne lifestyle, all modifications that have occurred in line with this mode of existence are known as volant adaptations.

Thrust, drag, as well as lift and weight, must be balanced in order to fly. Gravity gives rise to weight, whereas airflow over the wings produces lift.

Instead of being flat, bird wings are concave down and convex above. The pressure decreases as a result of the air speeding up as it passes over the top of the wing because it has more distance to travel and is applying pressure over a larger area above the wing than below. The wing is essentially sucked up by this. The air beneath the wing, however, has the opposite effect.

It raises pressure, slows down, and successfully lifts the wing. As a result, a bird that has air flowing over its wings will be pushed and pulled upward from underneath. The high pressure air beneath the wing attempts to fill the sink created by the low pressure air on top of the wings.

The effect of the wing is the reverse.

Wing Loading: Wing length divided by wing breadth yields the aspect ratio, which is used to quantify aerodynamic qualities. Longer wings are better for gliding but less effective for rapidly accelerating since they are more difficult to flap. The link between total body mass (measured in grams) and total wing area (measured in square centimeters) is known as wing loading.

Gliding or Non-flapping Flight:

Numerous gliding or soaring birds, such as vultures, hang in midair and ascend without using their wings. This basically indicates that their wings produce a great deal of lift without a lot of drag. Huge birds have adapted to be gliders in part because larger wings make gliding easier and mechanical flapping flying more difficult.

All birds, excluding hummingbirds, glide to some degree when they are in the air. In general, a bird's gliding range is limited and its sinking speed increases with size. Game birds have been known to glide. With quick wing beats, a pheasant takes off from the earth like a rocket and glides a short distance below to the trees nearby.

Flapping Flight:

The more intricate technique of flapping flight involves the bird's wing changing shape and angle of attack throughout both the upward and downward stroke. In essence, flapping flying involves rowing in the air while exerting additional effort to produce lift. A Blue Tit must be ready to land on a tree trunk or it will drop to the ground if it stops fluttering its wings. There are two different movements involved in flapping flight: the strength of the stroke and the reverse stroke. The wings travel forward and downward during the power stroke; the back stroke puts the wings back in the position where the next power stroke would start.

Soaring flight:

A bird that is soaring maintains its altitude and occasionally even ascends higher in the atmosphere than one that is gliding. A bird requires no internal energy to soar; instead, it is propelled by rising air masses known as thermal currents that occur over regions when the ground warms quickly. When wind currents are diverted by cliffs, mountains, or large structures, obstruction currents are created. Birds are lifted to great heights by the ensuing upward increase in air, which serves as a base for additional gliding. Large, broad wings are a must for soaring birds, and their body's weight to airfoil size ratio is small.

Hovering Flight:

A bird creates its own lift whilst hovering by beating its wings quickly. A bird in a hover shifts its wings in a horizontal plane, moving them forward and back, both phases of the stroke, while maintaining a nearly vertical body and flexed elbow joint produces lift. The structure of hummingbirds' wings allows them to function as lifting rotors when they are in motion. Instead of flapping and gliding like other bird wings, their pointed wings move up and down at a speed of 70 times per second to propel them into the air.

There are two types of flying adaptations acquired by birds:

a) Morphological adaptations b) Anatomical adaptations

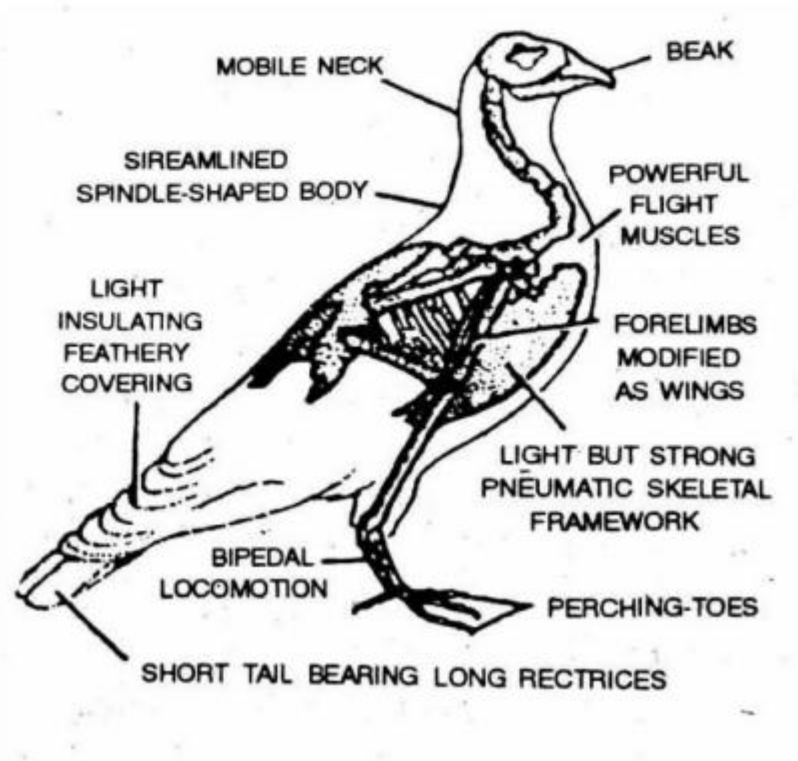


Fig 9.1 Detailed Stream lined body of a Bird

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9.1.1 Morphological Adaptations:

9.1.1.1 Flight Organs

- Wings are created from the forelimbs and are the only organs used for flying.
- The growth of longer remiges (flight feathers) increases the outermost area of the wings.
- These feathers create a wide, continuous surface that the bird can strike the air with when it is in flight and for support.

➢ Modification of forelimbs into Wings:

- The forelimbs have developed into the distinctive and potent wings, which serve as propelling organs (fig 9.2).

- These wings contain intricate anatomical designs that include a framework made of bones, muscles, blood vessels, nerves, feathers, etc.
- The front part of the trunk is where both wings originate. They remain folded against the edges of the body when at rest, but they expand when in flight.
- Due to the wing's unique design, which has a thick, powerful leading edge, a convex top surface, and a concave lower surface, there is less turbulence behind and less above. This aids in propelling the bird's forward and upward motion when in flight.

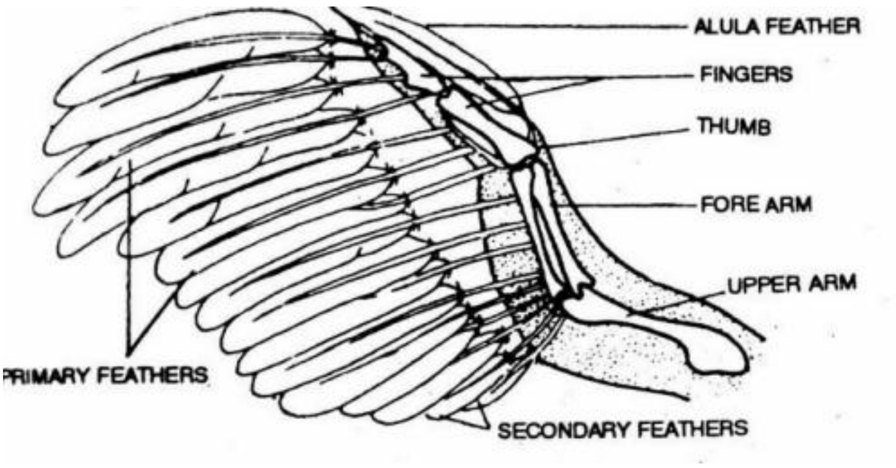


Fig 9.2 Wing of a Bird

Source: file:///C:/Users/LENOVO/OneDrive/Desktop/BSc-Zoology-Part-II-Flight-adaptation-in-birds.pdf

9.1.1.2 Feathers:

- The entire body is covered in closely fitted, backward-directed contour feathers, which streamline the body and lessen air friction.
- A specific volume of air is kept around the body and the feathered blanket.
- As feathers are non-conductive, they also aid in preserving body temperature. The air contributes to buoyancy.
- Lift is produced by the arrangement of feathers on the wings into airfoil shapes, which causes differences in pressure between the upper and bottom surfaces of the wing.
- Furthermore, feathers are robust but lightweight, enabling birds to maintain their agility in flight and withstand the strains of flying maneuvers.

Advantages of feathers:

- The body is streamlined by the smooth, closely fitting, and backwardly oriented contour feathers, which minimize friction and assist the bird fly through the air.
- The body is made lighter by the feathery covering, which also shields it from the temperature-related risks.
- The feathers greatly increase the body's buoyancy by encircling it with a thick layer of enclosing air.
- The bird's non-conducting feather covering perfectly insulates the body and stops heat loss, allowing it to withstand extreme cold at high elevations and maintain a steady body temperature.
- A wide area for crashing the air is formed by the feathers on wings.

9.1.1.2 Integument and Bipedal Locomotion:

Another adaptation for flying is the loose connection of the bones across the body, which allows the skeletal muscles to move widely.

The hind limbs developed stouter and moved somewhat forward on the thorax to support the weight of the body and crawl on the ground.

9.1.1.3 Perching:

- Perching is the term for the natural tendency of birds to use their hind limbs to hang onto a twig when they sit.
- To compensate for that, the muscles in the hind limbs are built in a way that causes the toes of a bird to reflexively shut around a twig when it sits on one.
- The reason for this is that as the bird settles on the twig, its flexor tendons are stretched, causing the toes to naturally bend around the perch with the effort of pulling.

9.1.1.4 Neck and Head

- With a beak or bill for preening, nest building, feeding, offense, and defense, the forelimbs' transition into wings is appropriately compensated.
- The mouth extends into a horny beak that functions as an extra set of forceps for picking up objects and performing other tasks like nest construction, pruning, etc.

- In addition to being incredibly long and flexible, birds' necks allow for the head movement required for a variety of tasks.

9.1.1.5 Short tail and compact body

- The tuft of long tail feathers called rectrices that spread out like a fan and act as a rudder when a bird is in flight, is attached to its short tail. During flying and perching, they also help with steering, lifting, and counter balancing.
- Their small, robust body is heavy ventrally and light dorsally, which aids in preserving airborne equilibrium.
- Other highly significant morphological facts include the wings' high attachment to the thorax, the high position of light organs such as the lungs and sacs, and the low central position of heavy muscles, the sternum, and digestive organs beneath the attachment of both wings as a result, the low center of gravity.

9.1.2 Anatomical adaptations:

9.1.2.1 Flight Muscles:

- The flying muscles, which weigh roughly one-sixth of the total weight of the bird, are highly developed and regulate the movement of the wings, although the back muscles are still far smaller.
- The striated muscle fibers that make up the flying muscles are highly vascularized and able to sustain lengthy action without becoming fatigued.
- Pectoralis majorly a big muscle, depresses the wings, whereas minor pectoralis elevates them. Smaller muscles assist the larger muscles in their operation.

9.1.2.2 Digestive system:

- Due to their extremely high metabolic rates, birds have high dietary requirements and quick digesting. Because most birds are extremely picky eaters, their beaks have undergone numerous modifications.
- Furthermore, the rectum shrinks significantly and never retains the undigested food because the amount of undigested waste is minimal and eliminated right away.
- The underdeveloped rectum of flying birds suggests that these animals are unable to support the weight of their excrement.
- In birds, the lack of a gall bladder reduces body weight to some degree.

9.1.2.2 Muscular system:

- The bird possesses approximately 175 distinct muscles. Their primary areas of control are the wings, tail, neck, and legs.
- The muscles of the bird that control its wings are the largest. Known as the pectorals or breast muscles, they comprise around 15 to 25 percent of a bird's whole body mass.
- They give birds the ability to fly by enhancing the force of their wing stroke and supplying the majority of the motions required for their downswing.
- Strong flying muscles are directly related to a bird's wings and sternum, or breastbone.
- Smaller muscles regulate wing movements and modifications during flight, but the pectoral muscles are the main flight muscles that drive the downstroke.
- These muscles contract quickly, enabling birds to flutter their wings rapidly and forcefully to produce the thrust required for flight.

9.1.2.3 Endoskeleton system:

- Instead of having bone marrow, the bone has turned pneumatic and has air holes in order to become lighter without sacrificing strength.
- The cranial bones have united. Teeth lost in the jaws to lighten the cranium
- The fusion of the first four to five thoracic vertebrae creates a stable base of support for the wings to operate against.
- The fusing of roughly fourteen vertebrae (thoracic-1 (latest), lumber-6, sacral-2, and caudal-5) culminates in the creation of the synsacrum, a plate-like structure (Fig 9.3). The latter serves as a girder to sustain the body's full weight.

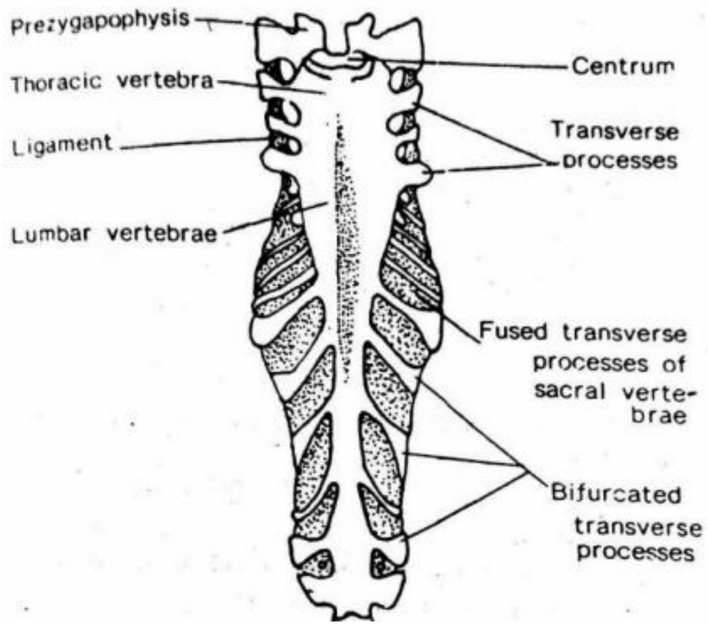


Fig 9.3 Ventral view of synsacrum

Source: https://bncollegebgp.ac.in/wp-content/uploads/2020/06/BSc-Zoology-Part-II-Flight-adaptation-in-birds.pdf

The sternum, a breast bone, is fully grown. The visceral organs are supported by its posterior elongation. It has a median ridge for the attachment of flight muscles, which is called the keel or carina. It stays securely joined to the coracoid (Fig 9.4).

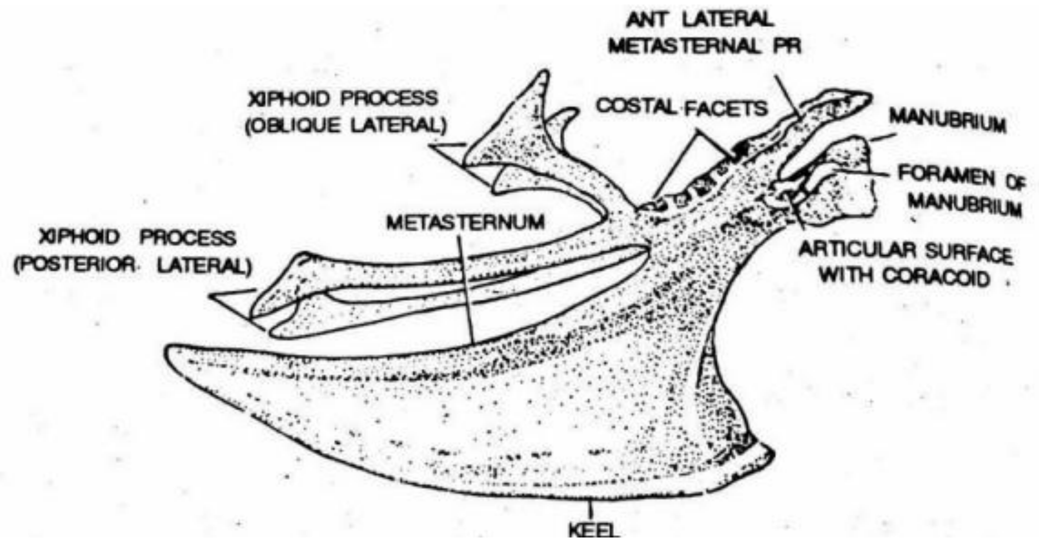


Fig 9.4 Lateral view of sternum

Source: https://bncollegebgp.ac.in/wp-content/uploads/2020/06/BSc-Zoology-Part-II-Flight-adaptation-in-birds.pdf

- Furcula, also known as the wish bone or Merry Thought Bone, is a "V"-shaped structure formed by the ventral fusion of the the clavicles of both pectoral girdles. It functions similarly to a spring connecting the two wings.
- The legs' remarkable strength for bipedality comes from the fusion of the proximal tarsals with the lower end of the tibia to produce the tibiotarsus and the fusion of the distal tarsals with the bones of the metatarsals to form tarsometatarsals.

9.1.2.4 Respiratory system

- Because flying demands strong, continuous power, the respiratory system of a bird is specialized to allow food to burn quickly and thoroughly, oxidizing it and releasing a significant amount of energy.
- The body tissues require more oxygen molecules in order to fulfill the high rate of metabolism.

  The extraordinary system of air sacs, which emerge from the lungs and fill every accessible space between internal organs even the hollow spaces in bonessupplies the thick, small, and inelastic lungs for this reason.
- The primary functions of the air sacs are to lower the bird's specific gravity and to enable full lung aeration.

9.1.2.5 Circulatory system

- An effective circulatory system can supply the tissues with a significant amount of oxygen, which is necessary for rapid metabolism. As a result, the avian heart is big, four chambered, strong, and effective.
- Its twofold circulation keeps the blood's oxygenated and deoxygenated components totally apart.
- Furthermore, a significant amount of hemoglobin, which is necessary for the rapid and ideal aeration of bodily tissues, is present in the red blood cell of birds.

9.1.2.6 Excretory system

- The uriniferous tubules containing Henle's loops are effective at absorbing water and retaining it. An additional effective organ of birds for absorbing water is the coprodaeum of the cloaca.

- In order to lose weight, there is no urinary bladder, and the partially solid urine is quickly expelled from the body rather than being held inside for an extended period of time.
- A crucial physiological volatile adaption occurs when the metabolic waste products containing nitrogen are transformed into less poisonous and insoluble organic molecules like urates and uric acid.

9.2 Migration in birds

Bird migration refers to the regular seasonal movement of birds between hatching and wintering areas, usually between the north and south via a flyway grounds. Numerous bird species travel. It mostly affects birds in the northern hemisphere, as natural obstacles like the Mediterranean or Caribbean Sea direct them down particular paths.

The Latin word migrar, which meaning to move from one place to another, is where the word "migration" originates. As stated by "Changes of habitat periodically repeating and changing in direction, which tend to secure optimal environment conditions at all times" is how L. Thomson (1926) defined bird migration (Fig 9.5).

Fig 9.5 Migration of birds

Source:https://en.wikipedia.org/wiki/File:Waders_in_flight_Roebuck_Bay.jpg

9.2.1 Why do Birds Migrate?

Birds migrate for a food and a secure breeding habitat which are necessary. Birds that reproduce in the summer months in the far north.

Due to the lengthy daylight hours and the fact that few major permanent predators can withstand the hard winter, summers in the Arctic are blessed with an abundance of food. In the Arctic, a lot of birds just lay their eggs on the soil in order to hatch. Because they can fly, they can escape the harsh winter weather and come early to take advantage of the summertime benefits.

Conduct is inherited. But in the absence of specific physiological environment cues, birds will not migrate. A migrating bird's migration is aided by the reduction in sunshine in the late summer.

Prolactin is produced by the pituitary gland, and corticosterone is produced by the adrenal gland. In turn, these hormones allow the birds to store a lot of fat beneath their skin, giving them the energy they need for the lengthy migration trips.

9.2.2 Types of migration:

9.2.2.1 Longitudinal:

The birds migrate longitudinally when they move from the east to the west and the reverse. Sturnus vulgarisa creature found in west Asia and eastern Europe, migrates toward the Atlantic coast. California gulls move west to winter on the Pacific coast. They reproduce and live in Utah.

9.2.2.2 Altitude Migration

Mountains are the location of the altitude migration. During the winter, a large number of birds that live on high peaks move to lowlands. The golden plover (pluvialis), which travels 11,250 kilometers from the Arctic tundra to the Argentinean lowlands

9.2.2.3 Partial Migration

Only a small number of a group's members migrate. Our nation's cocks and spoon bills, or platalea, may be an illustration of partical migration.

9.2.2.4 Latitudinal migration

Latitudinal migration refers to migration from north to south and vice versa. The Cuckoo travels around 7250 miles throughout the breeding season from India to southeast Africa.

Certain tropical birds travel to the outer tropics during the rainy season in order to reproduce, then they return to the center tropics during the dry season. The great shearwater, Puffinus, nests on tiny islands and migrates to Greenland in May, returning after a few months shift in latitude

9.2.2.5 Seasonal migration

Seasonal migration is the movement of certain birds at different times of the year in search of food or to breed. For instance, swallows, swifts, and cuckoos. They move throughout the summer, from south to the north. We refer to these birds as summer guests. Once again, there are many birds such as the grey plover, shore lark, redwing, and snow bunting which, in the winter, travel southward. We refer to them as winter visitors.

9.2.2.6 Daily migration

Some birds travel daily distances from their nests due to the effects of light, humidity, and temperature. Crows, herons, and starlings are a few examples.

9.2.2.7 Vagrant migration

Vagrant or irregular movement is the term used to describe certain bird species that migrate short- or long-distance in search of food and protection. Herons and black strok (Ciconia nigra), bee eaters (Merops apiaster), spotted eagles (Aquila clanga) and glossy ibis (Plegadis falcinellus)

9.2.2.8 Nocturnal anddiurnal migration

Diurnal: Numerous larger birds, including bluebirds, pelicans, cranes, geese, hawks, robins, swallows, jays, and crows. Move during the day time in search of nourishment.

Nocturnal: a few small passerine bird species, such as warblers and sparrows. Known as nocturnal birds, they migrate during the night. They are shielded from their foes by the night's darkness.

9.2.3 Advantage of Migration

The advantage is itoutweigh the risks associated with the migration, including high levels of stress and physical exertion.

Eleonora's falcon Falco eleonorae, which nests on Mediterranean islands, experiences a very late mating season that is timed to coincide with the autumn passage of southern passerine migrants, which it provides to its young. This can increase predation during migration. The larger noctule bat, which feeds on nocturnal passerine migrants, uses a similar tactic at stopover. a.reas,migratory birds are more likely to become infected with parasites and other pathogens, which calls for an increased immune response.

9.2.4 Disadvantage of Migration

Many young birds die throughout the long and exhausting voyage, making it impossible for them to achieve their destination. Unexpected variations in the weather, including storms. The reasons why migratory birds die are hurricanes, strong wind currents, and fog. Sometimes migratory birds die as a result of artificial high tours and lighthouses. The migrants' deaths are the result of human error.

They only shoot these poor birds for fun and entertainment.

Questions:

1. Differentiate between the morphological and anatomical adaptations.
2. Explain different types of Flight.
3. Describe different types of migration.
4. Why do birds migrate?
5. Elaborate the advantages of feathers in bird.
6. Write an advantage and disadvantage of bird’s migration.

UNIT-10

MAMMALS GENERAL CHARACTERS AND CLASSIFICATION UP TO CLASSES

Objectives:

At the end of the unit student will be able to understand:

- Elucidate key traits of mammals that have helped them succeed in their terrestrial lives
- Describe the nonplacental mammals
- Describe how whales' watery lifestyle and bats' ability to fly have evolved
- Examine the evolution of man, describe the dentition in mammals

10.1 General Characterstic:

1. Mammals have hair all over their bodies. The epidermal exoskeleton of mammals is made up of hairs and other features like nails, hooves, and claws on digits as well as scales that are present on the tails of some mammals, such as rats.

2. It is homeothermic in mammals. The skin's sweat glands and the body's hairy layer contribute to the regulation of body temperature.

3. Mammals' skin contains a variety of glands, including sebaceous, sweat, fragrance, and mammary (milk) glands.

4. Mammals have well-ossified skeletons. The skull's cranium is quite massive. The cranium has two occipital condyles, or is bicondylar. Teeth are classified as heterodont (having many tooth kinds), thecodont (having teeth inserted into jawbone pits), and diphydont.

5. In comparison to other animals, the brain is rather massive. The brain has matured well. Unlike the two optic lobes found in the brains of other vertebrates, the corpora quadrigemina consist of four. The cranial nerves are arranged in 12 pairs.

6. Mammals have four chambers in their hearts. The right and left chambers of the ventricle and auricle are entirely separated. The bicuspid valve protects the passage between the left auricle and the left ventricle, whereas the tricuspid valve guards the opening between the right auricle and the right ventricle (Fig 10.1). In mammals, these valves are a defining feature. The left aortic arch, which creates the dorsal arch, is the only aortic arch. It curves over to the dorsal side which forms dorsal aorta.RBC are non-nucleated except camel.

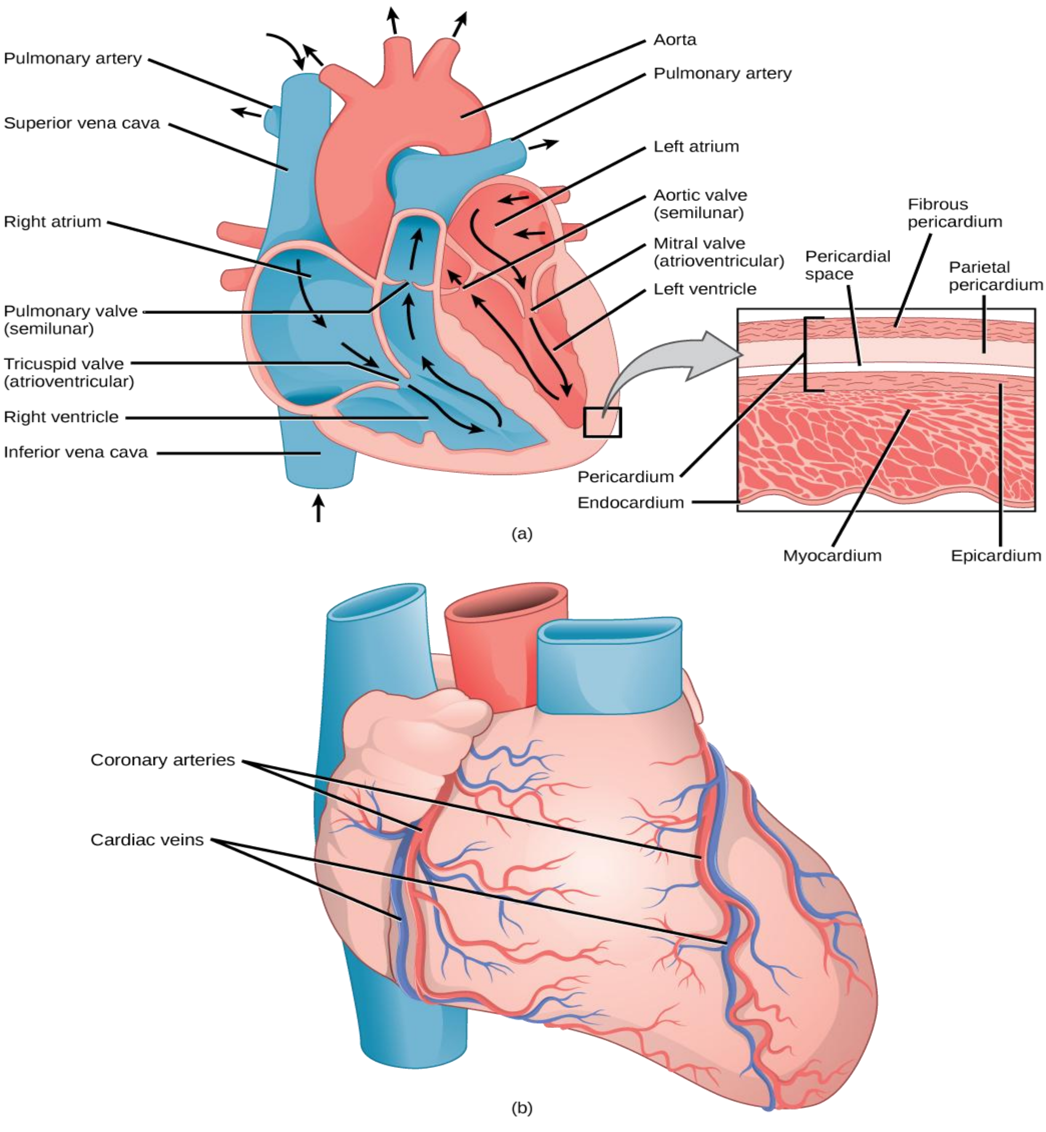


Fig 10.4: Structure of heart(a) internal Structure (b) Morphology

7. The thoracic and abdominal cavities are divided by a muscular diaphragm (Fig. 10.2). The diaphragm facilitates breathing. During breathing, the diaphragm rises and falls, drawing air into and out of the lungs.

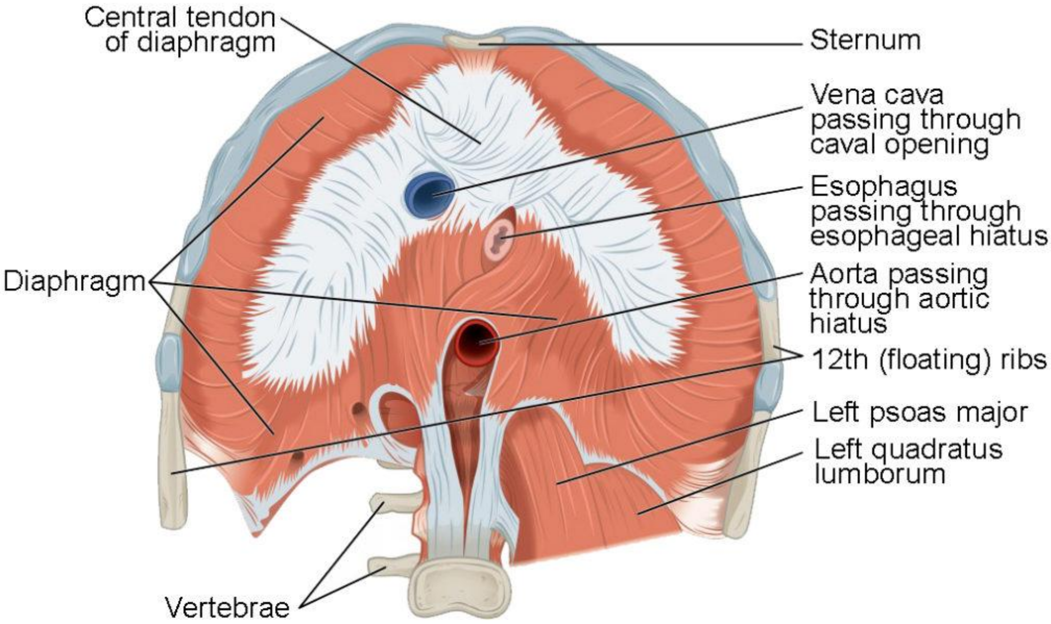


Fig 10.2: Diaphragm (inferior view)

8. The alveoli, which are tiny air sacs found within the lungs, are elastic. The trachea contains a voice box known as the larynx. It facilitates the creation of sound

9. An adult mammal's kidney develops from its metanephros. There is often a bladder to hold urine.

10. The sexes are distinct. Sexual dimorphism exists. The penis, a copulatory appendage found in male mammals, aids in the transport of sperm (semen) to the female genital canal during copulation. Typically, the testes are located in the scrotum, an additional abdominal sac-like structure.Fertilization occurs within.Mammals are viviparous, meaning their progeny develop inside their mothers' bodies. During the development of the embryo, a placenta is created. With the exception of Monotremata, the anus and urinogenital apertures are distinct, and there is no cloaca.

10.3 Classification

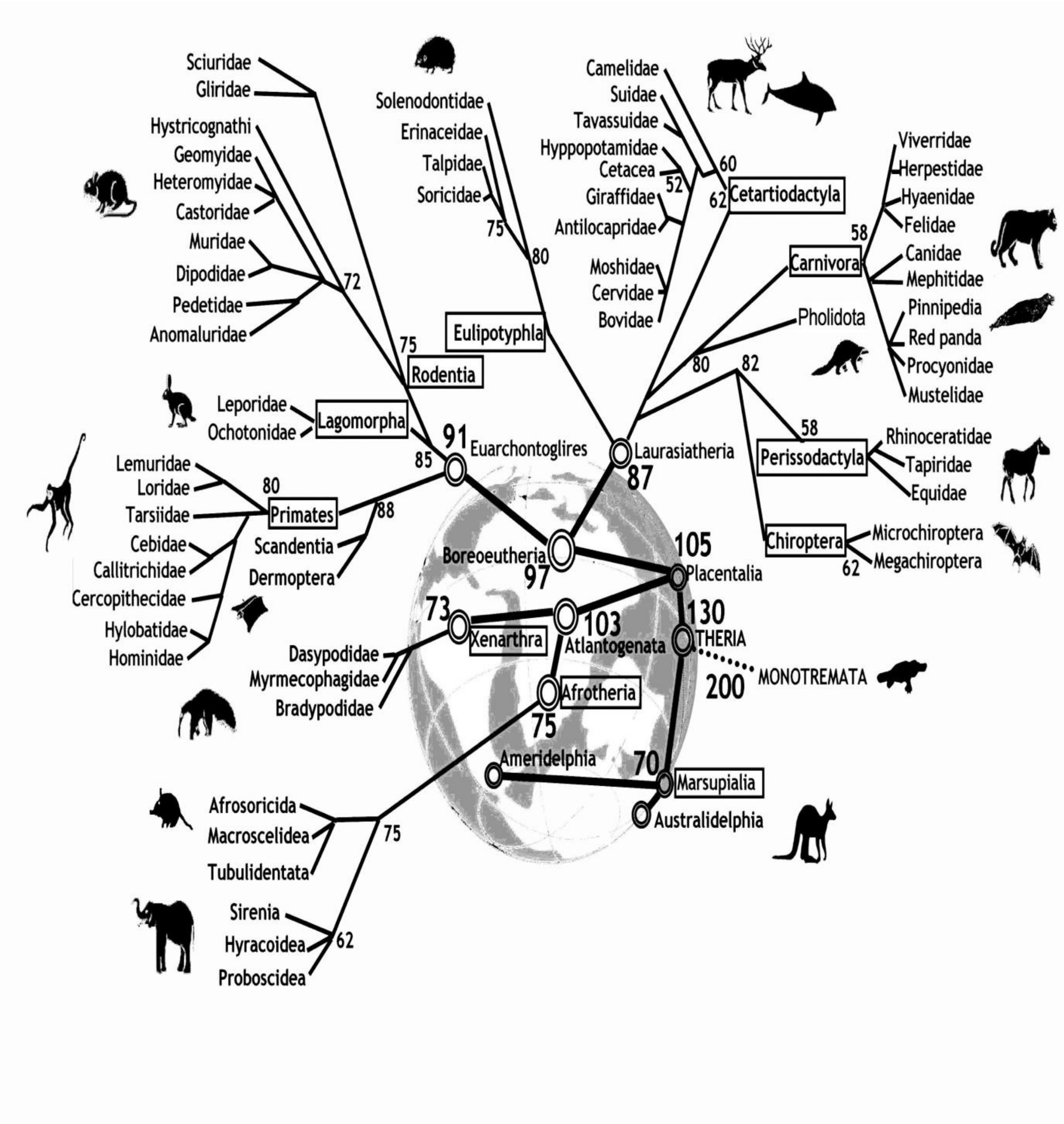


Fig 10.3: Classification of division Mammalia

Subclass I: Prototheria/Monotremata:

Among them are ancestor reptile-like mammals. They are fundamentally distinct from all other members of the class Mammalia, laying yolky eggs while secreting milk. The testes are positioned in the abdomen. They've got a cloaca. There is no pinna, the external ear. Only Australia, Tasmania, and New Guinea are home to them.

Example : Ant eater (Fig 10.4)

Fig 10.4: Ant eater

The mammal that lays eggs, the duckbill Platypus (Ornithorhynchus) (Fig. 10.5), combines traits of both reptiles and mammals. Uninogenital system, precoracoids, lack of pinna, etc. are characteristics of reptiles. Features unique to mammals include hair, a diaphragm, a four chambered heart, three ear ossicles, etc. The duckbill lives in rivers, puddles, and streams, digging up to 40-foot-long tunnels along riverbanks. Freshwater invertebrates that are carried in cheeck pouches are the animal's food source. The upper jaw produces a flattened beak with a free fold forming at the base of the beak, coated in smooth, hairless skin. An adult's jaws are covered in horny plates and lack teeth. Limbs feature webbed and five-clawed digits. The flattened tail is an adaptation for swimming. The mammary glands lack nipples. The female builds a root nest.

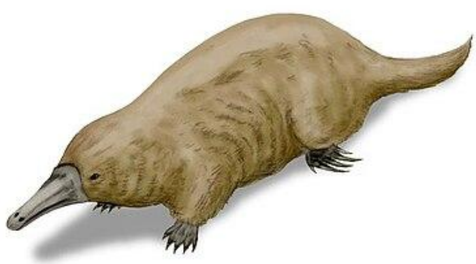


Fig. 10.5: The duckbill Platypus (Ornithorhynchus)

Subclass 11: Metatheria / Marsupialia

In females, there is a pouch called the marsupium located in the ventral abdomen. Within this pouch, the little ones are kept safe and secure. After a brief gestation period (13 days for kangaroos), the newborn pups are born and moved to the marsupium where they are fed and cared for until they can take care of themselves. The animals are kept in America and Australia.

The Macropus conguru, or kangaroo, (Fig. 10.6) has evolved into a primarily terrestrial species and has learned to move forward on two feet. Their ability to move on two legs requires adjustments to the ilia and thigh muscles, for which the tibia has a prominent anterior crest. The fourth digit's extended metatarsal gives the foot more leverage. The second and third fingers are tiny and syndactylous. Because kangaroos have a habit of jumping, It is not surprising that kangaroos have lengthy rear limbs given their habit of hopping, but it is startling to learn that their forelimbs are rather short. The long forearm bones, which are far longer than the humerus, supply the majority of the length. The animal will quickly come into contact with the earth if it leans forward. Do they serve any purpose in moving? The truth is that they do, as kangaroos utilize their tail and forelimbs as props as they crawl.

Fig. 10.6: The Macropus conguru, or kangaroo

Subclass 3: Eutheria / Placentalia

The infants are developed at a comparatively advanced stage upon birth. The milk that the mammary glands release is what they eat. There are a total of 28 orders, although only 16 of them have live representatives. Here are mentioned a few significant orders, located at the rear of this block, for a comprehensive classification of all living mammals.

Order I: Insectivora

Because of their unique behaviors, insectivores are primarily small, nocturnal animals that yet exhibit many of the oldest characteristics of mammals. They are suited for their habit of living underground and tunneling. They are often opportunistic feeders that consume a range of tiny invertebrates, including insects and worms and grubs. The small cranial cavity, low grade brain demonstrated by smooth cerebral hemispheres, inguinal testes, discoidal and dedrduate placentas with yolk sac placenta supply, and other primitive eutherian characteristics are all present in insectivores. A large number of insectivores hibernate in the winter and are equipped with unique fat reserves for this purpose. While the majority of them live alone, some engage in social behaviors such as exchanging smell and sound cues. They create basic nests(Fig 10.7).

Fig 10.7: Shrew

Order 2: Chiroptera (G.K. Cheir : hand, pteron : wing)

These are mammals that can fly (Fig. 10.8). With the exception of their flight specialization, bats are relatively close.the insect predator?These animals split up early, and the early Eocene is when their distinctive traits evolved. Mammals that can actually fly by flapping their wings are unique to them.

Fig 10.8: Mammals that can fly

Order 3: Edentata (toothless)

Eating a diet high in insects causes tooth loss or reduction. An armadillo and a scaly anteater are two examples (Figs. 10.9). They all have very large salivary glands and a lengthy tongue and nose. The peculiar lifestyles of Edentates are primarily responsible for their unique characteristics, which frequently result in strange outward manifestations like the armadillo's shell or the large snout of the great ant-eater. Because they are nocturnal and fossorial animals, armadillos have developed bony plates on their skin that are covered in horny scutes, providing them with protection. The teeth are homogeneous, basic pegs that develop continuously and have exposed roots without any enamel. When agitated, the tail becomes twitchy. Manis wraps its tail around its body and rolls its head between its forelegs.

Fig 10.9: An armadillo

Order 4: Lagomorpha (hare shaped)

The class resemble rodents in having long, continuously developing incisors, but they also have a second pair of peg-like incisors growing behind the first pair. They therefore have three sets of incisors. Rabbits and hares are two examples (Figs. 10.10).

Fig 10.10: A Rabbit

Order 5: Rodentia

Gnawers include rats, squirrels, mice, Figs. 10.11 and other rodent species. They make up around 40% of all mammal species and are distinguished by having two pairs of razor-sharp incisors that they utilize to chew through the toughest shells and pods in search of food. Their remarkable capacity to reproduce, their versatility, and their ability to infiltrate any terrestrial ecosystem make them extremely important ecologically.

Figs. 10.11: Squirrel

Order 6: Cetacea (whale-like)

These are mammals found in water. As nippers, the forelimbs are altered. It lacks hind limbs. There is little hair on the body. A single or twin blowhole on top of the skull represents the nostrils. Porpoises, whales, and dolphins (Fig. 10.12) are a few examples. Dolphins and whales of great size nap in the ocean. The features of a fish form of life have been largely adopted by whales, including their tapering, streamlined bodies, extended heads, and lack of necks. Dolphins can swim for hours at a speed of up to 40 km/h. The horizontally oriented tail flues provide the majority of the propulsive thrust. The elbow joint is rarely movable in the forelimb, the humerus is short, and the hand has grown in length and occasionally in diameter.

Fig 10.12: Dolphins

Order 7: Proboscoides (with a trunk)

These enormous, herbivorous terrestrial mammals (Fig. 10.13) have well-organized neural systems for locating food, effective ways to gather it, and spacious, well-organized surfaces for grinding it. When the elephant finds a tree that suits it, he shakes it with his trunk to check for fruits, then uses his weight to force it down with his forehead. They might use his tusks to scrape off the bark. The trunk, which has an incredibly long nose and top lip, suitable muscles, and a sensitive tip, is the primary organ of collecting. There are three molars in each jaw, but only one (or perhaps two) of them are ever used. This is due to the sequential development of molars. The working molar wears down and falls out after a few years.

Fig. 10.13: Herbivorous terrestrial mammals

Order 8: Carnivora (flesh eaters)

Carnivora, or "eating flesh" They're all sharp-tongued and have predatory tendencies. Teeth are designed specifically to grasp and tear prey. Their diet is carnivorous. Examples include dogs, fox, wolf, domestic cats, lions, tigers, leopards(Fig. 10.14)and common dogs.

Fig. 10.14: Herbivorous terrestrial mammals

Order 9: Artiodaetyla

Even-toed mammals, or Artiodaetyla, are arc-hoofed animals with ruminant stomachs and an even number of toes on their limbs. Antlers and horn are also features of animals. lists pigs as an example, followed by cattle, oxen, sheep, goats, deer, camels, and giraffes (Fig. 10.15). The hippopotamus and certain other ungulates have four toes, although the majority of these animals only have two. A cornified hoof envelops each toe. Many animals have horns, including sheep, deer, and cows. A large number are ruminants, or animals that chew their cud. They just consume plants.

Fig 10.15: Sus scrofa

Order 10: Perissodactyla

These are (Odd Toed) are herbivorous hoofed animals with an odd number of toes. Horses, zebras, rhinoceroses, donkeys, etc. are few examples. There is only one working toe in the horse family (Equidae), which include zebras and horses. Tapirs' nose and upper lip combine to form a small proboscis.

Order 11: Primates

They have an opposable thumb and five digits on both limbs and the hindlimbs collectively. Every finger has a nail. All but humans have hair covering their bodies. Both the forelimbs and occasionally the hindlimbs are designed for grabbing. Lemurs, tarsiers, monkeys, apes, and gibbons (Fig. 10.16) are a few examples.

Fig. 10.16:Gibbon

10.4: Self-Assessment

1. Write a detail about the heart and kidney of Mammalian.

2. Write the Classification of Mammalia.

3. Write comments on Chiroptera.

UNIT-11

ADAPTIVE RADIATION WITH REFERENCE TO LOCOMOTORY APPENDAGES: ZOOGEOGRAPHY ZOOGEOGRAPHICAL REALMS AND CONTINENTAL DRIFT THEORY

At the end of the Unit students will be able to understand:

- Adaptive radiation with reference to locomotory appendages
- Zoogeography Zoogeographical realms
- Continental drift theory

11.1 Adaptive radiation with reference to locomotory appendages

The concept was given by H.F. Osborn created the theory of adaptive radiation in evolution in 1898. Adaptive radiation is the process by which different genus species or groups of related species diversify to survive in various ecological or geographic environments. The emergence of new species is caused by this adaptive diversity. Examples that are frequently offered as proof include the Galapagos Islands' Darwin's finches, the different limb structures of mammals, Australian marsupials, etc.

11.2 Mammals' adaptive radiation in their limb structure

The pentadactylus limb is modified into mammalian limbs. Since the animals lived on land, modern mammals descended from these terrestrial ancestors. Adaptive radiation has recently been observed in five distinct lines or habitats with altered limb anatomy (Fig-1).

1. An evolutionary branch splits off to create arboreal forms, such as squirrels, sloths, monkeys, and so on, with limbs tailored for living in trees.

2. An additional line connects to an aerial depiction of mammals with flying adaptations, such as bats. The only real flying mammals are them. In keeping with this, we can include flying squirrels and other gliding mammals in the same arena.

3. Cursorial creatures, such antelopes and horses, originated from the third line of radiation.

Their limbs have evolved to allow for quick movements across the ground. Other mammals with less drastically altered limbs, such wolves, foxes, hyaenas, lions, etc., also evolved along this line.

4. The fourth line of radiation gave rise to the fossorial animals, which burrow. Although some fossorial mammals, such as moles, have altered their forelimbs to enable digging, their

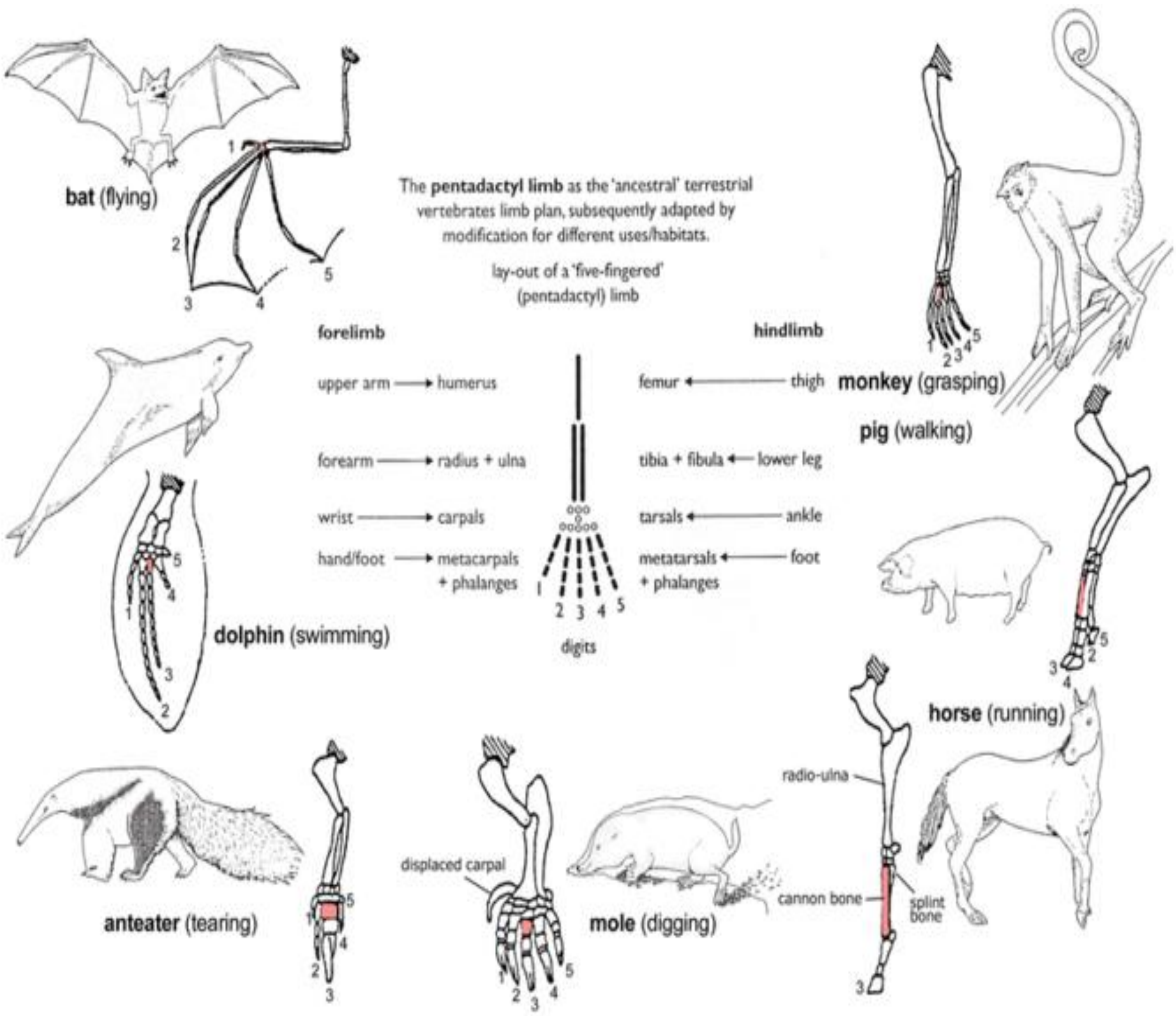
ground movement is not well suited to them. Some animals, such as pocket gophers and badgers, are skilled diggers, yet they have preserved structures that allow them to move around easily on the ground.

5. The aquatic mammals are reached by the fifth line of radiation:

(i) Although their limbs are highly adapted for aquatic life, whales and porpoises are immobile on land.

(ii) Although they can move around on land, seals, sea lions, and walruses have also had their limbs significantly altered for water existence.

(iii) The third category consists of polar bears, who are equally comfortable in the water as they are on land, and skilled swimmers like others(Fig 11.1)



Every mammal belonging to a distinct radiating line has limbs that are essentially designed for a specific type of movement. Each line begins at the same point, which symbolizes the pentadactylus, or short, limb found on land mammals.

Evolutionary lines extend outward in different directions from the center. Therefore, evolution that proceeds in multiple directions from a common ancestral type is known as adaptive radiation. However, the presence of this similar limb pattern suggests a close link between fish and mammals, as well as between birds, reptiles, and amphibians.

11.3 Zoogeography Zoogeographical realms

The planet can be split into many zones based on the presence or absence of various organisms. We refer to these areas as realms. Numerous scientists put presented various realm schemes.

The geographical regions of the Earth were split into six sections by P. L. Sclater in 1857 based on the distribution of birds.

Following that, a paper on zoogeographical realms was published by Alfred Russel Wallace in 1876. He kept Sclater's "six area concept," but he also studied all terrestrial animals and invertebrates.

His sole alteration was to rename the Sclater region from Indian to Oriental.

The realms they described were all divided from one another by recognizable walls. Wallace's suggested partition structure is shown here and realms are divided by dotted lines on global scale known as Wallace's line(Fig 11

a. Palaearctic Realm.

b. Nearctic Realm.

c. Neo-tropical Realm. d. Ethiopian Realm.

e. Oriental Realm.

f. Australian Realm.

Fig 11.2: Zoogeographic realms of world

a. The Palearctic Region:

A. Geographic Boundary:

The entire continent of Europe, the northern portion of Africa, the Asian Himalaya, and the Nanling Range of China make up this realm's geographical boundaries.

B. Subdivisions:

Wallace subsequently split this realm into four smaller parts.

(i) Black Kokesus, Northern and Central Europe, is the European Subregion.

(ii) The Mediterranean Sub-region, which includes Afghanistan, Baluchistan, Africa, Asia, and Europe.

(iii) Siberian Sub-region: Northern Asia, or the northern portion of the Himalaya.

(iv) Japan, Korea, Manchuria, Mongolia, and the Manchurian Subregion.

C. Climate:

This region is characterized by the extremes of heat from the Sahara desert and cold from Siberia.

D. Natural Conditions:

Mixed forest, coniferous forest, vast grassland, and deciduous woodland. This area also has tundra area.

E. Typical Fauna of Vertebrates:

(i) **Fish:** In this region's freshwater, carp, salmon, pike, and stickleback are frequently found.

(ii) **Amphibia:** Proteius, Hynobius, Bombinator, Alytes, Didocus, and European Salamander, among others.

(iii) **Reptiles:** Alligator, Trigonophis lizard, and Sand Boa.

(iv) **Avian species:** warblers, finches, pheasants, geese, Arctic terns, etc.

(v) **Animals**:Seluinidae and Ailuropodie are two of the 39 families of distinctive mammals that are endemic. Porcupines, dogs, wild boar, arctic cats, deer, and European bison are examples of other animals.

b. The Nearctic Realm:

A. Geographical Boundary: This area includes all of North America to the north, East Greenland, the west Aleutian islands, and Mexico to the south.

B. Subdivisions: It is further separated into four smaller regions.

(i) **Californian Sub-region**: This region includes portions of the Cascade Hill region, Nevada, and the Vancouver Island portion of British Columbia. It is referred to as the area with minimal biodiversity.

(ii) **Rocky Mountain Sub-region**: A high, rocky mountain range can be found in eastern California. Among the Nearctic region, this one has a significant zoo-diversity.

(iii) The Rocky Mountain Sub-region's eastern boundary is shared with the Allegheny Sub-region. The Great Lakes border its northern region. This area's subregion has mild

C. Climate Conditions:

Like Palaearctic area has extreme hot and cold conditions.

D. Ecological Condition:

Prominent ecological zonations include tundra regions, large grasslands, coniferous forests, arid terrain, and deciduous forest range.

E. Typical Vertebrate Fauna:

(i) Fish : Lepisosteus, Polydon, Acipenser, and other Perches.

(ii) Amphibian species include axolotl larvae, sirens, amphiuma, cryptobranchus, ambystoma, and ascaphys. The majority of them are caudata.

(iii) Reptiles : Notable snakes include Conophis, Chilomeniscus, Pituophis, and Farancia. Aromochelys and Chelydra are turtles, whereas Phrynosoma and Uta are lizards.
(iv) Avian creatures : owl, hawk, kite, saras, swan, crow, cuckoo, turkey, pelican, etc. They are primarily migratory birds.
(v) Mammal s: bison, reindeer, bat, goat, mask ox, deer, pronghorn, srew, mole, bear, wolf, and so forth. Pronghorn and the animal family Aplodontidae are indigenous.
c. Neo-tropical Realm:

A. Geographical Boundary: This region is made up of lower Mexico, the West Indies, and parts of South and Central America. The central American isthmus connects this region to the Nearctic region, whereas the sea borders other areas.

B. Subdivisions: There are four subregions inside this as well:
(i) The Chilean Sub-region is made up of the Andes mountain range, Bolivia, Peru, and the Western portion of South America. The faunal content is not as abundant.
(ii) The Brazilian Sub-region reaches the Panama Canal and includes the entirety of Brazil. The composition of the fauna is extremely rich.
(iii) The Mexican Sub-region is located on the northern side of the Panama isthmus, which is the border between North and South America. It has some significant wildlife.
This subregion is found on the northern side of the Panama isthmus, which is located in both North and South America. It has some significant wildlife.
(iv) Antillean Sub-region: This sub-region includes all of the West Indies, with the exception of Trinidad and Tobago. One of this sub-region's peculiarities is its low animal content.

C. Climatic Conditions: Tropical drylands cover the majority of this region. The only region in America with a moderate climate is the south.

D. Ecological Status: Tropical rain forest can be found in the Amazon valley. Savannah and grasslands are found in temperate regions. The environment of the arid western region of South America resembles a desert. Grasslands make up the majority of Argentina.

E. Typical Vertebrate Fauna:

(i) Fishes: This area is home to 120 genus of fish from the three families (Polycentridae, Gymnotidae, and Trigonidae). Fish that are commonly found include catfish, eels, and lepidosiren.

(ii) Amphibian species: salamanders, frogs, toads, caecilia, Siphonopsis, Hyla, etc.

(iii) Reptiles: Chelys, Gecko, Alligator, Boa, Epicrates, and so forth.

(iv) Avian Life: A total of 700 taxa of birds have been identified in this area. They include rea, tenemus, screamus, whatgin, thrush, parakeet, and to wean.

(v) Mammals: A total of 32 families are known to exist, some of which are significant. These include the American tapir, bat, spider monkey, lama, opossum, caenolestes, sloth, and armadillo.

Fig 11.3: America Tapir and Spider monkey

d. Ethiopian Realm:

A. Geographic Boundary: It includes Madagascar, the southern portion of Arabia, the southern portion of the Tropic of Cancer, and the majority of the African continent.

B. Subdivisions: It is further separated into four smaller regions.

(i) East African Sub-region: This subregion includes Arabia and the hot, arid regions of Africa.

(ii) The West African Sub-region: This sub-region includes Kongo and the western portion of Ethiopia.

(iii) South African Sub-region: This sub-region encompasses the entirety of southern Africa.

(iv) Madagascar: This sub-region encompasses the entirety of Madagascar.

C. Climate: Generally mild in most places, although it stays hot for the majority of the year.

D. State of the Ecosystem:

Rain forests can be found beside big rivers in West Africa and the equinoctial line. Deciduous forests, mostly dry, cover the remaining areas. The region's northern and southern regions turn into deserts.

E. Distinctive Vertebrate Fauna:

(i) Aquarium Fish There are various freshwater fishes(Fig 11.4 A,B)

(ii) Amphibians: There are Xenopus and a number of caecilian species. There is no group caudata at all.

(iii) Reptiles: Noteworthy species include Monotrophis, Cordylus, Agama, Chameleon, and snakes such as Leptorhynchus and Ramnophis.

(iv) Avian: There are 67 known families of Aves. Ostrich, cuckoo, parakeet, eagle, kite, pigeon, hornbill, etc. are a few significant species.

(v) Mammals: Of the 51 families that have been identified, 15 are endemic. Zebra, gorilla, antilope, leopard, two-horned rhinoceros, hippopotamus, lemur, gnu, beboon, lion, giraffe, chimpanzee, loxodonta, and more unusual species are among them(Fig 11.5).

Fig 11.4: Lung fish and Cat fish

Fig 11.5: gnu in its natural habitat

F. The Oriental Realm

A. Geographical Boundary: This region includes the majority of the Asian nations that are located on the southern slopes of the Himalaya. This region includes, among other places, India, Burma, Indo-China, Malay, Sumatra, Java, Bali, Borneo, and the Philippines.

B. Subdivisions:

It is divided into four smaller regions.

(i) Sub-region of India:

This sub-region includes the entire Indian subcontinent, extending from the base of the Himalaya. Division of the Indian Sub-region: Wallace (1876) divided the Indian sub-region according to the distribution of mollusks, reptiles, birds, and mammals. Mahendra further separated the Indian sub-region in 1942 according to the species of plants and animals found there.

The following are the divisions:

1. Northern India's arid and semiarid regions
2. The Himalaya's western flank
3. Southern part of Burma
4. Ganges Plateau
5. Southern India latitudes below 20°
6. The region above 20° latitude and the Ganga plateau 7. Tribankur
8. Ceylon
9. Islands of Nicobar
10. Islands of Andaman

(ii) Ceylonese Sub-region: This sub-region includes Sri Lanka and a portion of the Indian peninsula.

(iii) The Indo-Chinese Sub-region is bordered by South China, Burma, Thailand, and Indochina.

(iv) The Indo-Malayan Sub-region: This section of the Oriental realm is to the east. This subregion includes the islands of the East Indies and the Maldives.

C. Environmental Situation:

Most people experience a moderate environment. Rainfall totaling over 1500 mm every year.

D. Ecological Status: A thick rain forest covers the eastern portion. The western region has a desert. There is moderate forest in other areas.

E. Typical fauna of vertebrates:

(i) Fish: An assortment of carp, catfish, notopteridae, osteoglocid, cipriniformes, and other varieties.

(ii) Amphibians: There are several anuran species, some salamander species, and caecilian species.

(iii) Reptiles: a variety of lizards, including Gekko, Aagamid, Varanus, Chamellion, Crocodiles, and Gavialis; snakes, including vipers, pit vipers, kraits, and others. Turtles belong to the family Platysternidae.

(iv) There are birds: owls, finches, pheasants, peacocks, saras, etc.

(v) Mammals: Among them are rhinoceroses, unicorns, shrews, rabbits, dogs, cats, boars, rats, flying lemurs, elephants, oxen, tigers, orangutans, gibbons, tapirs, pangolins, and rhinoceroses. Only four of the thirty families are endemic.

F. Realm Australia:

A. Geographical Boundary: This realm includes certain surrounding islands as well as Australia, New Zealand, New Guinea, and Tasmania.

B. Subdivisions: There are four subregions within this.

(i) Austro-Malayan Sub-regions: This subregion is covered by the Malay archipelago, which includes Solomon Islands, New Guinea, and the Moluccas.

(ii) Australian Sub-region: This sub-region is made up of Australia and Tasmania.

(iii) The Polynesian Sub-region, which includes the islands of Sandwick and Polynesia.

(iv) The New Zealand Sub-region is made up of the islands of Macquarie, Norfolk Island, Auckland, Campbell, and New Zealand.

C. Climate: This area has both hot and moderate climates. A year's worth of rainfall averages 75 mm.

D. Ecological Condition: Notable ecological features include grasslands, eucalyptus forests, and rain forests.

E. Typical Fauna of Vertebrates:

(i) Neoceratodus fish Osteoglocidos, Gadopcidae, lung fish, etc.

(ii) Amphibians: The family Xenorhinidae is exclusive to New Guinea.

Other significant members include Pseudophryne, Pachybatrachus, Helioporus, and Pelodyrus.

There are 11 families total that are listed.

(iii) Reptiles: Pizopidae, Apracidae, and Liadidae are well-known lizard families; Phithonidae and Elapidae are significant snake families. The well-known remnant of the reptile family Rhynchocephalidae, found in New Zealand, is the sphenodon.

(iv) Avian species: Notable birds in this area include the casuary, liar bird, magpie, emu, kiwi, scrab, and bawar. There are 976 bird species known to exist in this area.

(v) Mammals: Among the notable species are Ornithorhynchus, a marsupial, Tachyglossus, an ant-eating mammal, Kangaroo, Dasyures, Dendrolagus, a climbing kangaroo, Petaurus, a flying opossum, and wolves.

Fig 11.5: Tachyglossus in its natural habitat

11.3 Self-Assessment

i) List the general traits of all mammals.

ii) Use appropriate examples and traits to classify mammals according to order.

iii) Write in detail about prototheria's affinities. IV. Adaptive radiation: What is it?

v) Write in detail about adaptive radiation in mammals using the limb structure as a guide.

UNIT-12
GLOSSARY

Protochordata: A subphylum of chordates comprising primitive marine animals, including Hemichordata, Urochordata, and Cephalochordata. They exhibit characteristics such as a notochord and dorsal nerve cord in at least some stage of their life cycle.

Hemichordata: A phylum of marine organisms within the subphylum Protochordata, characterized by a tripartite body plan consisting of a proboscis, collar, and trunk. They are often filter feeders and exhibit both solitary and colonial lifestyles.

Urochordata: Also known as tunicates or sea squirts, they are marine invertebrates characterized by a sac-like body enclosed in a tough tunic. They possess a notochord only in their larval stage, undergoing retrogressive metamorphosis as they transition into adults.

Cephalochordata: A subphylum of small marine chordates, commonly referred to as lancelets or amphioxus. They possess a notochord throughout their entire life cycle and exhibit characteristics resembling those of early vertebrates.

Retrogressive Metamorphosis: A developmental process observed in Urochordata, where the larval form undergoes regression and simplification to become the adult form. This includes the loss of complex structures such as the notochord and tail.

Agnatha: A superclass of jawless fishes, including the classes Cyclostomata and Ostracodermi. They lack true jaws and paired fins and are characterized by a cartilaginous skeleton and a cylindrical body shape.

Cyclostomes: A class of jawless fishes within the superclass Agnatha, including lampreys and hagfish. They possess a circular, sucking mouth and are often parasitic or scavengers.

Pisces: A superclass comprising all fish species. It is further divided into classes Chondrichthyes (cartilaginous fishes) and Osteichthyes (bony fishes).

Chondrichthyes: A class of fish characterized by a skeleton composed of cartilage, placoid scales, and a predominantly predatory lifestyle. Examples include sharks, rays, and skates.

Osteichthyes: A class of fish with a bony skeleton, usually covered in scales, and possessing gill covers. They are the most diverse group of vertebrates and include familiar fish species such as salmon, tuna, and trout.

Migration: The seasonal movement of fish populations from one region to another, often driven by factors such as food availability, reproduction, or environmental conditions.

Osmoregulation: The physiological process by which fish regulate the balance of water and salts within their bodies, crucial for maintaining internal homeostasis in varying aquatic environments.

Parental Care: Behaviors exhibited by fish species to protect and nurture their offspring, including nest building, guarding eggs or young, and providing food or protection.

Amphibia: A class of vertebrates encompassing frogs, toads, salamanders, and caecilians. They are characterized by a dual life cycle, spending part of their life in water and part on land.

Reptilia: A class of cold-blooded vertebrates, including turtles, lizards, snakes, crocodiles, and tuataras. They are characterized by their scaly skin, amniotic eggs, and ectothermic metabolism.

Poison Apparatus: Specialized structures found in some reptiles, particularly snakes, for del.

UNIT-13
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