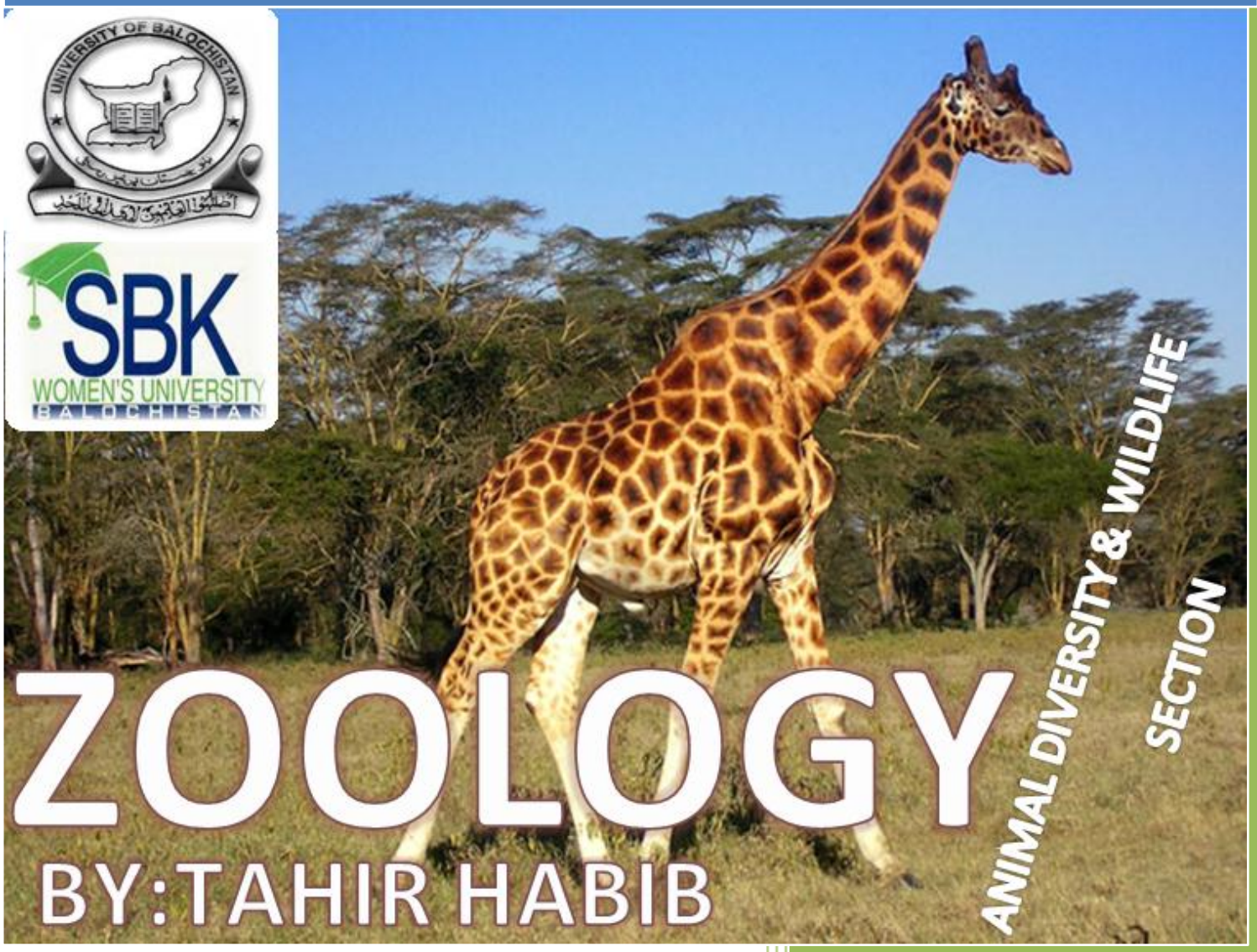
ZOOLOGY NOTES FOR CSS, PCS, M.SC , B.SC , LETURER & OTHER EXAMS



TAHIR HABIB

This book is meant for students of B.Sc., B.Sc (Hons.) and M.Sc. of biological group.

Students appearing in exams of **C.S.S, P.C.S. and for the post of Lecturer ZOOLOGY**., etc, may be immensely benefited by this book. This book has been written strictly according to syllabus of **H.E.C.** It is copied from different sources mostly from **Zoology of Miller and Harley**, and extra material is also included.

I am highly thankful to my Friends **Abdul Hameed Korai & Shahnawaz Silachi** because their inspiration always remained encouraging for me. I am also thankful to my teachers **Sir Asim Iqbal , Kashif Kamran Iqbal sahab , Walli Achakzai Sahab ,Saeed Essote , Zahoor Ahmad Badini , Liaqat sahab, Asmatullah Kakar , Faizullah and Atta ur Rahman Tarran.**

I am sure this book will prove to be an invaluable asset for the students and teachers.

To enhance your concept in Zoology please study 1. Zoology by Miller and Harley , 2.Integrated principles of Zoology by Hickman, 3. Zoology by Raven & Johnson and 4.Biology by Reece and Campbell and study three Books A.B.C Zoology for B.sc .

I shall feel highly obliged if suggestions for the improvement of the book are brought to my notice, so that future edition of the book may become more useful.

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Contents

CHARACTERISTICS OF INVERTIBRATES

Some General Features of Animals

Animals are the eaters or consumers of the earth. They are heterotrophs and depend directly or indirectly on plants, photosynthetic protists (algae), or autotrophic bacteria for nourishment. Animals are able to move from place to place in search of food. In most, ingestion of food is followed by digestion in an internal cavity.

1. **Multicellular Heterotrophs.** All animals are multicellular heterotrophs. The unicellular heterotrophic organisms called Protozoa, which were at one time regarded as simple animals, are now considered to be members of the kingdom Protista, the large and diverse group.

2. **Diverse in Form.** Almost all animals (99%) are **invertebrates,** lacking a backbone. Of the estimated 10 million living animal species, only 42,500 have a backbone and are referred to as **vertebrates.** The animal kingdom includes about 35 phyla, most of which occur in the sea. Far fewer phyla occur in fresh water and fewer still occur on land. Members of three phyla, Arthropoda (spiders and insects), Mollusca (snails), and Chordata (vertebrates), dominate animal life on land.

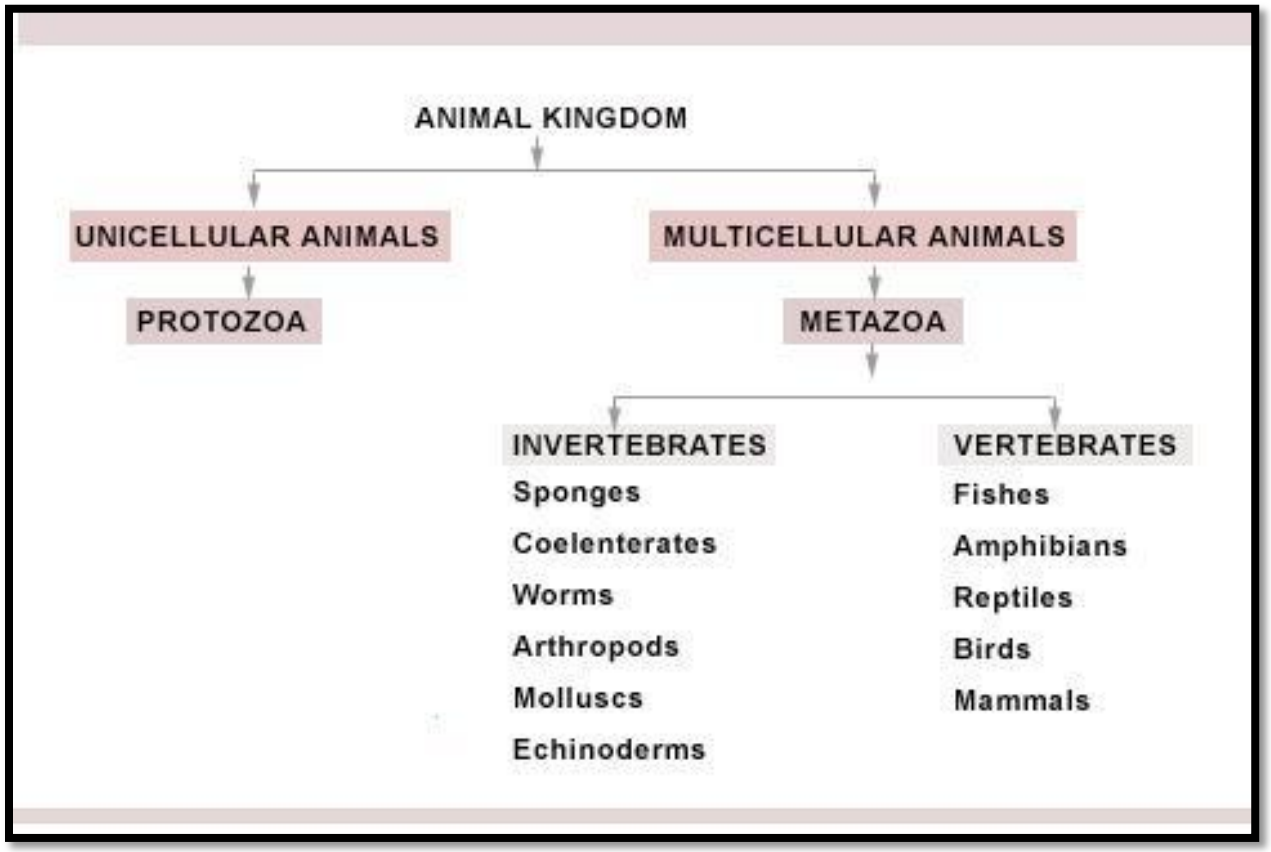
3. **No Cell Walls.** Animal cells are distinct among multicellular organisms because they lack rigid cell walls and are usually quite flexible.

4. **Active Movement.** The ability of animals to move more rapidly and in more complex ways than members of other kingdoms is perhaps their most striking characteristic and one that is directly related to the flexibility of their cells and the evolution of nerve and muscle tissues.

5. **Sexual Reproduction.** Most animals reproduce sexually. Animal eggs, which are non-motile, are much larger than the small, usually flagellated sperm. In animals, cells formed in meiosis function directly as gametes. The haploid cells do not divide by mitosis first, as they do in plants and fungi, but rather fuse directly with each other to form the zygote.

6. **Embryonic Development.** Most animals have a similar pattern of embryonic development. The zygote first under- goes a series of mitotic divisions, called *cleavage*, and be- comes a solid ball of cells, the **morula,** then a hollow ball of cells, the **blastula.** In most animals, the blastula folds in- ward at one point to form a hollow sac with an opening at one end called the **blastopore.** An embryo at this stage is called a **gastrula.**

CLASSIFICATION OF ANIMALIA KINGDOM:



CHAPTER 1 : PHYLUM PROTOZOA

Protozoa

Protozoa are single celled organisms. They come in many different shapes and sizes ranging from an *Amoeba* which can change its shape to *Paramecium* with its fixed shape and complex structure. They live in a wide variety of moist habitats including fresh water, marine environments and the soil.

Protozoa: Definition, Characteristics, Classification and Types

Definition:

Protozoa are eukaryotic, unicellular microorganisms, which lack cell wall.

Characteristics of Protozoa:

The major distinguishing characteristics of protozoa are given below:

1. They do not have cell wall; some however, possess a flexible layer, a pellicle, or a rigid shell of inorganic materials outside the cell membrane.
2. They have the ability during their entire life cycle or part of it to move by locomotor organelles or by a gliding mechanism.
3. They have heterotrophic mode of nutrition, whereby the free-living forms ingest particulates, such as bacteria, yeast and algae, while the parasitic forms derive nutrients from the body fluids of their hosts.
4. They are unicellular with some colonial and multicellular stages.
5. Most are microscopic.
6. All symmetries are present within members of the group.
7. No germ layers are present.
8. No organs or tissues are formed, but specialized organelles serve many of these functions

Classification of Protozoa:

The classification of protozoa is mainly based on their means of locomotion. They are subdivided into the following four classes (or subphyla by some taxonomists). Species marked with asterisks (*) have been described in details with illustrations.

1. Sarcodina:

Motility is due to the streaming of ectoplasm, producing protoplasmic projections called pseudopodia (false feet). Examples: Free-living form like Amoeba proteus* and parasitic form like Entamoeba histolytica*.

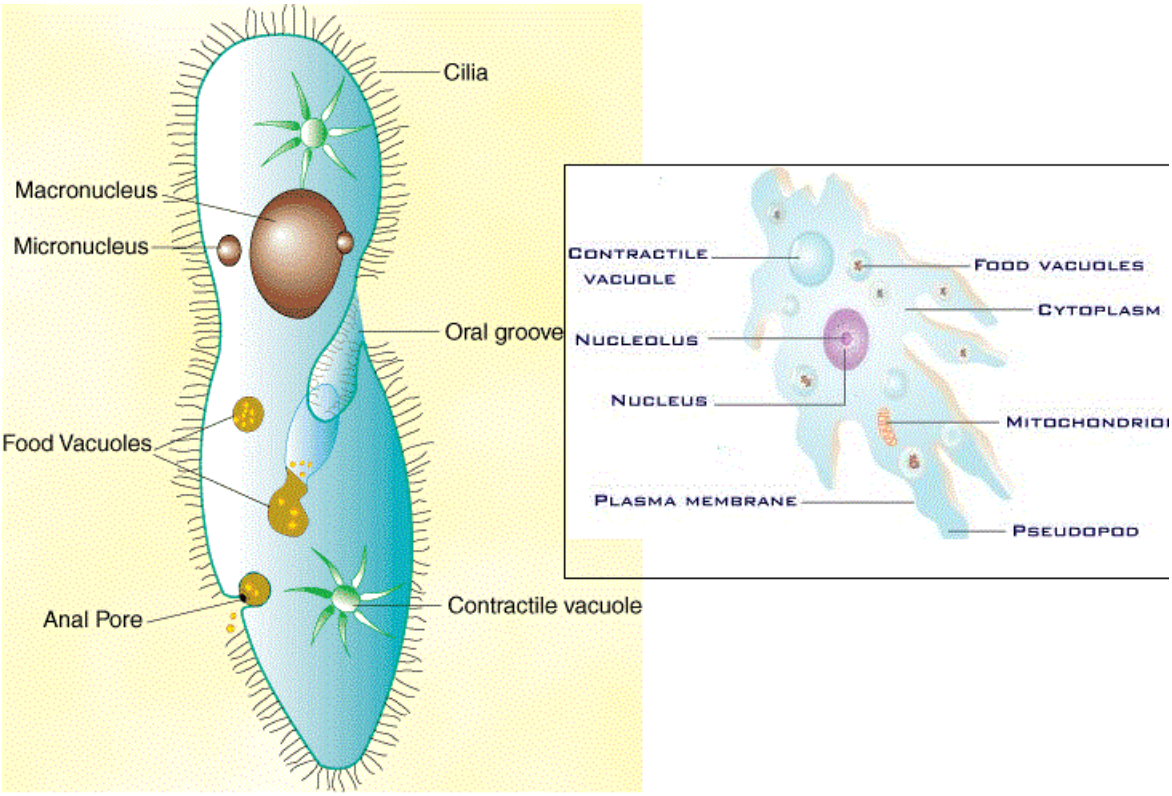
2. Mastigophora:

Locomotion is effected by one or more whip-like, thin structures called flagella. Examples: Free-living forms like Euglena viridis*, Cercomonas longicauda*, Heteronema acus* and parasitic forms like Trichomonas vaginalis, Trypanosoma gambiense*, Giardia lamblia*.

3. Ciliophora:

Locomotion is carried out by means of short hair-like projections called cilia, whose synchronous beating propels the organisms. Examples: Free-living forms like Paramecium caudatum*, Stentor polymorpha*, Vorticella campanula* and parasitic form like Balantidium

coli*.



4. Sporozoa:

Unlike the above three classless of protozoa, members of the class sporozoa do not have locomotor organelles in their mature stage; however, immature forms exhibit some type of movement. All the members of this group are parasites.

Examples: Plasmodium, the malarial parasites of animals and human beings.

Types of Protozoa:

Based on the mode of nutrition, protozoa are of the following two types:

1. Free-living protozoa: They ingest particulates, such as bacteria, yeast and algae.

2. Parasitic protozoa: They derive nutrients from the body fluids of their hosts.

ECONOMIC IMPORTANCE OF PROTOZOA:

1. Food to sea animals.
2. Some feed on algae so form a link in food chain.
3. They are used in research study to know cell function like reproduction.
4. In case of termites, they help in digestion.
5. With the stony shells they get fossilized to form limestone and chalk.
6. There are many protozoans cause diseases in man i-e, Giardiasis, malaria etc.

PROTOZOAN DISEASES

1. Amoebiasis

This disease is **caused by the sarcodina group of protozoa**. They secrete enzymes that are then absorbed by the tissue of the host. Amoebiasis is transmitted through contact with infected feces. **Food and water contaminated by feces is the most common route of transmission**, however, oral contact with fecal matter can also cause infection. Sometimes there are no visible symptoms but some common ones **include loose stools with varying amounts of blood and an inflamed colon.** This disease is treatable with an antibiotic such as **metronidazole**.

2. Giardiasis

This disease is also **transmitted through oral contact of feces as the parasite is found in fecal matter**. If hands are not properly washed after using the bathroom or changing a diaper, it is easy to come into contact with this parasite. Drinking water which has been contaminated by this parasite or even ingesting contaminated swimming water can cause giardiasis. **Symptoms include mucusy stools, diarrhea, nausea, abdominal pain and upset stomach.** This disease is treatable with an antibiotic such as metronidazole.

3. African Sleeping Sickness

African sleeping sickness is a disease caused by the **protozoa,** which **are carried by the tsetse fly** and are transmitted to humans through **tsetse fly bites.** This disease is fairly damaging to the human body and can cause serious illness. Symptoms of this disease include confusion, seizures, insomnia, personality changes, weight loss, slurred speech and trouble talking or walking.

4. Leishmaniasis

This disease is caused by **the Leishmania parasite**. These parasites are found mainly in southern Europe, the tropics and subtropics. The most common form of this disease being spread is through the bite of a sand fly, which carries the parasite**. External leishmaniasis will affect the skin and internal leshmaniasis affects the inner organs such as the spleen and liver.**

Those parasites that affect the skin cause sores, which will enlarge and become deeper as the disease progresses without treatment. Internal infection will cause weight loss, organ enlargement, fever and extremely high or low blood levels.

5. Toxoplasmosis

Toxoplasmosis is caused by one of the most common parasites in the world, according to the Mayo Clinic. Many of the people infected by this disease do not have any symptoms. However, for those who have weak immune systems such as infants and people suffering from chronic illnesses, this parasite can cause serious illness. Infants who are born to mothers who carry the infection can experience complications at birth. Other symptoms include body aches, fatigue, fever, sore throat and swollen lymph nodes. **Symptoms are very similar to flu like symptoms and this disease can sometimes be mistaken for the flu.**

6. Malaria

Malaria is a very common disease in some countries and is **spread through mosquito bites of** mosquitoes that have been infected by one of the many different malaria-causing parasites. In the United States, there are more than 1300 cases of malaria reported. This is mainly reported by individuals travelling to or coming from the South Asian subcontinent or the sub-Saharan Africa who may be carrying the parasite**. Malaria symptoms include headache, chills, tremors, aches and shaking.**

7. Babesiosis

This disease is **caused by the Babesia** parasite that is **transmitted through ticks**. It can also be transmitted through blood transfusions of donors who carry the Babesia parasite. This parasite is common throughout the United States, in cities such as New England, New Jersey, New York, Wisconsin and Minnesota. Those individuals infected with the Babesia parasite may not experience any symptoms. However, common signs and **symptoms include nausea, body aches, fatigue, fever, chills, weight loss and a decreased appetite**. For those who are already suffering from health problems and those who have a compromised immune system, this disease can be life threatening and cause serious health problems.

8. Trichomoniasis

This disease is caused by the protozoan parasite, **Trichomonas vaginalis**. This disease is most commonly transmitted sexually. Symptoms of this disease differ per gender. In woman, vaginitis may occur which will cause **white green discharge , inflammation of vagina,vulva and malodourous** . Men may experience a **burning while urinating**. This disease is treatable with an antibiotic such as metronidazole.

Feeding and Nutrition

- Heterotrophs: Obtain food from external sources can not synthesis its own.
- Photoautotrophs
- Mixotrophs: Can switch between heterotrophy and autotrophy, depending on conditions

Nutrition occurs in four phases:

- Ingestion
- Digestion –mechanical and/or chemical
- Absorption
- Elimination

◆ Digestion typically intracellular. Food is phagocytized and a food vacuole is created. Digestive enzymes are dumped into vacuole

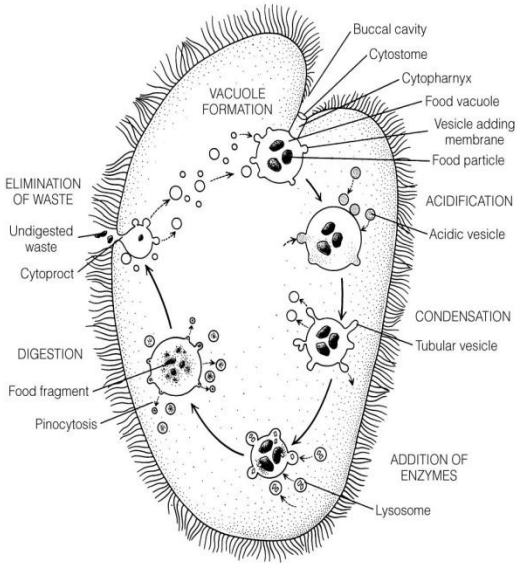


FIGURE 3-21, page 40: Alveolata: Ciliophora. Intracellular digestion in ciliates. © 2004 Brooks/Cole-Thomson Learning

CHAPTER 2 : PHYLUM PORIFERA

Etymology:- From the Latin *porus* for pore and *Ferre* to bear, hence an animal with with pores.

Definition:

a phylum of primitive invertebrate animals comprising the sponges and having a cellular grade of construction without true tissue or organ formation but with the body permeated by canals and chambers through which a current of water flows and passes in its course through one or more cavities lined with choanocytes

Characteristics of Porifera:-

1)No definite symmetry.
2)Body multicellular, few tissues, no organs.
3)Cells and tissues surround a water filled space but there is no true body cavity.
4)All are sessile, (live attached to something as an adult).
5)Reproduce sexually or asexually, sexual reproduction can be either gonochoristic or hermaphroditic.
6)Has no nervous system.
7)Has a distinct larval stage which is planktonic.
8)Lives in aquatic environments, mostly marine.
9)All are filter feeders.
10)Often have a skeleton of spicules.

MORPHOLOGY

Have 4 very loosely differentiated cells:

Pinacocytes- outer cells covering sponge; equivalent of epiderm

Porococytes- cells which line the pores of the sponge; through which water is drawn

Choanocytes- similar to choanoflagellates; collared cells with flagella which create water current and collect food matter or sticky contractile collar; may also produce sperm.

Amoebocytes- amoeba-like cells found throughout the sponge; store, digest and transport food, excrete wastes, secrete skeleton and also may give rise to buds in asexual reproduction; there are several different types:

Large Amoebocytes- distribute food to other cells of sponge; move by way of pseudopods

Archeocytes- undifferentiated sponge cells that can give rise to more differentiated cells such as pinacocytes, porocytes or oocytes.

Scleroblasts- produce spicules; two types

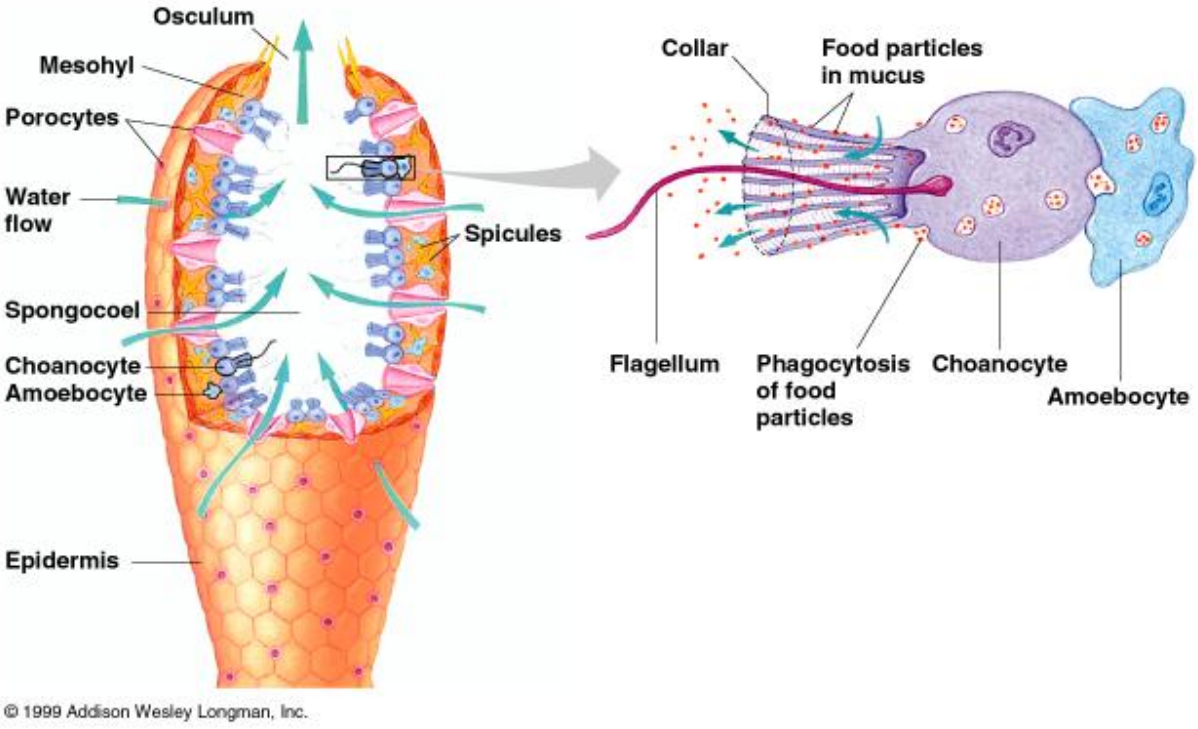
Calcoblasts- make calcium carbonate spicules

Silicoblasts- make silicious spicules

Body Structure

A sponge, being a filter-feeding animal, has thousands of little pores and canals running through its body. Water is drawn in and shunted throughout its tissue for filtration. In fact, the vast number of pores in a sponge's body are actually where the phylum derives its name from; Porifera literally means 'bearing pores.'

The most abundant pores, called **ostia**, are used to draw water into the animal's interior cavity, called the **spongocoel**. Other cells, such as the **osculum** are exit pores that expel filtered water out of the organism. Once water passes through the ostia, and into the organism, it usually enters a series of canals that connect little chambers within the tissue, called **radial canals**. The surface of these canals is lined with specialized cells, called choanocytes, whose sole purpose is to filter any organic particulate out of the water for feeding or, if the season is right, to filter eggs and sperm out of the water during reproductive spawning events.



Types of Canal System of Porifera

The body of the sponge is traversed by numerous canals opening to the outside by many minute pores. These canals and pores of Sponge constitute the canal system.

Types of Canal system :-

There are four types of Canal system in Sponges. They are as follows-

(1) Ascon Type :-

It is the simplest type of Canal system. It is exhibited by sponges like Olynthus and Leucosolenia. These animals are cylindrical in shape. The body wall is formed of three layers, namely an outer ectoderm, a middle merenchyme & an inner choanocytes. The wall contains many pores called Ostia. These pores are intra-cellular because each pore is formed by the perforation of a single cell called Porocyte. All the ostia open into a central cavity called Spongocoel which is outside at the free end & by a large circular opening called Osculam. The beating of the flagella of the choanocytes creates a water current. The water flows in the following route.

Ostia → Spongocoel → Osculam

(2) SYCON SPONGE-CANAL TYPE:

Sycon is a sedentary sponge. It leads an aquatic life The **body of sycon** shows pores and canals which form a complex canal system. It is called sycon type of canal system. It is useful to draw water current inside the body. These water currents bring in food and oxygen. The body wall of sycon contains outer dermal layer and inner choanoderm. in between these two layer mesenchyme is present. The body wall is folded regularly and develop a regular canal system.

1) Ostia : The body wall is folded. In between two folds an incurrent canal is present. The opening of incurrent canal shows a pore membrane. This will show one or two ostia, through which water enters into the incurrent canals. The ostium is surrounded by myocytes. These amoebocytes will work as sphincters. They can close these openings or open them to regulate the inflow of water.

2) Incurrent canals : In between two folds of the body wall an incurrent canal is present. These canals end blindly towards inside. This is lined inside by pinacocytes. These are flat cells and are contractile.

3) Prosopyles : The incurrent canal opens into the radial canal through prosopyles'.

4) Radial canals: In between two incurrent canals a radial canal is present. It ends blindly to the exterior. It leads into excurrent canal internally.

5) **Apopyle** : Radial canal opens into excurrent canal through an opening called apopyle. The apopyle is also surrounded by Myocytes.

6) **Excurrent canal**: It is short and wide chamber. It opens into spongocoel. This canal is lined with flat epithelial cell like the spongocoel. The board opening between excurrent canal and sponogocoel is also called internal ostium.

7) **Spongocoel**: The central part of the cylinder of sycon will show a hollow cavity called spongocoel. it is lined with epithelial cells. At the apex it opens out through osculum.

Because of the action of flagella of choanocytes water is drawn into the body. This is called incurrent water. This brings in food and oxygen. Hence it is called nutritive current. The water that goes out of the osculum is called excurrent water. **Written by Tahir Habib**

Functions of Sponge Canal System :

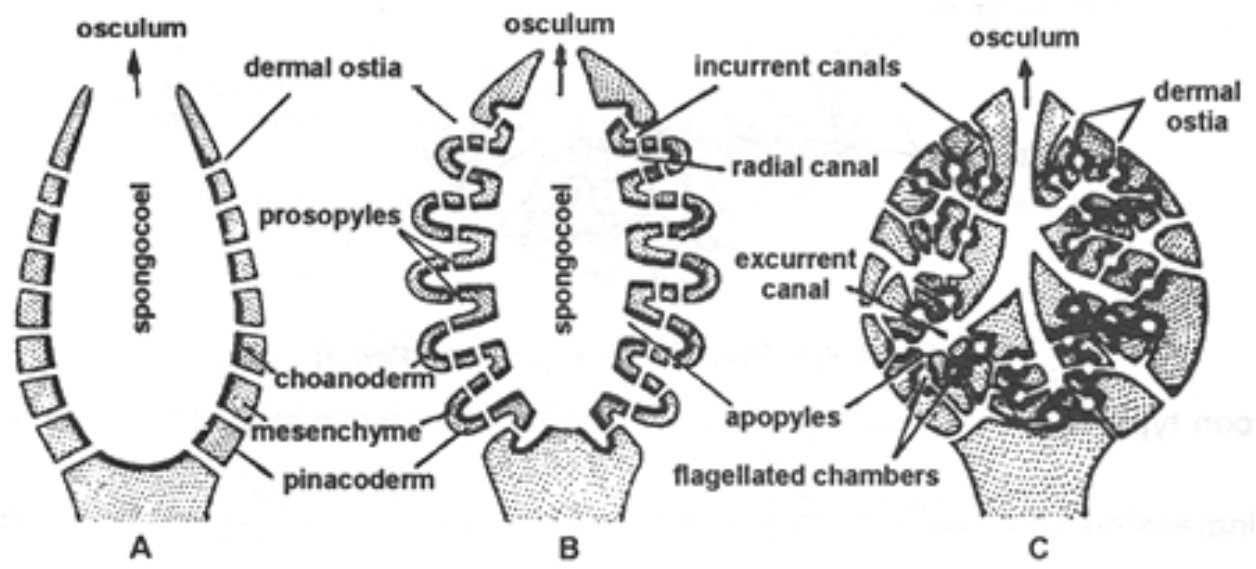
1) It brings constant supply of water into the body and helps in respiration.

2) Water brings with in small food particles which are used by the sponge

3) It helps in the process of reproduction.

4) It helps in the process of discarding waste matter out of the body.

Incurrent canal →Prosopyle → Radial canal → Apopyle → Spongocoel → Osculam



Spicules: Meaning, Classification and Development

Meaning of Spicules:

The spicules or sclerites are definite bodies, having a crystalline appearance and consisting in general of simple spines or of spines radiating from a point.

They have an axis of organic material around which is deposited the inorganic substance, either calcium carbonate or hydrated silica. They present a great variety of shape and as reference to the shape is essential in the description of sponges, a large terminology exists.

Classification of Spicules:

First, spicules are of two general kinds—**megascleres and microscleres**. The spicules are further classified according to the number of their axes and rays. Words designating the number of axes end in axons, those referring to the number of rays end in actine or actinal.

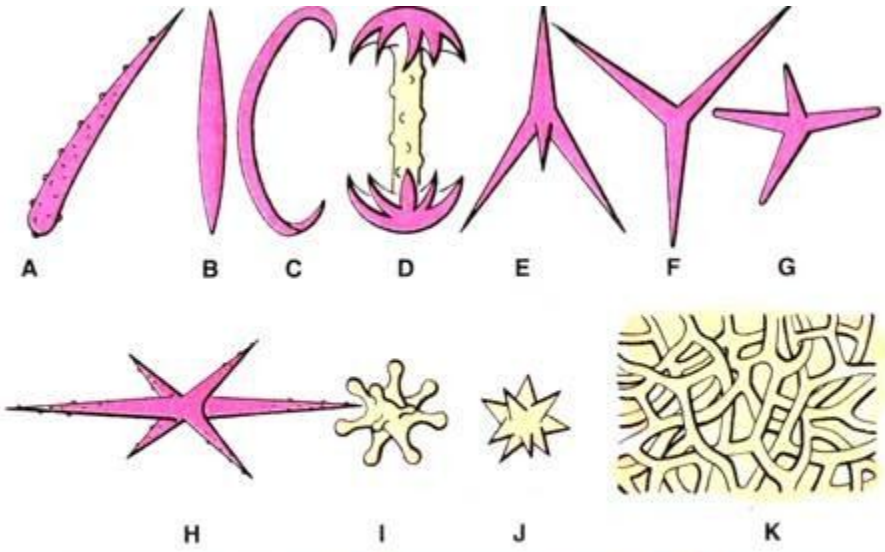


Fig. 28.9. Spicules and spongin. A—Monactinal monaxon; B—Diactinal monaxon; C—Curved monaxon; D—Monaxon with hooked ends; E—Tetraxon; F—Triradiate; G—Calthrops; H—Hexactinal triaxon; I and J—Polyaxon; K—Spongin fibres.

1. Megascleres:
The megascleres are the larger skeletal spicules that constitute the chief supporting framework of the sponge. There are **five general types of megasclere spicules, viz., 1.monaxons, 2.tetraxons, 3.triaxons, 4. polyaxons and 5.spheres**.

(i) Monaxons: These are formed by growth in one or both directions along a single axis, which may be straight or curved. When growth has occurred in one direction only, the spicule is called monactinal monaxon or style.
(ii) Tetraxons: Tetraxon spicules are also called tetractines and quadri radiates. They consist typically of four rays, not in the same plane, radiating from a common point. The four rays of the tetraxon spicule may be more or less equal, in which case the spicule is called a calthrops.

(iii) Triaxons: The triaxon or hexactinal spicule consists fundamentally of three axes crossing at right angles, producing six rays extending at right angles from a central point.

(iv) Polyaxons: These spicules in which several equal rays radiate from a central point.

(v) Spheres: These are rounded bodies in which growth is concentric around a centre.

(vi) Desma: A special type of megasclere known as desma occur in a number of sponges. A desma consists of an ordinary minute monaxon, triadiate,or tetraxon spicule, termed the crepis, on which layers of silica have been deposited irregularly

HIGHER CLASSIFICATION OF SPONGES

There are 4 classes of sponges:

1.Class Calcarea

- found in shallow coastal waters
- all are marine
- Having calcareous spicules

2.Class Hexactinellida - glass sponges

- chiefly live in 500-1000 meter depth
- are syconoid sponges
- all are marine
- Having six-rayed (hexasters) siliceous spicules.

3.**Class Demospongiae**

- spicules are silicious if present otherwise skeleton is made of spongin or both
- variously shaped some are huge
- all are leuconoid , all but two families are marine- Spongillidae and Metaniidae- are freshwater with about 300 freshwater species; in North America are about 27 species in 11 genera (most belong to Spongillidae)
- this is the group from which we get our commercial sponges
- Having siliceous spicules and spongin fibres.

4.Class Sclerospongiae

- have silicious spicules and spongin
- also have an outer covering composed of calcium carbonate
- are leuconoid sponges

Written by Tahir Habib

CHAPTER 3 : PHYLUM COELENTERATA (CNIDARIA)

Etymology:- From the Greek *knide* for nettle.

Definition: any invertebrate animal, as a hydra, jellyfish, sea anemone, or coral, considered as belonging to the **phylum Cnidaria**, characterized by the specialized stinging structures in the tentacles surrounding the mouth; a coelenterate

Introduction: The Cnidaria (pronounced nidaria)as a group of animals are well known to many people under their common names, Sea Anemones, Corals and Jellyfish are all Cnidarians as are Hydras, Sea Whips, Sea Fans and Sea Pansies. They are linked together by their carnivorous feeding habits their simple anatomical design and the possession of nematocysts, though one species of Ctenophora possesses nematocysts as well.

Characteristics of Phylum Coelenterata(CNIDARIA)

- Diploblastic body with two layers of cells, outer layer called ectoderm or epidermis and the inner layer known as the endoderm or gastro dermis.
- Phylum coelenterate characteristics is they have a single opening into the body which acts as both the mouth and anus which functions in taking food and expelling wastes.
- Coelenterates contain body cavity known as the coelenteron, where the digestion of food occurs. The name coelenterata for these animals is coined due to this character.
- Existence as tubular sessile polyp forms and swimming medusa forms is also phylum coelenterates characteristics.
- Polyp bodies often contain exoskeleton and endoskeleton.
- These skeletons are generally composed of minerals like calcium carbonate.
- Medusa generally have only hydrostatic skeletons.
- Coelenterates are generally carnivorous in nature, except some species, such as coral, that get some of their food from special symbionts living within them.
- They lack such sensory organs like eyes.
- They hunt food passively i.e., they just wave their tentacles and when prey does come in contact with the tentacles using special structures known as nematocysts either inject a toxin that paralyses and or kills the prey, or entangles the prey.
- Nematocyst is common in all coelenterates is phylum coelenterates characteristics and is one of major trait that distinguishes this phylum from the others. Also contains structures called spirocysts and ptychocysts.
- The mouth lining of coelenterates are known as cnidae the phylum coelenterates characteristics, which is how this phylum is named currently.
- All coelenterates are aquatic and mostly are marine in nature, found from the shallow water to the depths of the abyss. Some species of the class hydrozoans are found in freshwater ponds and lakes.

- The phylum is divided in to 4 major classes namely, anthozoa, cubozoa, hydrozoa, and scyphozoan.

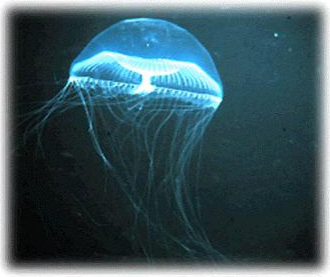
General Features:
1)Radially Symmetrical.
2)Body multicellular, few tissues, some organelles.
3)Body contains an internal cavity and a mouth.
4)Two different forms exist, medusa and polyp
5)Reproduction is asexual or sexual.
6)Has a simple net like nervous system.
7)Has a distinct larval stage which is planktonic.
8)Lives in aquatic environments, mostly marine.
9)Mostly carnivorous otherwise filter feeders.
10)May have a minimal skeleton of chiton or calcium carbonate.

A) Examples of Cnidarians

1.Hydras

-Class Hydrozoa
-Spend most of life as a polyp
- No medusa stage

2. Jellyfish/ Scyphozoa



-Class Scyphozoa
-Jellyfish go through the
same life-cycle stages as hydrozoans.
-In Scyphozoans the medusa is large and longer living, and the poly
larval stage.
-The nematocysts (stinging threads on tentacles) of most jellyfish are harmless to humans, but a few can cause painful stings**.**

3. Sea Anemones and Corals
-Class Anthozoa
-Anthozoans have only the polyp
stage in their life cycle.


Classification:

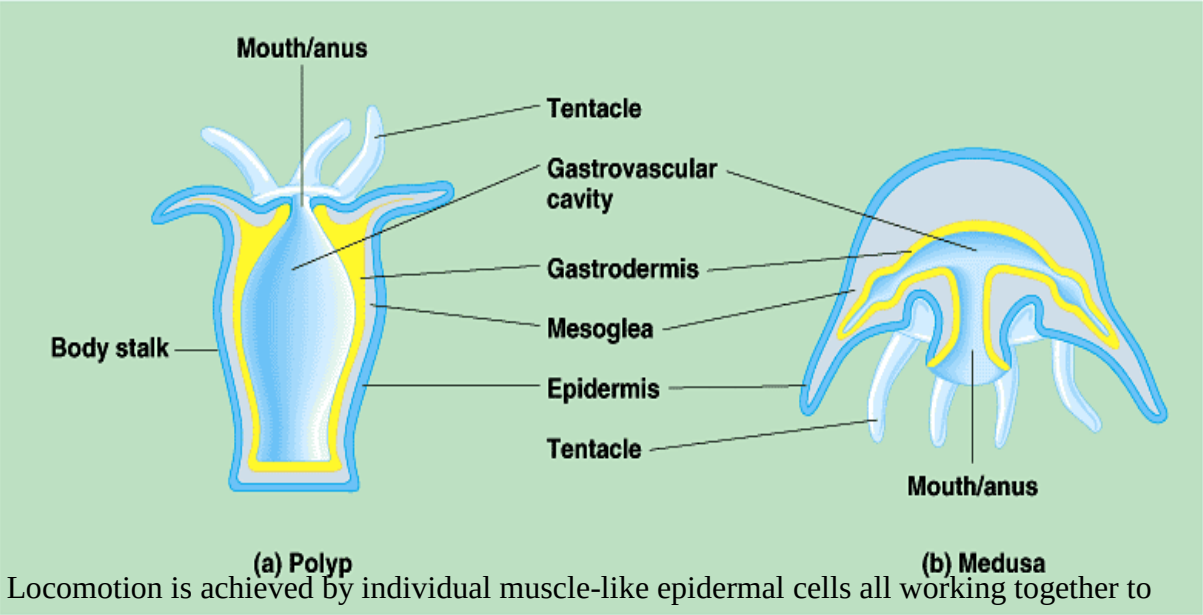
Class	Life Style	Form	Habitat	Genera
Hydrozoa	Solitary or colonial, sessile as adult	Sexual polyps and asexual medusa either of which may be absent.	Freshwater and Marine	*Hydra, Obelia, Physalia, Tubularia*
Scyphozoa	Solitary, nearly all free swimming	Sexual medusa with a reduced or absent polyp	Marine only	*Aurelia, Cassiopeia, Chironex, Rhizostoma*
Anthozoa	Solitary or colonial sessile as adult	Polyp only	Marine only	*Adamsia, Cerianthus, Gorgonia, Renilla*

B) Cnidarian Characteristics:

Body Plan:
- Radially symmetrical body with a single opening.
- Opening will allow food to enter and wastes to leave.
- Surrounding the mouth is a ring of tentacles (usually contains stinging cells)
- Tentacles contain nematocysts; when touched, the nematocyst thrusts out a spring-loaded poisonous thread into its prey, paralyzing or trapping it.
- Separating the outer ectoderm from the inner endoderm is a layer of mesoglea. (Mesoglea offers support for the animal).
-The body has two alternate but similar body forms.

a) ***POLYPS***
– Usually attached to some object with the mouth and tentacles directed upwards.
- Sessile (non-motile stuck to the bottom)

b) ***MEDUSA –***
Is free swimming with the mouth and tentacles directed downwards.



- Locomotion is achieved by individual muscle-like epidermal cells all working together to change shape.

- Nematocysts fire on contact; after paralyzing its prey, it pushes the food into its mouth with its tentacles.

Difference between Medusa and Polyp:

- Medusa is a free-swimming stage while polyp is a sessile form.
- Medusae are prominent in Scyphozoans while polyps are the only forms in the Anthozoans.
- Medusa is the reproductive stage and polyp is the asexual stage of Hydrozoans.
- Medusa has its mouth directed downwards while polyp has it directed upwards.
- Medusa has a pneumatophore but, not in polyp.
- Polyp has a simple and mostly uniform body shape while the shapes are slightly different among medusae.
- Mesoglea is thicker in medusa than in polyp.
- Tentacles are more prominent in medusa than in polyp.

Various Body Systems:

1) DIGESTION: Food is pushed into the central cavity where gland cells release enzymes in order to digest food. Other cells of the endoderm will then absorb the digested nutrients. Indigestible material will then be eliminated out of the mouth.

2) CIRCULATION: There is no true circulatory system. Food nutrient particles will be passed through the central cavity by body movements and by flagellated cells in the endoderm. Thus the cavity is involved in both digestion and circulation. This cavity is called the gastrovascular cavity.

3) RESPIRATION and EXCRETION:
-Both take place by diffusion with the water that bathes the tissues.

4) NERVOUS:
There is a limited amount of nervous and sensory tissue. This "nerve net" is used for co-ordination. Sensory cells are sensitive to touch and various chemicals.

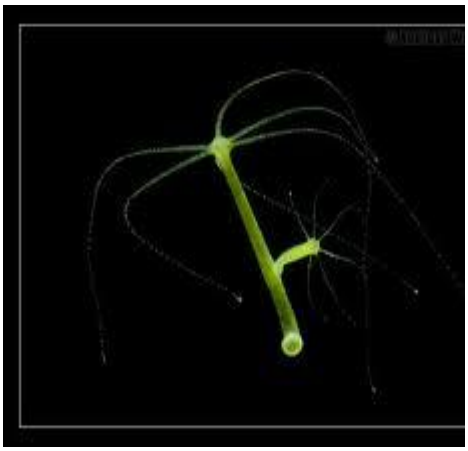
5) MUSCULAR: Lack muscle cells, but epidermal cells can contract and change shape when stimulated.

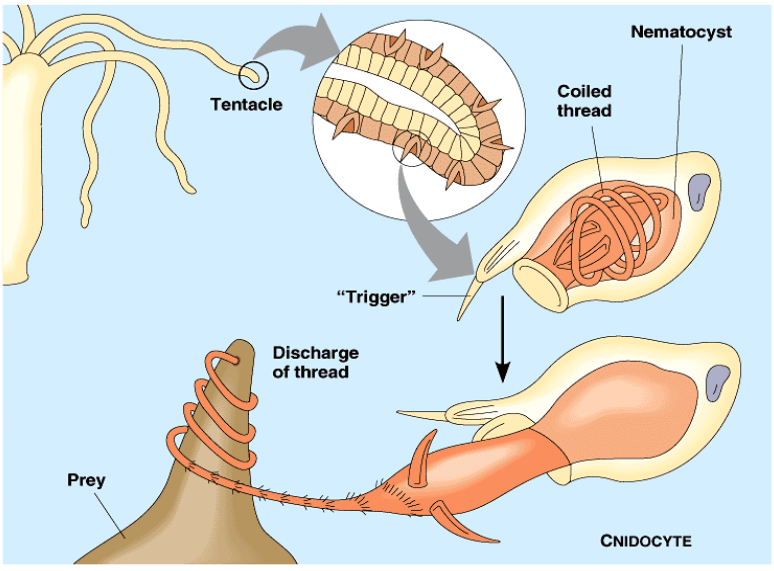
6) REPRODUCTION:
Asexual- Many polyps will reproduce by budding, this may form new polyps or medusae.

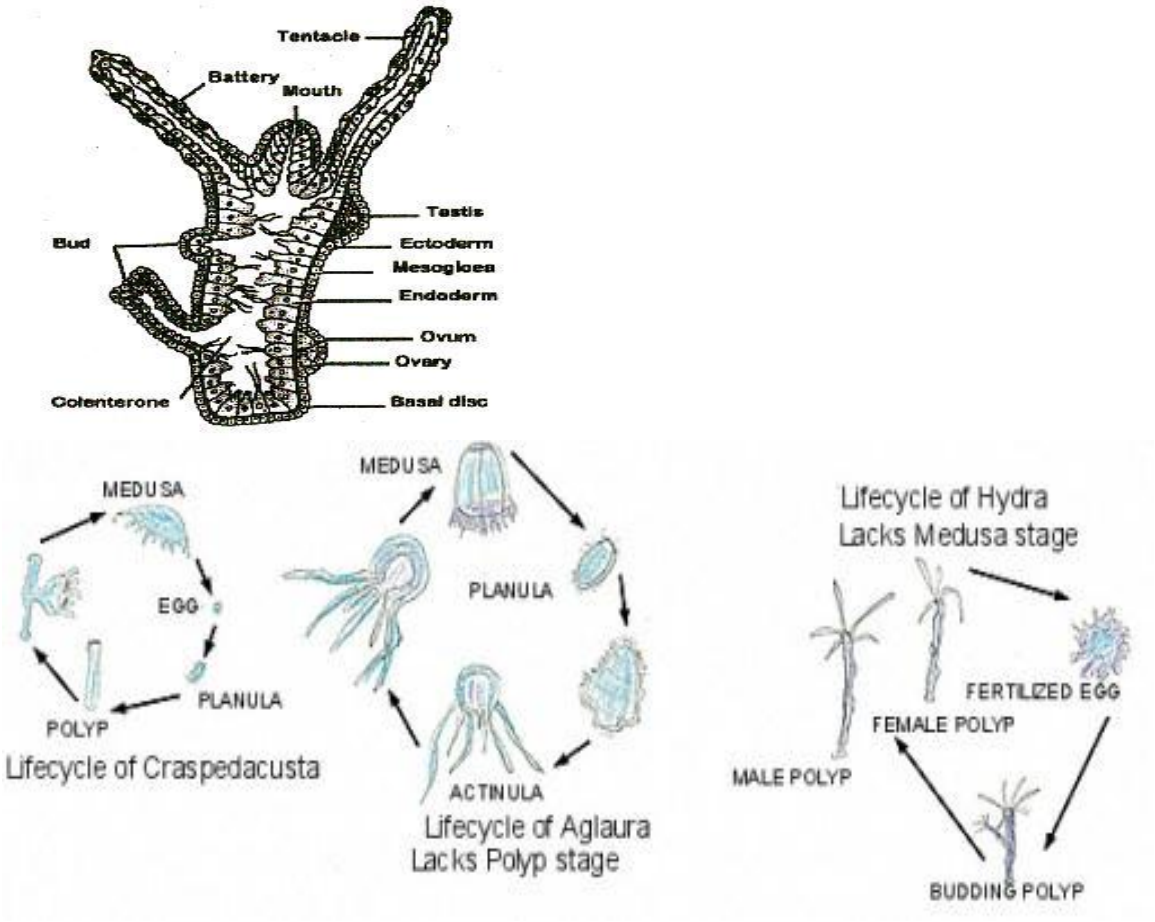
Sexual - Medusae reproduces sexually. Testes will produce sperm which travel through the water to the ovary which has produced eggs.

- The fertilized eggs are released out of the mouth to develop into ciliated larvae (Planulae), this stage will usually develop into a young polyp.

- Some Cnidarians (ex hydra, sea anemone) have polyps that can also reproduce sexually.







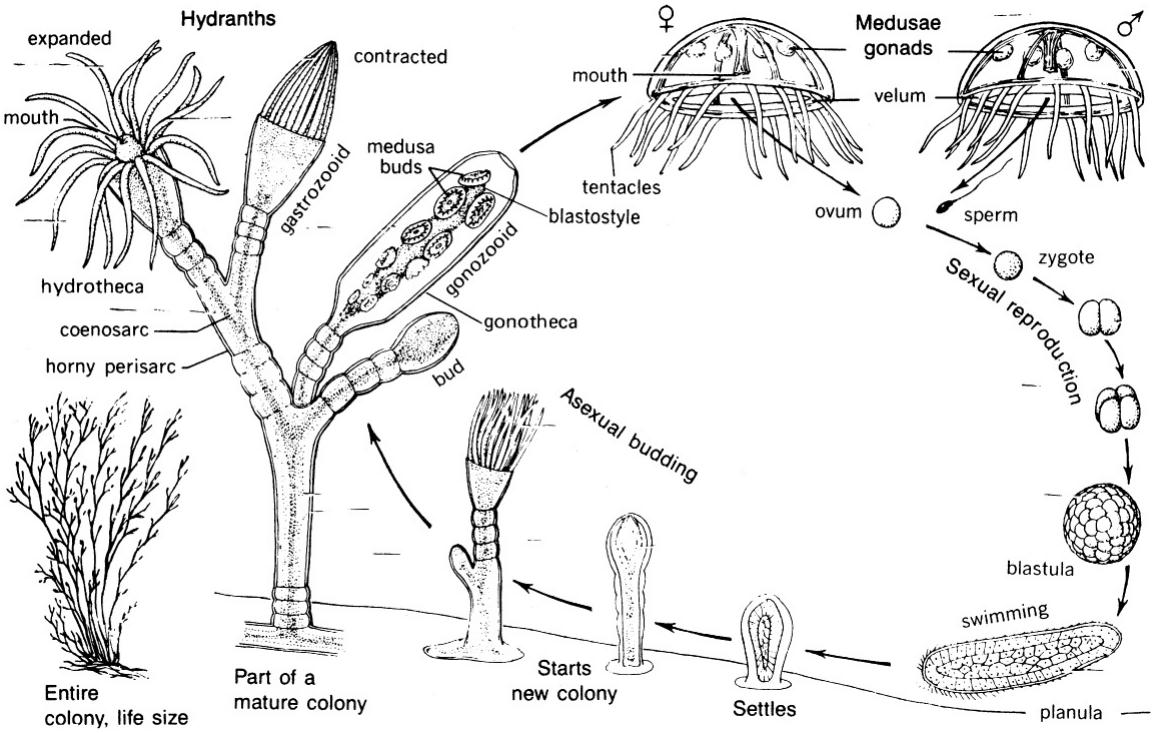
D) Advantages of Motile and Non-Motile Stages/Forms In Life Cycle:

a) If motile, organism can find new food; if non-motile, you stay in one place and you can run out of food.
b) Advantage of being sessile (non-motile) is that they can hide from predators and they don't have to worry about washing ashore.
c) Disadvantage of being motile is that you can easily get carried away by the water currents**.**

E) Ecological Roles of Cnidarians:

- Form symbiotic relationships with other animals.
- Coral reefs are shelter for many marine animals.
They contain tunnels, caves, and deep channels in which animals live. Coral reefs provide habitat for many fish and food for many other animals that produce valuable shells, pearls, and jewelry.
-Protect land from erosion by reducing wave action. If destroyed, large amounts of shoreline maybe washed away.
-Medical research of chemicals produced by many Cnidarians. - New Antibiotics
- New Anticancer Chemicals

Alternation Of generation in Cnidarians:



POLYMORPHISM IN CNIDARIA (COELENTERATE)

Coelenterate animals may show a number of zooids. They are of different forms. They take up different functions. These are called polymorphism. This phenomenon is called polymorphism. (Such a colony is called 'Polymorphic' colony). Polymorphism denotes division of labor among the zooids of the individual.polymorphism is one of the Coelenterate animals characteristics feature .

A polymorphic colony contains many individuals called zooids. They are mainly two types.

1. Medusae
2. Polyps.

Polyp is sedentary. It shows mouth and tentacles at the free end. The medusa is free swimming. Hydra is a Monomorphic form. It is represented by polyp form. It performs all functions. Obelia like animals Show two forms, polyp nutritive zooid and medusa reproductive zooid. This is called dimorphic organism In a colony of obelia

1) Hydranth (a Polyp stage),
2) Blastostyle (asexually, reproducing zooid).
3) Medusae are present.

POLYMORPHIC TENDENCY IN SIPHONOPHORA ANIMALS

The polymorphic tendency reached its peak in coelenterate organisms belonging to order 'Siphanophora' of class 'Hydrozoa'. Many siphonophora organisms will show complicated structures.

Structure of a typical Siphonophora organism:

Polymorphism-siphonophora:

In Hydrozoan coelenterates polymorphic tendency is well developed. The order Siphonophora organisms are exhibiting this tendency to a maximum extent. In a generalised siphonophora organism several forms are seen. These forms or zooids are developed from polyps or medusae. These individual zooids are attached to a common stalk called Coenosarc.

POLYPOID ZOOIDS ARE :
1)Gastro zooids
2) Dactylo zooids
3)Gono zooids

MEDUSOID ZOOIDS ARE:
1) Pneumatophore
2) Nectocalyces
3) Bracts
4) Gonophores

1. Gastrozooids : The nutritive polyps are called gastro zooids. They alone take up nutrition in the colony. They are tubular. A **mouth is present at the tip of the hypostome**. Near the base of a gastrozooid usually a single, long and contractile tentacle arises. **It shows batteries of nematocysts.** Lateral branches are present called tentilla. **Gastrozooids catch the prey and digest it. The digested food is thrown into the coenosarcal canal.**

2. Dactylo zooids : They are called **Palpons, feelers or tasters**. They resemble the gastrozooids. They do not show mouth. Their basal tentacle is un branched. In Physalia, the tentacle is very long. In velella and Porpita the margin of the colony bears long and hollow tentacles. These **zooids are protective in function**. They bear **batteries of nematocysts.**

3. Gonozooids : The **reproductive zooids** are called **gonozooids**. They have no mouth. In Physalia the gonozooid shows branched stalk, bearing clusters of gonophores (gonopalpon). Gonozooids produce medusae called gonophores.

MEDUSOID FORMS :

1. Pneumatophores : It **functions as a float**. It is an inverted medusan bell. The walls are two layered and highly muscular. **The epidermal lining becomes glandular to form a gas gland. The gas gland secretes gas into the air-sac**

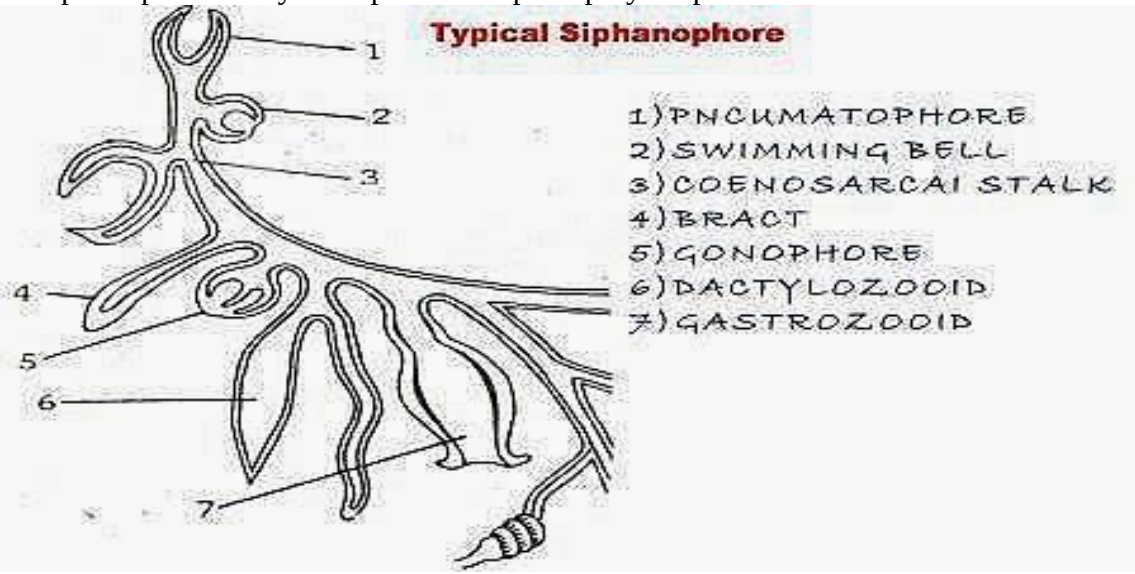
1)The pneumatophore is small in Halistemma.

2)The pneumatophore is very large in Physalia.

3)It is disc-shaped in porpita.

2.Nectocalyces : These are **swimming-bells**. They are medusoid. Mouth, manubrium, tantacles and sense organs are absent. They are helpful in swimming.

3.Bracts : They are also known as hydrophyllia. They are leaf like. In Halistemma a bract covers the zooids of a cormidium.
In Siphonophora many examples can explain polymorphism.



Written by Tahir Habib

CORAL REEF

Coral reefs are diverse underwater ecosystems held together by calcium carbonate structures secreted by corals. Coral reefs are built by colonies of tiny animals found in marine waters that contain few nutrients. Most coral reefs are built from stony corals, which in turn consist of polyps that cluster in groups. The polyps belong to a group of animals known as Cnidaria, which also includes sea anemones and jellyfish. Unlike sea anemones, corals secrete hard carbonate exoskeletons which support and protect the coral polyps. Most reefs grow best in warm, shallow, clear, sunny and agitated waters.

Coral reefs are rocky mounds and/or ridges formed in the sea by living things through the accumulation and deposition of limestone (calcium carbonate).
These undersea palaces are home to more species of fishes, corals, and many other type of marine life than any other ocean habitat.
Coral reefs also provide many valuable services to humans. Food, shoreline protection, and medicines are just a few of these benefits. These are also the best places to visit if you want to experience marine life - up close and personal.

What are coral reefs?
Hard corals extract abundant calcium from surrounding seawater and use this to create a hardened structure for protection and growth. Coral reefs are therefore created by millions of tiny polyps forming large carbonate structures, and are the basis of a framework and home for hundreds of thousands, if not millions, of other species. Coral reefs are the largest living structure on the planet, and the only living structure to be visible from space.

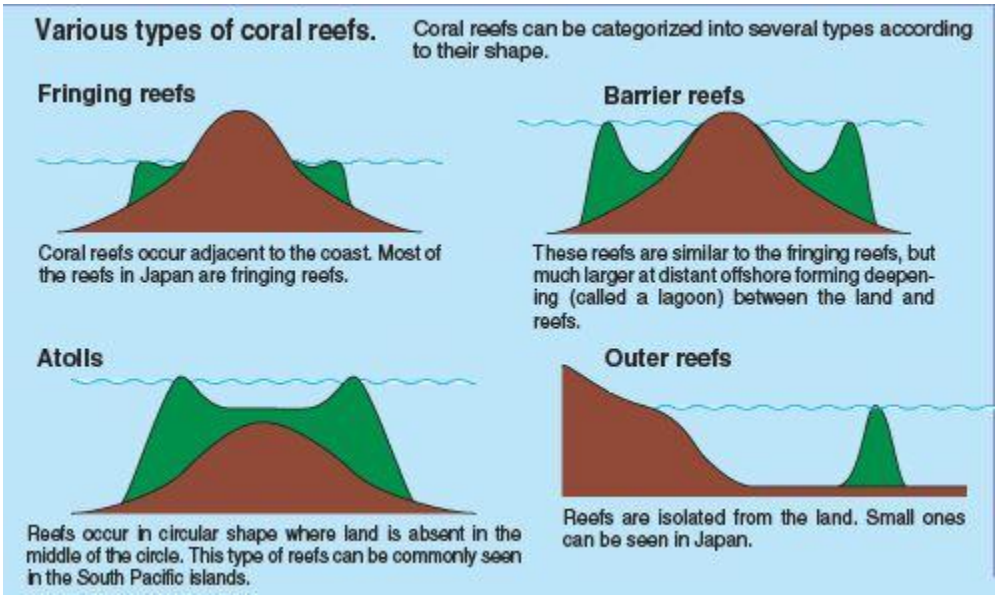
Types of Coral Reefs
Most reef scientists generally recognize three MAJOR types of coral reefs:
1:Fringing Reefs,
2:Barrier Reefs,
3:Atolls.

It was Charles Darwin who originally classified coral reefs as to their structure and morphology, and described them as follows:

- **Fringing reefs** lie near emergent land. They are fairly shallow, narrow and recently formed. They can be separated form the coast by a navigable channel (which is sometimes incorrectly termed a "lagoon").

- **Barrier reefs** are broader and lie farther away from the coast. They are separated from the coast by a stretch of water which can be up to several miles wide and several tens of metres deep. Sandy islands covered with a characteristic pattern of vegetation have sometimes formed on top of a barrier reef. The coastline of these islands is broken by passes, which have occupied the beds of former rivers.

- **Atolls** are large, ring-shaped reefs lying off the coast, with a lagoon in their middle. The emergent part of the reef is often covered with accumulated sediments and the most characteristic vegetation growing on these reefs consists of coconut trees. Atolls develop near the sea surface on underwater islands or on islands that sink, or subside.



Written by Tahir Habib

CHAPTER 4: PHYLUM PLATYHELMINTHES

The name Platyhelminthes was de-rived from the Greek "platys" flat and helminthes worms. **Gagenbaur 1859 coined the word Platyhelminthes** for the flat worms which are considered as the most primitive of all helminthes. This group includes free living or parasitic forms. Minot (1876) separated nemertines from flat-worms and group them as phylum Platyhelminthes. The branch of biology study of helminthes is known as Helminthology.

The **simplest animals that are bilaterally symmetrical** and **triploblastic** (composed of three fundamental cell layers) are the Platyhelminthes, the flatworms. Flatworms have no body cavity other than the gut (and the smallest free-living forms may even lack that!) **and lack an anus**; the same **pharyngeal opening both takes in food and expels waste**. Because of the lack of any other body cavity, in larger flatworms the gut is often very highly branched in order to transport food to all parts of the body. The lack of a cavity also constrains flatworms to be flat; they must respire by diffusion, and no cell can be too far from the outside, making a flattened shape necessary.

PHYLUM PLATYHELMINTHES GENERAL CHARACTERS

1. They are soft bodied, unsegmented worms.
2. They show bilateral symmetry and dorsiventrally flat worms
3. They show three germinal layers i.e. ectoderm, mesoderm and endoderm.
4. The epidermis is soft, syncitial. It is ciliated in Turbellaria. It is covered by cuticle in Trematoda and Cestoda worms.
5. **Exo or Endo skeleton is completely absent**.
6. The parasite shows **suckers or hooks** or both for attachment to the host body.
7. They are the first animals to illustrate the development of organ system.
8. A true body cavity or **coelom is absent**, and the space between the body organs is filled with loose parenchyma.
9. **Muscular system is well developed.** It is mesenchymal in origin. The system consists of circular, longitudinal and oblique muscles beneath the epidermis.
10. The alimentary canal is either absent or highly branched. Anus is absent.
11. **Circulatory and respiratory systems are absent**.
12. Excretory system consists of flame bulbs or flame cells **or protonephridia** connected to the excretory ducts.
13. Asexual multiplication and alternation of generations are seen in some examples.
14. Nervous system and sense organs are poorly developed.
15. **Usually hermaphrodite animals**.
16. Fertilization is internal and development may be direct or indirect.

17. May be free living (Turbellaria), ectoparasitic or endoparasitic. A few may be commensals.

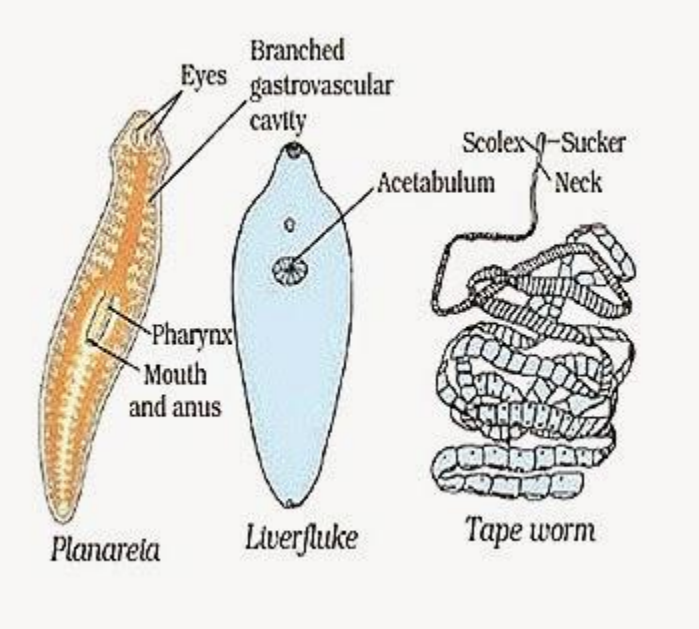
CLASSIFICATION OF PHYLUM PLATYHELMINTHES

Phylum Platyhelminthes is divided into three classes: The following classification done by Hymen based on Platyhelminthes characteristics

CLASS I-TURBELLARIA

CLASS II-TERMATODA

CLASSIII-CESTODA



CLASS I: TURBELLARIA :

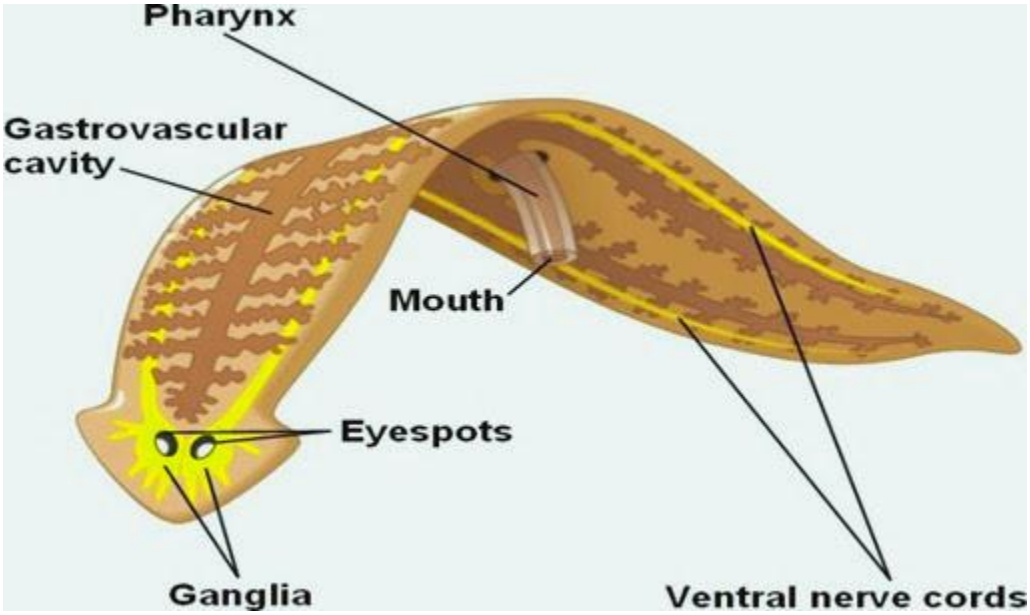
1. Mostly free - living forms found in fresh or sea waters or on land.
2. Body is un segmented and is dorso ventrally flattened.
3. Epidermis is cellular or syncytial.
4 Intestine is either absent (Acoela) or simple and sac like (Rhabdocoela) or branched.

Order (1): Acoela: They are marine and small. Mouth and pharynx are simpleor absent. Oviducts 2 yolk glands are absent. Ex : Convoluta.

Order (2) : Rhabdocoela : They are small. A digestive bad is present and intestine is sac like. Many are free swimming. Reproductive organs are present
Ex : Microstomum, Temnocephala.

Order 3 : Alloeocoela : Small sized worms are included **in** this order. Intestine is simple or branched. They are mostly marine
Ex : Otoplana, Bothnoplana.

Order 4 **:TricIadlda** : Dorsiventrally flat body is seen. Intestine has two lateral limbs and one median limb Genital aperture is single.
Ex: Bipalium. Planaria.



Order 5 **: Polyciadida** : These are leaf like turbellarians. Intestine shows a number of branches Genital apertures are separate.

Ex : Thysanozoan, Planocera.

CLASS II : TERMATODA :

These are commonly known as flukes. These are ectoparasitic or endoparasitic forms. Body is unsegmented and enlongated. Adhesive organs are, one or two suckers without hooks and spines. Digestive tract is bifurcated and highly diverticulated. Anus is absent.

Trematoda class or "trematodes" are commonly known as flukes. Flukes are flat worms. Parasitic flukes live in the intestine, tissue or in the blood.

Their life cycle begins when molluscs such as snails get infected with fluke larvae. The first stage larvae are called miracidia. They have tail-like structures, cilia, for moving and finding molluscs. Depending on the fluke species the larva goes through different developmental stages which are:

Miracidium >> sporocyst>> redia > cercaria >> mesocercaria >> metacercaria

Written by Tahir Habib

Adulthood is reached inside the final host, humans. Adults reproduce either sexually or asexually. Eggs exit the body with the feces and infect new molluscs.

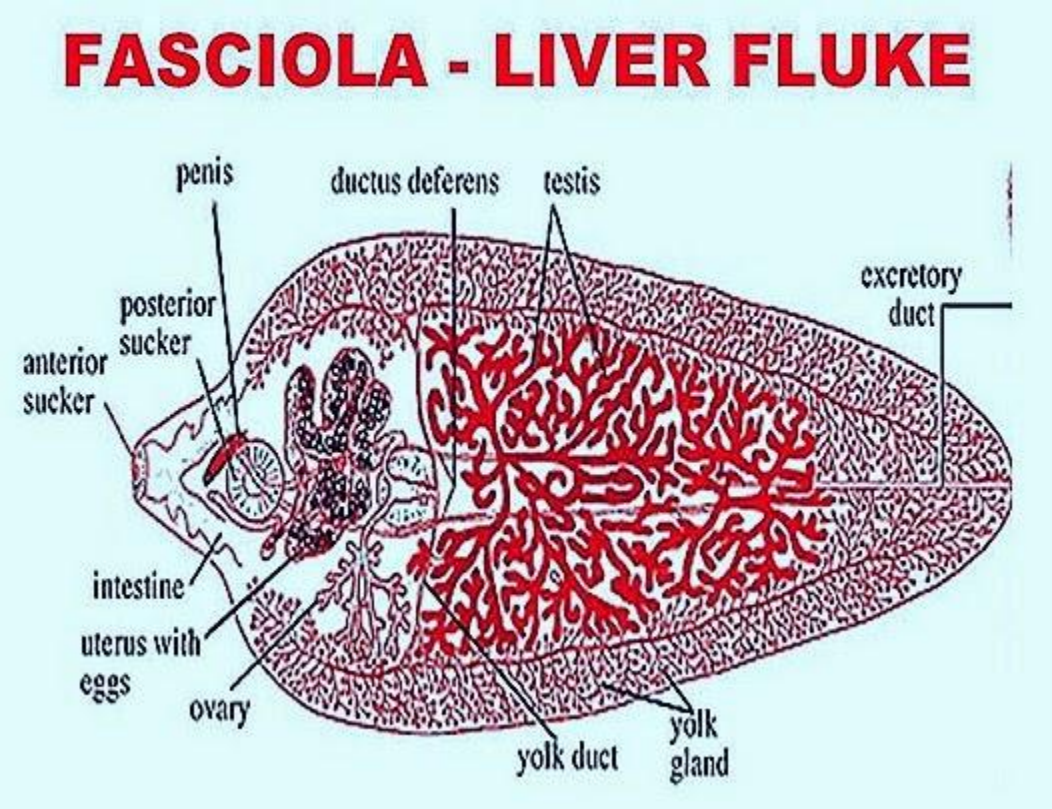
Fasciola Hepatica - Liver Fluke Fasciola hepatica is a flat worm that eats your blood and liver. Find information such as parasite life cycle, symptoms, diagnosis and treatment as well as pictures and videos.

Fasciolopsis Buski - Intestinal Fluke ,Fasciolopsis buski is a parasitic fluke that lives in your small intestine causing fasciolopsiasis (disease).

Paragonimus Westermani - Lung Fluke

Paragonimus westermani is a lung fluke. It causes a parasitic disease called paragonimiasis. Symptoms, diagnosis, treatment and pictures.

Schistosoma - Blood Flukes , Find information such as Schistosoma life cycle, symptoms, diagnosis and treatment as well as pictures and videos. Schistosoma (blood flukes) cause **schistosomiasis (snail fever) in humans.**



CLASS 3:CESTODA:

Totally endoparasitic forms. Body covered with thick cuticle. Mouth,digestive tract and sense organs are absent. Fertilization is internal. It is divided into 2 sub-classes.

The body of the cestodes, also known as **tapeworms**, has lost the typical turbellarian form. Although there are a few unsegmented species, the bulk of a typical cestode body consists of a series of linearly arranged reproductive segments called proglottids. There is no mouth or digestive system; **food is absorbed through the cuticle**. Adults live in the digestive tract of

vertebrates, and larval forms encyst in the flesh of various vertebrates and invertebrates. Cestoda - Tapeworms

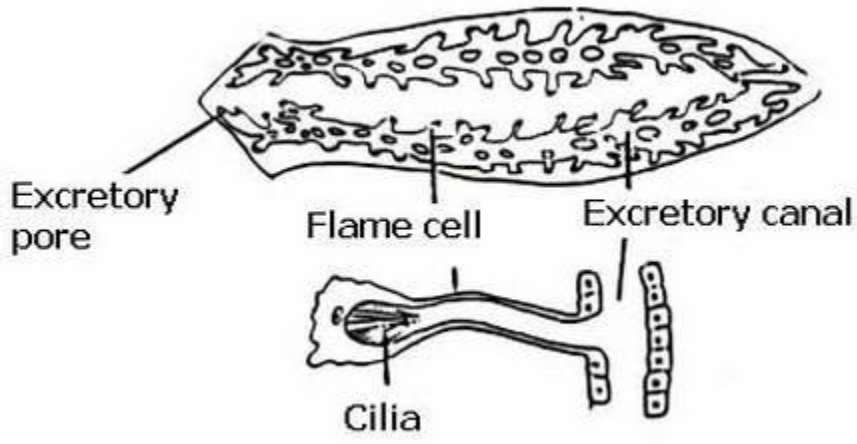
- Diphyllobothrium Latum - Fish Tapeworm
- Hymenolepis Nana - Dwarf Tapeworm
- Taenia Saginata - Beef Tapeworm
- Taenia Solium - Pork Tapeworm

The body of an adult tapeworm is virtually a reproductive factory. Behind a small securing knob, called a scolex, which bears a circle of hooks or other attachment organs, the proglottids constantly bud off and gradually enlarge. As they mature they become filled with male and female reproductive organs. Cross-fertilization takes place with adjacent worms or neighboring proglottids; in some cases self-fertilization occurs. In some species the ripe proglottids, filled with eggs, are shed. In others the fertilized eggs leave the adult host in the feces. If the eggs are consumed by the intermediate host, the life cycle continues. Tapeworm species that infest human intestines as adults include **Taenia saginata, T. solium, the dwarf tapeworm, Hymenolepsis nana, and the fish tapeworm, Diphyllobothrium latum**, which can reach lengths of up to 50 ft (15 m)..

Protonephridia : Excretory System

A protonephridium (proto = "first") is a network of dead-end tubules lacking internal openings found in the phyla Platyhelminthes, Nemertea and Rotifera. The ends are called flame cells (if ciliated) or solenocytes (if flagellated); they function in osmoregulation and ionoregulation, respectively. The terminal cells are located at the blind end of the protonephridium. Each cell has one or more cilia and their beating inside the protonephridial tube creates an outward going current and hence a partial pressurization in the blind of the tube. Because of this, pressurization drives waste fluids from the inside of the animal, and they are pulled through small perforations in the terminal cells and into the protonephridium. The perforations in the terminal cell are large enough for small molecules to pass, but larger proteins are retained within the animal. From the bottom of the protonephridium the solutes are led through the tube, formed by the canal cells, and exits the animal from a small opening formed by the nephridiopore. Selective reabsorption of useful molecules by the canal cells occurs as the solutes pass down the tubule. Protonephridia are generally found in basal organisms such as flatworms. Protonephridia likely first arose as a way to cope with a hypotonic environment by removing excess water from the organism (osmoregulation). Their use as excretory and ionoregulatory structures likely arose secondarily.

These are excretory systems in phyla Platyhelminthes and are also called blind tubules. These tubules bear a tuft of cilia or flagellum. An organ of excretion in flatworms: a hollow cup-shaped cell containing a bunch of cilia or flagellum, whose movement draws in waste products and wafts them to the outside .



Parasitic adaptation in platyhelminthes

- Fitness of an organism to its environment
- It is the characteristic which results in suitable & convenient morphological & functional correlation between an organism & its environment

Parasitic adaptation

- Platyhelminthes have undergone profound adaptation to suit their parasitic modes of life
- These adaptations- parasitic adaptations
- Are of morphological & physiological nature

1. **Morphological adaptations**

1. Body covering
2. Organs of adhesion
3. Organs of locomotion
4. Organs of nutrition (Trophic organs)
5. Neurosensory system
6. Reproductive system

Body covering

Thick tegument frequently provided with scales affords suitable protection to the parasite
This thick protoplasmic layer is continually renewed by mesenchymal cells forming it

B. Organs of adhesion

- For a firm grip on/in the host's body, some special organs of adhesion are needed
- Flatworms are variously armed with suckers, hooks & spines
- Suckers may be with/without hooks/spines
-

Organs of locomotion

- Locomotion is actually an effort of procuring food
- But parasites habitually inhabit such places in host's body, where sufficient food is available without effort
- Thus, organs of locomotion such as cilia of turbellarians- absent in parasitic forms
- Locomotory organs present in free living larvae of parasitic forms
- Miracidium possess cilia & cercaria bears a tail for locomotion
-

D. Organs of nutrition (Trophic organs)

- Food of parasite comprises readily available & digested/ semi digested food of the host
- Elaborate organs of nutrition not needed
- Trematodes have an incomplete gut & in most cases a suctorial pharynx for sucking food
- An eversible pharynx is present in free living turbellarians
- In cestodes, parasite freely bathes in digested food of host which is absorbed directly
- Thus, total absence of alimentation in tapeworms

E. Neurosensory system

- Need for quick & efficient "response to stimuli" is associated with free active life & not with a quiet parasitic life in a safe environment
- In parasites therefore, there is preferred reduction of nervous system & a total absence of sense organs
- But the free living miracidium possesses eye spots

F. Reproductive system

- Best developed system in helminth parasites, designed & preferred to meet the need for tremendous egg production
- Parasitic flatworms with a few exceptions like Schistosoma, are monoecious (hermaphrodite)
- Hermaphroditism is of distinct advantage to the parasite because:

1. It ensures copulation even when a few individuals are present
2. After copulation both individuals lay eggs, doubling the rate of production
3. In absence of companion parasite can reproduce offspring

- In cestodes reproductive system is much more elaborate & each mature proglottid possesses 1 or2 complete sets of male & female genitalia
- In gravid proglottid all other organs of the system degenerate to make room for the uterus which becomes highly enlarged & branched to accommodate large number of eggs

2. Physiological adaptations

a. Protective mechanism b. Anaerobic respiration
c. Osmoregulation d. High fertility

a. Protective mechanism

- Inside the alimentary canal the parasites have to protect themselves from the action of digestive juices of host
- Tapeworms accomplish this:

1. By stimulating walls of gut to secrete mucus, which then forms a protective clothing around parasite
2. By secreting antienzymes to neutralize the digestive enzymes of host
3. By probably continually renewing their protective body covering i.e., tegument

b. Anaerobic respiration

- Environment in gut & bile ducts is devoid of free oxygen
- Flatworms inhabiting these places, therefore, respire anaerobically by breaking down glycogen

c. Osmoregulation

- Osmotic pressure of endoparasite's body fluids, especially in case of trematodes is almost the same as that of host
- This renders osmoregulation unnecessary
- But in intestinal tapeworms, osmotic pressure is little higher
- This permits ready absorption of host's digested food by tapeworms

•

d. High fertility

• Eggs produced by a parasitic flatworm face a very uncertain future while passing through the complex life cycle, these potential offsprings face several hazards as a result of which a very small percentage of total eggs produced reaches adulthood
• This threat to the very existence of species is suitably met by parasite which in its life time may produce eggs in millions
• Reproductive organs of flatworms are according

CHAPTER 5: PHYLUM NEMATODA

The nematodes /ˈnɛmətoʊdz/ or roundworms constitute the phylum Nematoda.They are a diverse animal phylum inhabiting a very broad range of environments. Nematode species can be difficult to distinguish, and although over 25,000 have been described, of which more than half are parasitic, the total number of nematode species has been estimated to be about 1 million. Unlike the phyla Cnidarians and Platyhelminthes (flatworms), nematodes have tubular digestive systems with openings at both ends.

Characteristics of phylum Nematoda

1. Body bilaterally symmetrical, cylindrical in shape
2. Body covered with a secreted, flexible, nonliving cuticle
3. Motile cilia and flagella completely lacking; some sensory endings derived from cilia present
4. Muscles in body wall running in longitudinal direction only
5. Excretory system of either one or more gland cells opening by an excretory pore, a canal system without gland cells, or both gland cells and canals together; flame cell protonephridia lacking
6. Pharynx usually muscular and triradiate in cross section
7. Male reproductive tract opening into rectum to form a cloaca; female reproductive tract opening a separate gonopore
8. Fluid in pseudocoel enclosed by cuticle forming a hydrostatic skeleton.

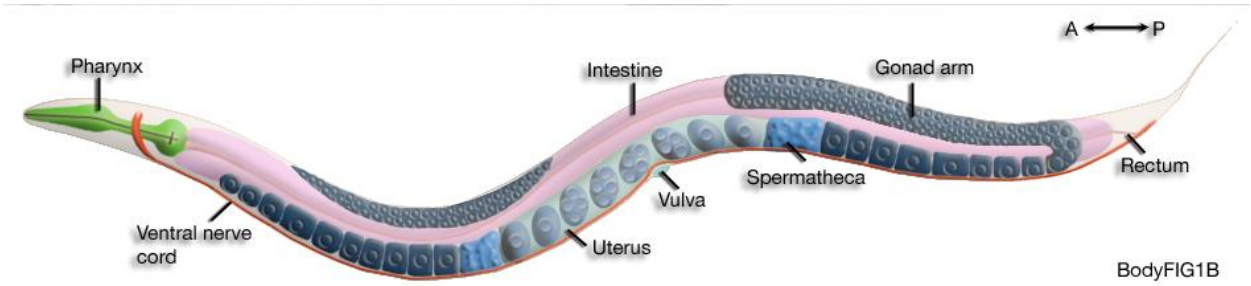
Morphology

Like mollusks, nematodes are triploblastic (having three primary germ layers: the ectoderm, mesoderm, and endoderm) protostomes. However, unlike mollusks, which have a true coelom (eucoelom; fluid filled body cavity with a complete lining derived from the mesoderm), the nematodes have a pseudocoelom (a "false cavity," whereby tissue derived from the mesoderm only partly lines the fluid filled body cavity). In nematodes, as with rotifers (Phylum Rotifera), the body cavity is lined on the inside by endoderm and on the outside by mesoderm (Towle 1989**).**

Nematodes are thin and are round in cross section, though they are actually bilaterally symmetric. Most bilaterially symmetrical animals have a true coelom, unlike the nematodes.

Nematodes are one of the simplest animal groups to have a complete digestive system, with a separate orifice for food intake and waste excretion, a pattern followed by all subsequent, more complex animals. As a pseudocoel, the body cavity lacks the muscles of coelomate animals that force food down the digestive tract. Nematodes thus depend on internal/external pressures and body movement to move food through their digestive tracts. The mouth is often

surrounded by various flaps or projections used in feeding and sensation. Excretion is through a separate excretory pore.



Nematodes have no circulatory or respiratory systems, so they use diffusion to breathe and for circulation of substances around their body. Nematodes have a simple nervous system, with a main nerve cord running along the ventral side. Sensory structures at the anterior end are called amphids, while sensory structures at the posterior end are called phasmids.

Parasitic Nematodes:

Common and scientific names means of infection; prevalence in humans.

Hookworm (Ancyclostoma duodenale: Contact with juveniles in soil that burrow into skin; common in southern states and Necator americanus) Hookworms. The most common hookworms are **Ancylostoma duodenale** and **Necator americanus.** Adults attach to the walls of the jejunum and females lay large numbers of eggs that are passed out with the feces. The eggs hatch in the soil and infect man by usually burrowing through the soles of the feet. The larvae then migrate to infect the heart and lungs before passing into the tracheae, pharynx and then the small intestine.

Pinworm (Enterobius vermicularis): Inhalation of dust with ova and by contamination with fingers; most common worm parasite in United States, **Enterobiasis. Enterobias vermicularis** is a small thread-like "**pinworm"** mainly infecting young children. The female emerges to the perianal region usually at night and lays some 10,000-15,000 eggs and then dies. In the process they cause severe pruritis (itching). The embryonated eggs are infectious on ingestion and hatch in the duodenum. The larvae pass to the cecum where they mature into adults. Because of the pruritis, children often re-infect themselves from eggs under their fingernails. Bedding is also a source of infection and can be a means of spreading the organism in families and institutions such as orphanages and boarding schools.

Intestinal roundworm (Ascaris lumbricoides): Ingestion of embryonated ova in contaminated food; common in rural areas of Appalachia and southeastern states. **Ascariasis.** Adult worms of **Ascaris lumbricoides** live in the small intestine where they lay large numbers of eggs that are passed out with the feces. Unlike the hookworms, the eggs are the infectious form in which the larvae develop. **When ingested, the eggs hatch in the jejunum, penetrate the mucosa and are carried through the hepatic circulation to the heart and lungs. They again**

enter the stomach via the tracheae and esophagus before growing to adulthood in the small intestine. Pneumonitis and intestinal obstruction may accompany heavy infestations.

Trichina worm (Trichinella spiralis): Ingestion of infected muscle; occasional in humans throughout North America. **Trichinosis. Trichinella spiralis** is the cause of **trichinosis** in man. The nematode circulates between rats and pigs with man becoming infected from eating raw or inadequately cooked pork products. Encysted larvae in the meat ex cyst (hatch) in the intestine and develop into minute adults in the mucosa. These mature and the females deposit larvae that then migrate through the tissues to reach skeletal muscles in which they encyst. Human infections may be asymptomatic but can include fever, orbital edema, myalgia and eosinophilia. In the extreme, infection can be fatal through myocarditis or encephalitis.

Whipworm (Trichuris trichiura): Ingestion of contaminated food or by unhygienic habits; usually common wherever Ascaris is found. **Trichuriasis. Trichuris trichiura ("whipworm") inhabits the cecum** where they attach to the mucosa. Eggs from the mature worms are passed with the feces and develop in the soil**. When swallowed, the eggs hatch in the small intestine and the developing larvae pass directly to their attachment sites in the large intestine. Heavy infections can cause abdominal pain and chronic bloody diarrhea** that may result in rectal prolapse.

Nematodes - the filariases : These are arthropod (insect)-borne infections caused by filarial worms. The classic example is elephantiasis caused by **Wuchereria bancrofti**. Larvae of W. bancrofti develop in the mosquito and, as in malaria, human infection results from the bite of the insect. When bitten, the larvae (as male and female forms) pass through the lymphatics and mature to thread-like adults, 4-8 cm long, in the lymphatic glands. After mating the females develop eggs and larvae that are released as microfilariae into the peripheral circulation.

The localization of the adult filariae in the lymph glands causes obstructions in the lymphatic drainage. This then results in the grossly disfiguring condition of elephantiasis that typically involves massive swelling of the legs, scrotum and other extremities.

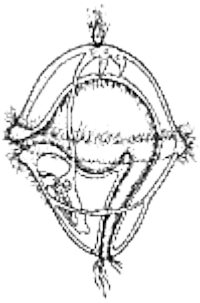
table 9.1 Common Parasitic Nematodes of Humans in North America

Common and scientific names	Means of infection; prevalence in humans
Hookworm (*Ancylostoma duodenale* and *Necator americanus*)	Contact with juveniles in soil that burrow into skin; common in southern states
Pinworm (*Enterobius vermicularis*)	Inhalation of dust with ova and by contamination with fingers; most common worm parasite in United States
Intestinal roundworm (*Ascaris lumbricoides*)	Ingestion of embryonated ova in contaminated food; common in rural areas of Appalachia and southeastern states
Trichina worm (*Trichinella spiralis*)	Ingestion of infected muscle; occasional in humans throughout North America
Whipworm (*Trichuris trichiura*)	Ingestion of contaminated food or by unhygienic habits; usually common wherever *Ascaris* is found

PHYLUM MOLLUSCA

Characteristics

- Soft-bodied invertebrate covered with protective mantle that may or may not form a hard, calcium carbonate shell
- Includes chitons, snails, slugs, clams, oysters, squid, octopus, & nautilus
- Second largest animal phylum
- Have a muscular foot for movement which is modified into tentacles for squid & octopus
- Complete, one-way digestive tract with a mouth & anus
- Have a fully-lined coelom
- Cephalization - have a distinct head with sense organs & brain
- Have a scraping, mouth-like structure called the radula
- Go through free-swimming larval stage called trochophore



Trochophore Larva

- Body organs called visceral mass lie below mantle
- Have circulatory, respiratory, digestive, excretory, nervous, & reproductive systems
- Bilaterally symmetrical
- Most have separate sexes that cross-fertilize eggs
- Gills between the mantle & visceral mass are used for gas exchange

Includes 4 classes ---

1. **Polyplacophora** (chitons),
2. **Gastropoda** (snails, slugs, nudibranchs, conchs & abalone),
3. **Pelecypoda or Bivalvia** (clams, oysters, & mussels), &
4. **Cephalopoda** (squid, octopus, & nautilus)

Written by Tahir Habib

Class Polyplacophora

Characteristics

- All marine
- Have a shell divided into 8 over-lapping plates
- Live on rocks along seashore feeding on algae

Class Gastropoda

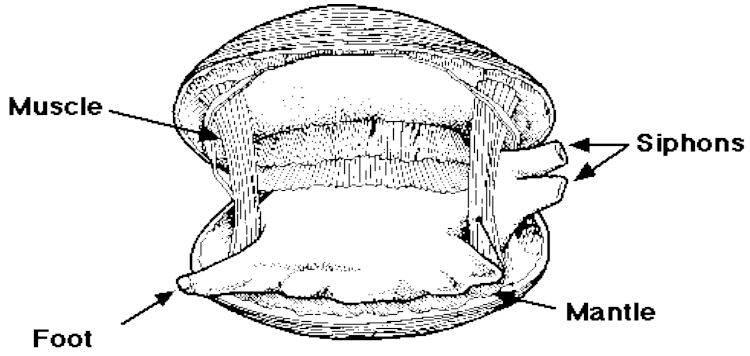
Characteristics

- Head has a pair of retractable tentacles with eyes located at the ends
- Have a single shell or valve (snails) or none (slugs)
- Known as univalves
- **Snails**
  * May be marine, freshwater, or terrestrial
  * Aquatic snails breathe through gills & use their radula to scrape algae for food
  * Terrestrial snails use their mantle cavity as a modified lung & saw off leaves
  * Retreat into shell in dry periods & seals opening with mucus
  * Have open circulatory system
  * Secrete mucus & use muscular foot to move
  * Land snails are hermaphrodites
  * Aquatic snails have separate sexes
  * Use internal fertilization

Class Bivalvia or Pelecypoda

Characteristics

- Sessile or sedentary
- Includes marine clams, oysters, shipworms, & scallops and freshwater mussels
- Filter feeders
- Have two-part, hinged shell (2 valves)
- Have muscular foot that extends from shell for movement
- Scallops clap valves together to move



- Shell secreted by mantle & made of 3 layers --- outer horny layer protects against acids, middle prismatic layermade of calcium carbonate for strength, & inner pearly layer next to soft body
- Mantle secretes substance called "mother of pearl" to surround irritants like grains of sand
- Oldest, raised part of shell called umbo
- Powerful anterior & posterior adductor muscles open & close shell
- Lack a distinct head
- Have an incurrent & excurrent siphon that circulate water over the gills to remove food & oxygen

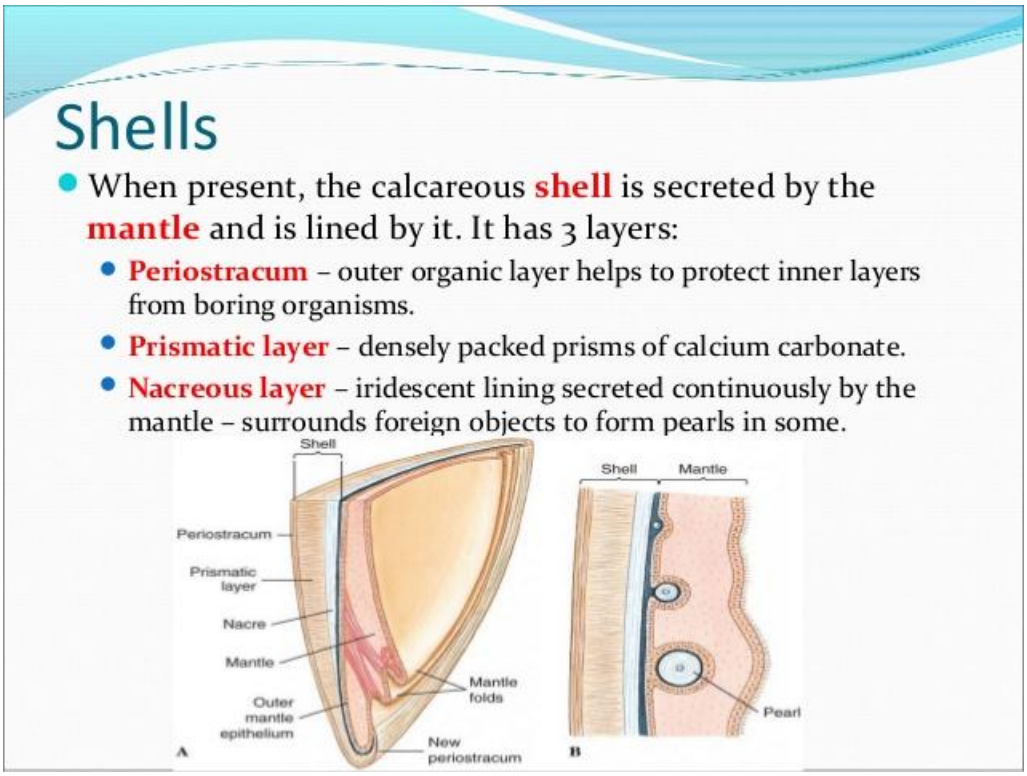
Economic Importance of Mollusks

- Used by humans for food
- Pearls from oysters
- Shells used for jewelry
- Do crop & garden damage
- Serve as intermediate hosts for some parasites such as flukes

Shells in Molluscs:

Shells are lovely natural objects, equals in beauty to any flower or butterfly, they are more than just pretty baubles found on beaches. They are the exterior skeletons (exoskeletons) of a group of animals called mollusks. The word "mollusk" means "soft-bodied;" an exterior skeleton is very important to these creatures, providing them with shape and rigidity, and also with protection, and sometimes camouflage, from predators.

Mollusks are classified into major groupings according to the characteristics of their shells. Snails (Gastropoda) have a single shell which spirals outward and to one side as it grows. Most Cephalopoda (octopi and squid) have no shell, but the Chambered Nautilus of that group has a shell. This shell does coil, but it coils flatly, in a single plane. Tusk shells (Scaphopoda) also have a single shell, but it does not coil at all; it grows in a narrow and very slightly curved cone shape. Bivalves (Bivalvia), including oysters, clams, scallops and mussels, have two parts to their shells that enclose their tender bodies like the two halves of a hinged box. Chitons (Polyplacophora) are little armored tanks, with a row of eight overlapping plates protecting them. The Neopilina (Monoplacophora), are deep-sea "living fossils;" they have a single shell which hardly coils at all, but fits over their bodies like a protective cup. (Some gastropods (the limpets) have shells like this too, but their body structure is very different.) Last are the deepsea worm-like Aplacophora, with no shell at all, but little calcareous spines on their bodies.



Mollusks make their shells from calcium they derive from their environment, either the food they eat or the water they dwell in. When a tiny mollusk hatches from its egg, it comes into the world equipped with a tiny shell. This shell is actually a part of the animal, growing as it grows, accommodating its needs. Each different species of mollusk makes a shell that is, in most cases, unique to it alone. Indeed, this uniqueness of form is partly what allows amateur shell collectors (conchologists) and professional scientists who study mollusks (malacologists) to determine a mollusk's species. Each species is destined genetically to develop the same type of shell its progenitors did. But, just as with humans, there are many distinct differences. Food, climate, environment, accident, and the mollusk's particular heredity all play their parts in making each shell an individual.

TORSION & DETORSION IN GASTROPODA

Prof. Girish Chandra

Written by Tahir Habib

TORSION

In freshwater and terrestrial molluscs, there is no free swimming larval stage. Both trochophore and veliger stages are passed inside the egg and a tiny snail hatches out of the egg. Early larva is symmetrical with anterior mouth and posterior anus and gills lie on the posterior side. As the larva develops shell its visceral mass starts twisting in anticlockwise direction to rearrange the visceral organs so that they are accommodated inside the coils of the shell and openings of organs are shifted to the anterior side where the shell opening lies.

During torsion visceral and pallial organs change their position by twisting through 180°. Posterior mantle cavity is brought to the front position. Gills and kidney move from left to right side and in front which helps in breathing. In nervous system the two pleurovisceral connectives cross themselves into a figure of 8, one passing above the intestine and the other below it. Alimentary canal twists in the visceral mass and opens by anus on the side of the head on the anterior side. After torsion the foot can be withdrawn after the head.

During torsion head and foot remain fixed and rotation takes place in the visceral mass only behind the neck so that the visceral organs of the right side come to occupy the left side and vice versa. Before torsion the visceral mass points forward and the mantle cavity is posterior in position. This position is called **exogastric**. After torsion the position becomes **endogastric** in which visceral mass points backwards and intestine lies in the whorls of the shell and anus opens on the anterior side.

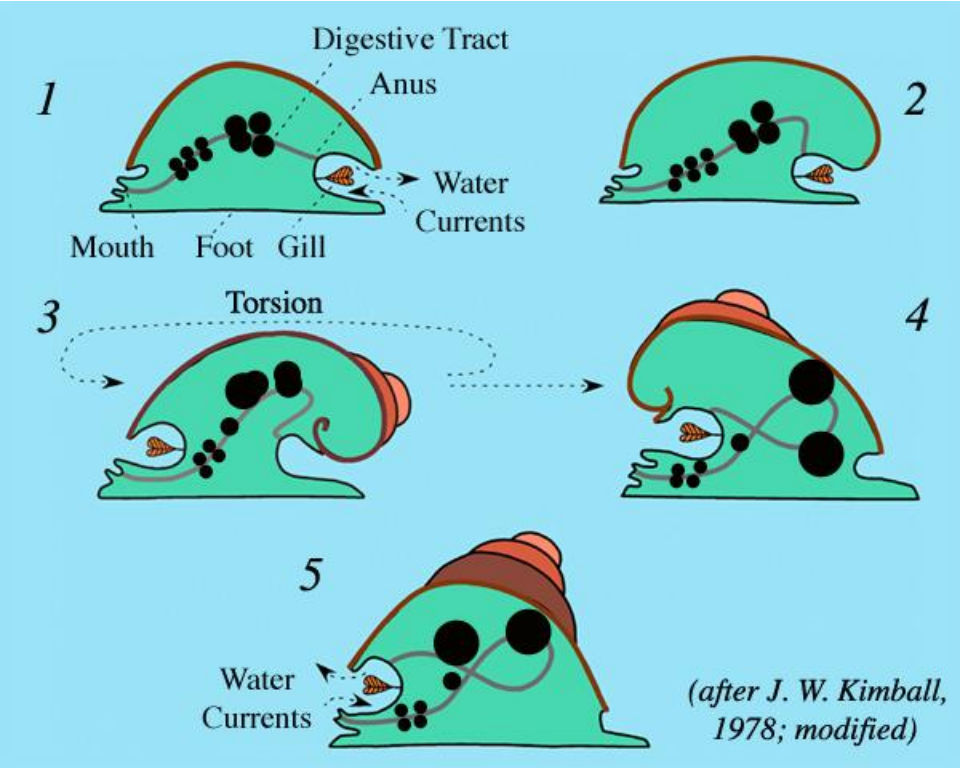
Ninety percent of the torsion is affected by the **right retractor muscle** which is quite prominent in the larva while the left retractor muscle is rudimentary. Rest of the 10% of torsion is caused by the differential growth of the visceral mass. Torsion takes place quickly and is completed from 15-30 minutes.

Anticlockwise rotation of the visceral mass causes **dextral** (right handed) coiling of the shell, which happens in majority of the cases. However, rarely clockwise rotation of visceral mass also takes place, which causes **sinistral** (left handed) coiling of the shell.

SIGNIFICANCE OF TORSION

As gastropod shell has only one opening, it has to serve as entrance as well as exit for all visceral organs. Both mouth and anus must open on the anterior side. Mantle cavity also must

open on the anterior side for easy respiration. Respiratory current opposes locomotion after torsion which increases availability of water inside the branchial chamber. Visceral mass has to undergo rearrangement so that openings of kidneys, gonads and anus should migrate to the front side which is the only opening of the shell. The small chemoreceptor **osphradium** also migrates to the front side so that it could chemically analyse water current entering the mantle cavity. The bulky buccal mass migrates to the anterior side that provides stability during locomotion. Torsion allows foot to be retracted after the head for better protection of head.



PHYLUM ARTHROPODA (JOINTED APPENDAGES ANIMALS)

MAIN CHARACTERS

- Arthropoda is the largest Phylum of the animal kingdom including 10, 00000 species of different types of animals.
- The word Arthropods is derived from Greek Arthos – Jointed and Podos – Foot.

HABIT AND HABITAT

Arthropodes have undergone an adaptive radiation for aerial, aquatic, terrestrial and parasitic environment. They are widely distributed in each and every place of the world.

NATURE

Arthropoda are "bilaterally symmetrical," metamerically segmented metazoa.

EXTERNAL FEATURES

- Their body is covered by an exo-skeleton of "chitin" and protein.
- They possess paired jointed appendages.
- Their metamers are not alike but are specialized and their number is generally fixed.
- The head is well developed.

INTERNAL FEATURES

- Musculature is not continues but comprises separates striped muscles.
- The coelomic space in Arthropods is occupied by the blood vascular system and is thus called "Haemocoel."
- Digestive tract is complete; mouth and anus lie at the opposite end of the body.
- Circulatory system is open with dorsal heart and arteries but without capillaries.
- Respiration through general body surface, by gills in aquatic forms, trachea or book lungs in terrestrial forms.
- Excretion by "Malpighian tubules" or Coelomoducts.
- Sexes are generally separate and sexual dimorphism is often exhibited by several forms.
- Fertilization is internal.
- Development is usually indirect through the larval stage.
- Nervous system of arthropods is quite similar to that of annelids and consists of dorsal anterior brain and a double ventral nerve cord.

CLASSIFICATION OF ARTHROPODA

Phylum Arthropoda is divided into following five classes:

1. CLASS MEROSTOMATA

- Almost all members of the class Merostomata are extinct. The only living merostomes, the king Crabs have survived.
- The animals are horse-shoe shaped.
- The long spike like tail that extends, posteriorly is used in locomotion. It is called "Telson."
- They feed on mollusks, worms and other invertebrates that they find on the ocean floor.
- King Crabs a hors-shoe crabs have a tough "Carapace" jointed to a smaller abdomen.
- E.g:Limulus Polyphemus (King Crab).

2. CLASS ARACHNIDA

- This class includes spiders, scorpions, mites, ticks and many other terrestrial arthropods.
- The Arachnid body consists of a cephalothorax and abdomen.
- Cephalothorax is comprised of fused head and thorax.
- Arachnids have six pairs of jointed appendages.
- Most Archnids are carnivorous and prey upon insects and other small arthropods.
- Respiration in archnids takes place either by trachea or book lungs or by both.
- They are mainly terrestrial arthropods.
- They have no antenna.
- Cephalothorax is non-segmented.

E.g: Scorpions, Ticks & Mites, Spiders

3. CLASS CRUSTACEA

- They live both in marine and fresh waters.
- A few are terrestrial.
- Crustaceans are unique among arthropods in possessing two pairs of antenna.
- They always have one pair of mandibles and two pairs of maxillae around the mouth.
- Mandibles are usually adapted for biting and chewing. Maxillae are used for holding the food.
- Their body is divided into three distinct parts, i.e. the head, thorax and abdomen.
- Respiration usually takes place through gills associated with appendages.
- The sexes are usually separate and the reproduction is sexual.
- The thoracic and abdominal appendages may be variously modified for walking, swimming, feeding, respiration or as accessory reproductive structures.

E.g: Sacculina (Parasitic Crustacean), Astacus (Cray-fish), Prawns, Shrimps, Lobsters and Crabs etc.

4. CLASS MYRIAPODA

- All the animals are terrestrial.
- Their body is divided into a head and an elongated trunk with many segments.
- Each segment bears one or two pairs of legs.
- They are carnivorous /herbivorous.
- Eyes may present or absent.

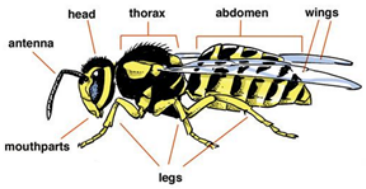
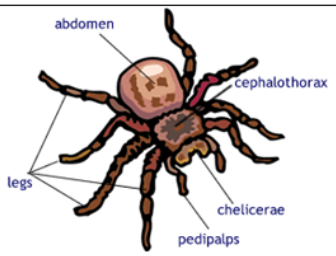
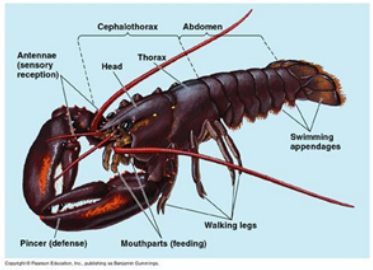
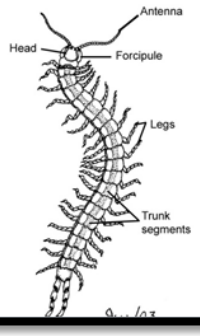
E.g: Millipedes and Centipedes etc.

5. CLASS INSECTA (HEXAPODA)

- Insecta is the largest class of the animal kingdom.

Arthropods

Arthropods are the biggest group of invertebrates. All arthropods have an **external skeleton** that protects their body. They also have **many legs**.

INSECTS	ARACHNIDS	CRUSTACEANS	MYRIAPODS
• **6** legs. • Exoskeleton • 3 body parts (**head, thorax and abdomen**). • Two **antennae**. • Many have **wings**. • Examples are wasps, ants, butterflies…	• **8** legs. • Exoskeleton. • 2 body parts (**cephalothorax and abdomen**). • Most have 8 eyes. • Don´t have antennae or wings • Examples are spiders, scorpions…	• **10** legs. • Exoskeleton. • 2 body parts (**cephalothorax and abdomen**). • Two **antennae**. • Examples are crabs, prawns…	• **Lots** of legs. • Exoskeleton. • Two **antennae**. • Body has lots of segments.
			

HABIT AND HABITAT

- In their adaptive radiation, approximately a 8,50,000 species of insecta have occupied all types of terrestrial habitat.
- Some live in fresh water, however one small group is marine.

NATURE AND ADAPTATIONS

- The great success of insects can be attributed partly to the development of flight in them.
- Flight has provided them the great capacity of dispersal, access to food sources, and favourable habitat and escape from enemies.
- Corresponding to their number of species, there exists a huge variation in their structural and biological adaptations.

EXTERNAL FEATURES

- All insects have their body divided into three well-defined regions i.e. the head, thorax and abdomen.
- There is always a pair of antenna on the head.
- The thorax always consists of three segments:

(a) Prothorax
(b) Mesothorax
(c) Metathorax

- Each thoracic segment bears a pair of legs.
- Head consists of six fused segments and a pair of compound eyes and mouth parts.
- Abdomen comprises 7-11 segments and devoid of appendages.

MOUTH PARTS

The feeding appendages consists of three pairs:
(a) Mandibles
(b) First Pair of Maxilla
(c) Second Pair of Maxilla

- The second pair of maxillae have fused together to form the "LABIUM," or lower lip
- The upper lip is formed by the projections head and is called the "LABRUM.'

Types:- The mouth appendages have been greatly modified to form five basic types of pattern:
(i) Biting
(ii) Chewing
(iii) Piercing
(iv) Sucking
(v) Siphoning or Sponging

INTERNAL FEATURES

- Heart is elongated, tubular and divided into chambers situated in the abdomen.
- Excretion takes place through "Malpighian tubules."
- Liver is absent but salivary glands are usually present.
- Respiration is by "TRACHEA". External gills may be present as accessory respiratory organs in some aquatic insects.

REPRODUCTION

Reproduction is sexual in most insects. However it takes place parthenogenetically i.e. eggs developing without being fertilized by sperms in a number of insects e.g: Aphids and Termites etc.

METAMORPHOSIS

- The development of insects after hatching from egg into adult stage involves considerable growth and in some cases drastic morphological changes.
- The entire post-hatching development is termed as "Metamorphosis."

(A) INCOMPLETE METAMORPHOSIS

- In some insects the immature form that hatch from the egg are essentially similar in shape to their adults, but are smaller in size, lack wings and reproductive organs
- They attain adult characters after some growth period. This type of metamorphosis is called "Incomplete Metamorphosis."
- Three stages are Egg → Nymph → Adult.

For example Cockroach, Grasshopper, Bugs etc.

(B) COMPLETE METAMORPHOSIS

- In this type the animal shows following stages during its complete development: Egg → Larva → Pupa → Adult.

For example Mosquito, Butter fly, House fly etc.

ECONOMIC IMPORTANCE OF INSECTS

Insects are of very great importance to man.

BENEFICIAL INSECTS

1. Apis, the honey bees produce honey and also give wax.
2. Insects bring about the cross-pollination.
3. Bombyx and Eupterote are silk-moths and produce silk.
4. The larvae of Lucilla and Pharmia are used in wound healing of bones.
5. Some insects feed upon and destroy harmful insects.
6. Some insects are Scavengers

HARMFUL INSECTS

1. Many types of mosquitoes, flies, fleas, lice and bugs transmit diseases to man and animals.
2. Human food is spoiled by cockroaches, ants and flies.
3. Tinea and Teniola are cloth-moths and destroy cloths.

4. Tenebrio is mealworm. They eat meal, flour and grains.
5. Lepisma destroy the books.
6. Termites destroy books and wood.

RESPIRATION IN ARTHROPODA

(Prof. Girish Chandra)

Arthropods constitute three-fourth of the animal kingdom and inhabit a variety of habitats. They breathe air as well as water and some are accomplished amphibians. Their respiratory organs vary according to their way of living as described below.

RESPIRATORY ORGANS OF CRUSTACEANS (e.g. Prawn)

In smaller crustaceans, such as Copepods and Ostracods oxygen simply diffuses through the body surface since small animals have larger surface area as compared to the body mass. In majority of crustaceans gills are the chief respiratory organs. In prawn gills are enclosed in a gill chamber on each side of the cephalothorax and are covered by a carapace, inner side of which is called branchiostegite and has vascularised respiratory epithelium.

Epipodites are highly vascularised leaf-like membranous structures attached on the coxa of the three maxillipedes. They carry out respiratory function.

The gills are regarded as primary respiratory organs and they are three types in prawn, namely podobranchs, arthrobranchs and pleurobranchs.

Podobranchs are one pair of small gills that are attached on the coxa of the second maxillipedes.

Arthrobranchs are two pairs, one smaller and the other larger, attached to the arthrodial membrane of the third maxillipedes.

Pleurobranchs are 5 pairs of arched gills attached in the gill chamber on the outer margin of cephalothorax, just dorsal to the walking legs. The gill lamellae are flat, plate-like arranged parallel to each other like the pages of a book.

Water current flows through the gill chamber by the action of **scaphognathite** which is a fan-like appendage of maxilla and lies near the entrance of the gill-chamber. It is also called baler as it forces water over the gill chamber. Fresh water enters the gill chamber from behind in the form of a current. The highly vascularised gill-plates are covered with permeable membrane for the passage of gases.

RESPIRATORY ORGANS OF ARACHNIDS (e.g. Scorpion)

Scorpion breathes air through four pairs of book lungs or pulmonary sacs that open to the outside through four pairs of stigmata on the ventral side of mesosoma.

Book lungs are sac like structures, within which there are delicate folds that are arranged like the leaves of a book. These folds are richly supplied with blood. The four pairs of book lungs are located in the third, fourth, fifth and sixth mesosomal segments. Each book lung consists of an air cavity or **atrial chamber** on the ventral side which opens to the outer side by a slit-like spiracle or **stigmata** that opens on the ventro-lateral side of the sternum. Dorsal part of book lung consists of nearly 150 vertical folds or **lamellae** arranged like leaves of a book. Each lamella is a hollow structure, made of two thin layers of respiratory epithelium.

The air breathing in the book-lungs is effected by the action of the **dorso-ventral** and **atrial** muscles. Contraction of the dorso-ventral muscles compresses the pulmonary chamber so that the air from the chamber is forced out through the stigmata. When the atrial muscles contract the book-lungs expand creating vacuum and sucking fresh air in through the stigmata.

RESPIRATORY ORGANS OF INSECTS (COCKROACH)

Great majority of insects breathe air by means of an elaborate and most efficient gas exchange system made of branching elastic air tubes or tracheae called the **tracheal system**. In majority of insects tracheal system serves for transport of oxygen and carbon dioxide. Each trachea is an air tube lined with epithelial cells and spiral ridges called the **taenidia**. Tracheae open externally by small openings called **spiracles** through which the air enters the system. The tracheae are branched into finer branches called **tracheoles** which are air capillaries without inner taenidial ridges. Breathing is affected by the paired **tergo-sternal muscles** which connect dorsal side of body with the ventral side and hence their contraction compresses the abdominal cavity forcing air to move out. Relaxation of these muscles brings the abdominal cavity into its original shape, sucking the air into the tracheal tubes.

In many aquatic insects such as mayfly and dragon fly larvae there are tracheal gills for respiration in water. Tracheal gills are leaf-like extensions on the terminal abdominal segments that carry respiratory epithelium.

Inside the body of cockroach there are three pairs of parallel longitudinal **tracheal trunks**, one dorsal, one ventral and one pair lateral in position, which are connected together by transverse commissures. The cuticular lining of these tracheae is spirally thickened to form **taenidia** which prevent the tracheal tubes from collapsing. **Tracheoles** profusely branch and anastomose and penetrate in all parts of body and connect to the muscle and tissue cells. Tracheoles have a

diameter of only 1 micron only and their cavities are intracellular and walls are very thin and devoid of cuticular thickenings. Instead they are lined by a protein called **trachein** and are usually filled with a fluid in which oxygen dissolves and diffuses to the tissues. The tracheal system carries oxygen directly to the body cells and does not require blood to transport it. Generally there are 10 pairs of spiracles in insects, two pairs are thoracic and eight pairs are abdominal.

METAMORPHOSIS IN INSECTS

Insect life cycle is generally complex involving several stages of the larval and pupal development. Adults are generally quite different from the larval forms. When the larvae undergo considerable change to become adults it is called metamorphosis. Insects show various types of metamorphosis as described below.

1. PALEOMETABOLA, AMETABOLA OR ANAMORHOSIS

This type of metamorphosis occurs in orders Protura, Diplura, Collembola and Thysanura that include insects such as telson-tails, campodeids, spring tails and silverfish. The nymph upon hatching from the egg is similar to the adult in general morphology but there are only 8 abdominal appendages and cerci are lesser in number. Size is small. As the nymph grows and molts its segments in abdomen increase gradually to become 11 in adult. These nymphs live in the same environment as the adult and feed on the same diet as the adult. The insects are wingless both in larval as well as in adult stages. Some biologists do not consider it as metamorphosis or called it Anamorphosis as there is little change during development.

2. HEMIMETABOLA

There are 15 orders of insects which demonstrate this kind of metamorphosis in which juveniles are similar to the adults and there is a gradual change from nymphs to adults. The transformation takes place in the growth of wings as external buds and development of secondary sexual characters. Nymphs generally live in the same environment as the adults. The examples are: grasshoppers, locusts, cockroaches, dragon flies, Mayflies, earwigs, lice, bugs, thrips etc. Hemimetabola includes two categories as given below.

(i) HETEROMETABOLA

These insects do not show any dormant stage during development and nymphs are active throughout their growth stage. Wings develop externally.

(a) Archimetabola

Those insects whose larvae are aquatic while adults are a flying terrestrial insects show differences in the morphology of their nymphal stages owing to their aquatic habitat. Such

nymphs are called NAIADS which are generally carnivorous in habit. Examples are: Odonata (dragon and damsel flies), Ephemeroptera (may flies) and Plecoptera (stone flies). The larvae breathe with tracheal gills attached on the tip of abdomen. Wings develop as buds externally on the thorax. The last nymphal instar climbs on a blade of grass and molts outside water to give rise to adult.

(b) Paurometabola

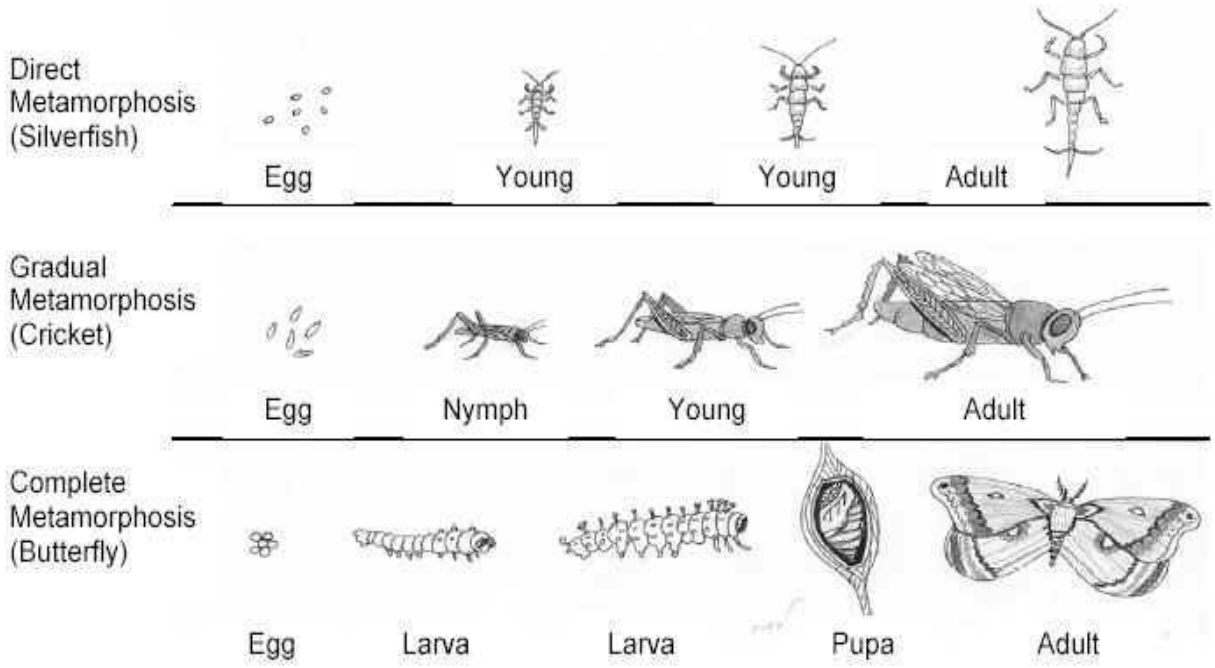
The immature stage is called a nymph and lives in the same habitat as the adult and eats similar food. The examples are: Orthoptera (grass hoppers and locusts), Dictyoptera (cockroaches and mantids), Hemiptera (bugs) and lice. The wings develop externally and become larger after each molt and size gradually increases. There is no dormant stage in the development.

(ii) NEOMETABOLA

This type of metamorphosis is found in Thysanoptera and coccids. Nymphs live in the same environment as the adults and feed on the same kind of food. But they have a dormant or resting stage after the larval development is completed. This dormant stage is different from the pupal stage of the Holometabolous insects as the there is no covering or cocoon or pupal case outside the resting larva. Owing this unique development thrips are assigned a different category of Neometabola.

3. HOLOMETABOLA

This type of metamorphosis is found in endopterygotes, namely, Lepidoptera, Hymenoptera, Coleoptera, Siphonoptera, Diptera, Trichoptera etc. Larvae and adults are completely different in general feature and eat different type of food and live in a different type of habitat. The larva after completing its development transforms into a dormant stage called pupa, which is sometimes enclosed inside a cocoon made of silken threads. The development of the adult takes place inside the pupal case and cannot be seen from outside. The adult is a flying insect that emerges after rupturing the pupal case. This type of development can be seen in silkworm, butterflies, houseflies and beetles.



Written by Tahir Habib

PHYLUM ANNELIDA (SEGMENTED WORMS)

MAIN CHARACTERS

NATURE

Annelida are triploblastic, symmetrical, coelomata and segmented metozoa.

HABIT AND HABITAT

Annelida are mostly aquatic, marine or fresh water, burrowing or living in tubes, some free living forms.

EXTERNAL FEATURES

- The most important feature of annelida is their metameric segmentation. (External segmentation)
- Segmentation is indicated externally by circular constrictions or grooves on the body wall.
- Outer covering of the body is cuticle secreted by the underlying epidermis.
- Appendages, when present are unjointed.
- Locomotory organs are segmentally arranged, paired setae or chaetae.

INTERNAL FEATURES

- Body wall is contractile, consists of an outer epidermis, circular and longitudinal muscles.
- The gut, longitudinal blood vessels and the nerve cord extend throughout the body length, whereas other structures are repeated in each segment.
- Important character of annelida is the development of series of coelomic compartments in their body between the gut and the body wall.
- The Coelom is a cavity, which develop within the mesoderm and is lined by mesodermal cells.
- Segmented musculature plays an important part in locomotion of Annelids.

SYSTEMS OF BODY

- Alimentary canal is tube like extending straight from mouth to anus.
- Respiration through general body surface, by gills in some forms.
- Blood vascular system is closed type.
- Blood is red due to haemoglobin.
- Excretory organs are Nephridia usually one pair in each segment.
- Nervous system consists of dorsal brain and longitudinal ventral nerve cord.
- Sexes may be united or separate.

- Development is direct when sexes are united and indirect when sexes are separate.

EXAMPLES

Nereis, Earthworm and Leeches etc.

CLASSIFICATION OF PHYLUM ANNELIDA

Phylum Annelida is divided into four classes:

1. Polychaeta
2. Oligochaeta
3. Hirudinea
4. Archiannelida

1.POLYCHAETA

LOCOMOTORY ORGANS

The Polychaetes possess paired parapodia functioning as locomotry appendages, are present only in the class Polychaeta.

PROSTOMIUM

Usually there is a distinct head or Prostomium bearing sensory and feeding appendages.

MODE OF LIFE

The Polychaetes may be carnivorous, scavengers, or filter feeders.

REPRODUCTION

The sexes are separate and fertilization of eggs takes place outside body. Their free swimming larva is called Trochophore.

RESPIRATION

The respiration takes place through the body surface in many but in some gills may be present as respiratory organs.

EXAMPLES

Some well-known examples of marine polychaetes are Nereis, Arenicola and Sabella. Nereis lives beneath stones and in crakes of rocks.

2.CLASS OLIGOCHAETA

LOCOMOTORY ORGANS

The Oligochaetes possess fewer numbers of Setae as compared to the Polychaetes. The setae help the earth worms in crawling.

SENSE ORGANS

There anterior end lacks eyes, or sensory appendages.

CLITELLUM

At sexual maturity, all of the oligochaetes develop in several segment, glandular epithelium, called clitellum.

MODE OF LIFE

- Oligochaetes live either in fresh water or on land.
- There is no free swimming larval stage in their development
- Majority of oligochaetes are scavengers, feeding on decomposing organic matter.
- Some fresh water species feed on algae.
- Burrowers like earth worm ingest a large quantity of soil, digest the organic matter and the living fauna.

RESPIRATION

Respiration takes place through their general body surface. Some aquatic species possess anal gills.

ECONOMIC IMPORTANCE

Earthworms increase the fertility of soil by physically over turning it. They ingest the soil, break it down and deposit it in the form of casts. The over turned soil is relatively in proportions of total nitrogen, organic carbon, calcium, magnesium and phosphorus.

3.CLASS HIRUDINEA

BODY SEGMENTS

Unlike polychaetes and oligochaetes, the number of body segment in leeches is fixed at 34.

SUCKERS

The anterior and posterior body segments are fused to form suckers.

LOCOMOTION

Leeches either swim or crawl.

RESPIRATION

Respiration generally takes place through the body surface. Leaf like gills may be present.

PARASITIC NATURE

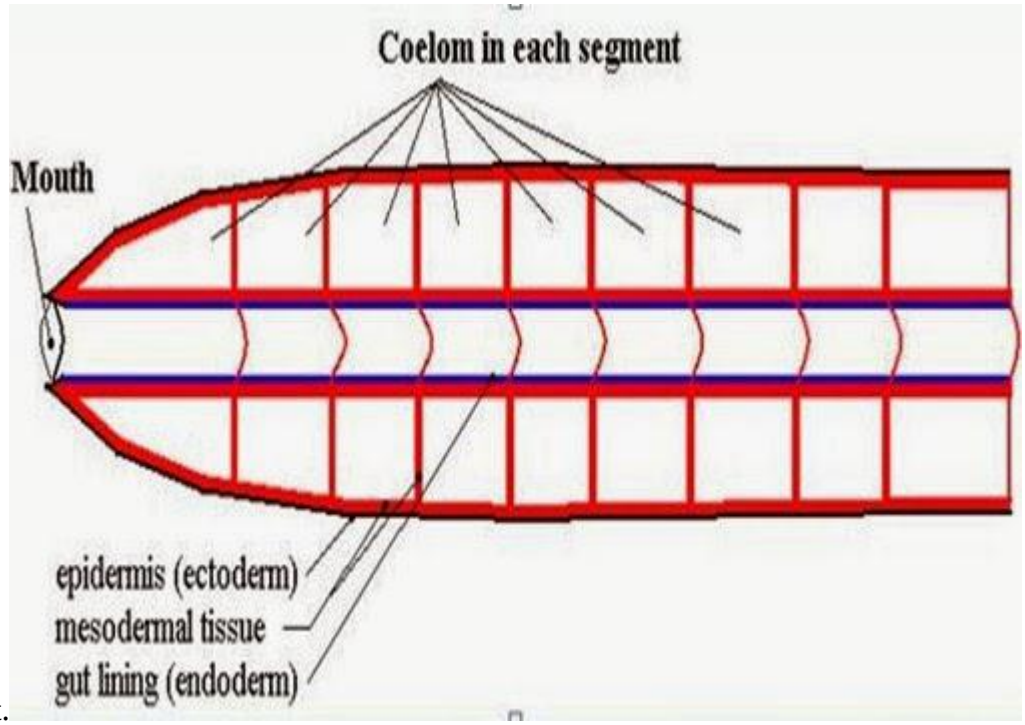
Most leeches feed by sucking blood of aquatic invertebrates and vertebrates.

4.ARCHIANNELIDA

- It is a small group of marine worms.
- They are not segmented externally and don't have bristles.
- They live in the sea and show annelid characteristics to a minor extent.
- Their development is also characterized by Trochophore Larva.

METAMERISM IS SEEN IN DIFFERENT ANIMALS

The body of Annelids is divided into a number of segments longitudinally. All the segments look alike. They are called metameres and this is called metamerism. In these segments all systems are repeatedly arranged. Usually the metamerism is confined to the trunk region of the organisms. Cephalic and anal regions may not show metameric nature in the caphalic region sense organs are concentrated, where in the anal region new segments are produced in front of anal segment.



1. Metamerism first observed in Annelida in the animal kingdom.
2. The most successful animals of animal kingdom like arthropoda and chordate will also show metameric segmentation.
3. In annelids the metameric segmentation is both external and internal. The body is divided into a number of segments which contain all body organs repeatedly but the alimentary canal is long and straight tube extending through all the segments.
4. In arthropods the segmentation is external.
5. In chordates the segmentation is internal.

Significance of Metamerism :

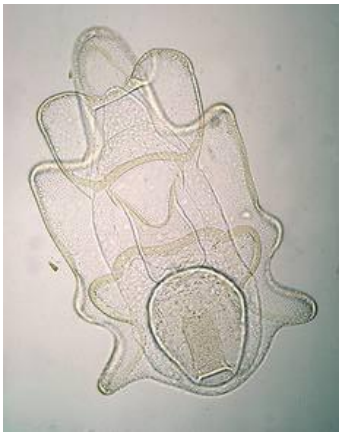
1. Metameric segmentation helps the animals in their locomotion.
2. The segments will show high structural development which gave scope for evolution.

ECHINODERMS

PHYLUM ECHINODERMATA

Characteristics

- All marine
- Known as spiny-skinned animals
- Endoskeleton known as the test is made of calcium plates or ossicles with protruding spines
- Includes sea stars, brittle stars, sand dollars, sea urchins, & sea cucumbers
- Undergo metamorphosis from bilateral, free-swimming larva to sessile or sedentary adult
- Larval stage known as dipleurula or bipinnaria
- Adults have pentaradial (5 part) symmetry
- Lack segmentation or metamerism
- Coelomate
- Breathe through skin gills as adults
- Capable of extensive regeneration



Bipinnaria Larva

- Ventral (lower) surface called the oral surface & where mouth is located
- Dorsal (upper) surface known as aboral surface & where anus is located
- Have a nervous system but no head or brain in adults
- No circulatory, respiratory, or excretory systems
- Have a network of water-filled canals called the water vascular system to help move & feed

- Tube feet on the underside of arms help in moving & feeding
- One-way digestive system consists of mouth with oral spines, gut, & anus
- Deuterostomes (blastopore becomes the anus)
- Separate sexes
- Reproduce sexually & asexually

CLASSIFICATION:

Includes 5 classes:

*** Crinoidea -** sea lilies & feather stars
*** Asteriodea -** starfish
*** Ophiuroidea -** basket stars & brittle stars
*** Echinoidea -** sea urchins & sand dollars
*** Holothuroidea -** sea cucumbers

Class Crinoidea

Characteristics

- Sessile
- Sea lilies & feather stars
- Have a long stalk with branching arms that attach them to rocks & the ocean bottom
- Can detach & move around
- Mouth & anus on upper surface
- May have 5 to 200 arms with sticky tube feet to help capture food (filter feeders) & take in oxygen
- Common in areas with strong currents & usually nocturnal feeders

Class Asteroidea

Characteristics

- Usually sedentary along shorelines
- Starfish or sea stars
- Come in a variety of colors
- Prey on bivalve mollusks such as clams & oysters
- Have 5 arms that can be regenerated
- Arms project from the central disk
- Mouth on oral surface (underside)

Class Echinoidea

Characteristics

- Includes sea urchins & sand dollars
- Internal organs enclosed by endoskeleton or test made of fused skeletal plates
- Body shaped like a sphere (sea urchin) or a flattened disk (sand dollar)
- Lack arms
- Bodies covered with movable spines
- Have a jawlike, crushing structure called Aristotle's lantern to grind food
- Use tube feet to move
- **Sea Urchins:**
- * Spherical shape
- * Live on ocean bottom
- * Scrape algae to feed
- * Long, barbed spines make venom for protection
- **Sand Dollars:**
- * Flattened body
- * Live in sand along coastlines
- * Shallow burrowers
- * Have short spines
-

Feeding & Digestion

- Tube feet attach to bivalve mollusk shells & create suction to pull valves apart slightly
- Starfish everts (turns inside out) its stomach through its mouth & inserts it into prey
- Stomach secretes enzymes to partially digest bivalve then stomach withdrawn & digestion completed inside starfish

Other Body Systems

- No circulatory, excretory, or respiratory systems
- Coelomic fluid bathes organs & distributes food & oxygen
- Gas exchange occurs through skin gills & diffusion into the tube feet
- No head or brain
- Have a nerve ring surrounding the mouth that branch into nerve cords down each arm
- Eyespots on the tips of each arm detect light
- Tube feet respond to touch

Reproduction

- Separate sexes

- Two gonads (ovaries or testes) in each arm produce eggs or sperm
- Have external fertilization
- Females produce up to 200,000,000 eggs per season
- Fertilized eggs hatch into bipinnaria larva which settles to the bottom after 2 years & changes into adult
- **Asexually reproduce by regenerating arms**

WATER VASCULAR SYSTEM OF STARFISH

Introduction **:-**

The water vascular system is a modified part of coelom & consists of a system of sea water filled canals having certain corpuscles. It plays most vital role in the locomotion of the animals & comprises madreporite stone canal, ring canal, radial canal, Tiedman's body, lateral canals & tube feet.

(1) ***Madriporite*** **:-**

The madreporite is a rounded calcareous plate occurring on the aboral surface of the central disc in inter-radial position. Its surface bears a number of radiating, narrow, straight or wavy grooves or furrows. Each furrow contains many minute pores at its bottom. Each pore leads into a very short, fine, tubular pore-canal. Which passes inward in the substance of the madreporite. There may be about 200 pores and pore-canal. The pore-canals unite to form the collecting canals. Which open into an ampulla beneath the madreporite.

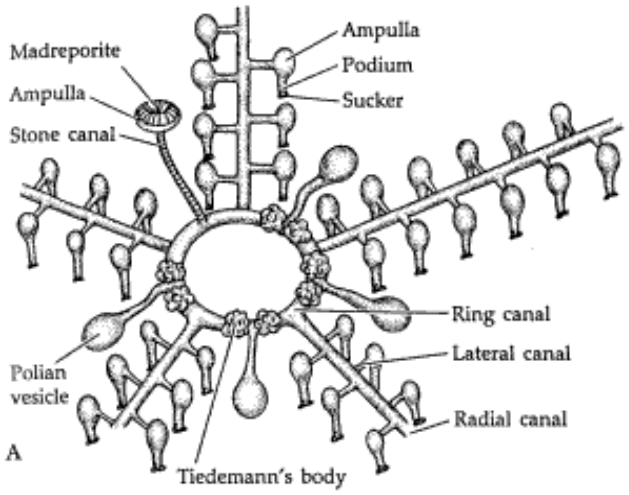


Fig : Water vascular system of Starfish

(2) *Stone Canal* :-

The ampulla opens into a "S" shaped stone canal. The stone canal extends downwards (orally) and opens into a ring canal, around the mouth. The walls of stone canal are supported by a series of calcareous ringd. The lumen of stone canal is lined by very tall flagellated cells. in embryonic stages and young Asterias, the stone canal remains a simple tube but in adult Asterias, lumen of stone canal possesses a prominent ridge with two spirally rolled lamellae.

(3) *Ring Canal* :-

The Ring canal or water ring is located to the inner side of the peristomial ring of ossicles and directly above (aboral) to the hyponeural ring sinus. It is wide and pentagonal or five sided.

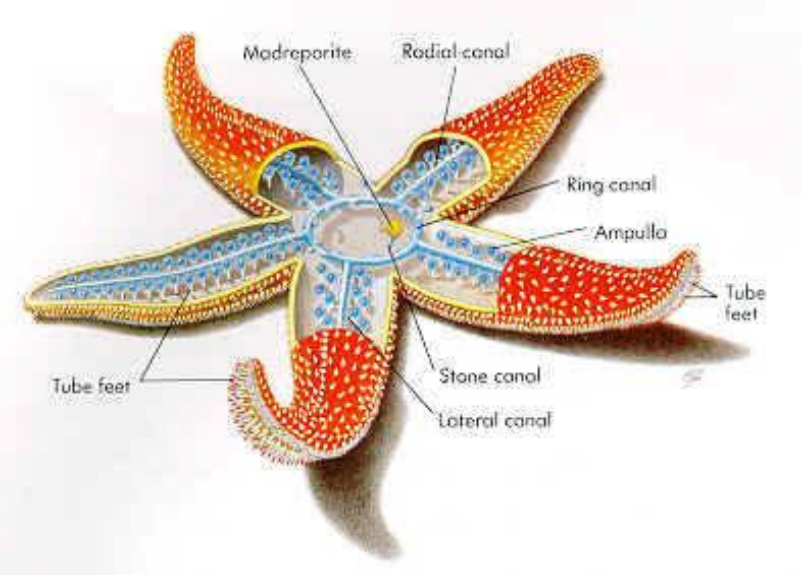


Fig : Star fish

(4) *Tiedmann's Bodies* :-

The ring canal gives out inter radially nine small, yellowish, irregular or rounded glandular bodies called racemose or Tiedmann's bodies from its inner margins. The Tiedmann's body rest upon the peristomial ring of ossicles. The actual function of tiedmann's bodies is still unknown, however they are supposed to be lymphatic glands to manufacture the amoebocytes of the water vascular system.

(5) *Pollian Vesicles* :-

The ring canal gives off on its outer side in the inter radial position one, two or four little, pear shaped, thin walled contractile bladder or reservoirs with long necks called pollian vesicles. They are supposed to regulate pressure inside ambulacral system and to manufacture amoeboid cells of ambulacral system.

(6) *Radial Canal* :-

From its outer surface the ring canal gives off a radial water canal into each arm that runs throughout the length of the arm and terminates as the lumen of terminal tentacle. In the arm the radial water canal runs immediately to the oral side of the ambulacral muscles.

(7) *Lateral Canal* :-

In each arm, the radial canal gives out two series of short, narrow, transverse branches called lateral or podial canals. Each lateral canal is attached to the base of a tube foot and its provided with a valve to prevent backward flow of fluid into the radial canal.

(8) *Tube feet* :-

As already mentioned, there are four rows of tube feet in each ambulacral groove. A tube foot is a hollow. elastic, thin walled, closed cylinder or sac-like structure having an upper sac like ampulla, a middle tubular podium & a lower disc like sucker. The ampulla lies within the arm, projecting into the coelom above the ambulacral pore which is a gap between the adjacent ambulacral ossicles for the passage of the podium. The tube feet are chief locomotory and respiratory organ of Asterias.

***Function of Water Vascular System* :-**

The water vascular system has three main functions. They are as follows-

(1) *Locomotion* :-

The water vascular system is used mainly for locomotion. The inner wall of the water vascular canals are provided with cilia. The beating of the cilia causes the seawater to enter through the madreporite. Finally, the seawater reaches the tube feet and their ampullae.

The ampullae contract ; the valves at the junction of the lateral canals and tube feet, prevent the flow of water into radial canals.

The water is forced into the podia. The podia are elongated and protected out through the ambulacral groove. Then the suckers are applied to the substratum.

The tube feet now contract & push the body forward. The water from the tube feet is pushed into the ampulla. Hence, the tube feet shorten. The suckers are released. Then the ampulla contracts & the whole process is repeated.

(2) *Food Capture* :-
The tube feet are used to capture the prey. The suckers are used to open the shells of molluscas.

(3) *Attachment* :-
The Starfish can be attached to the rocks by the tube feet.

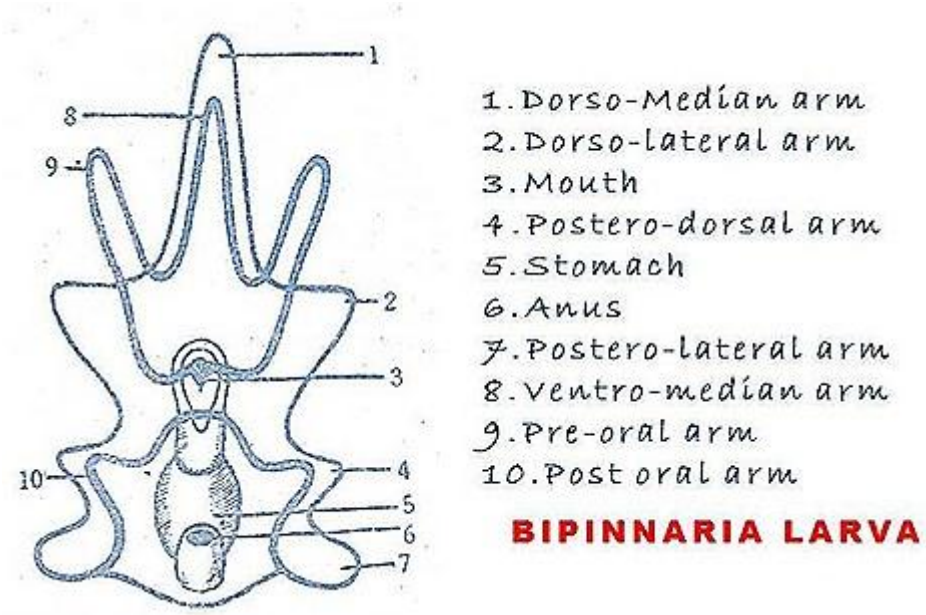
ECHINODERMATA LARVAL FORMS

Echinoderms are unisexual animals. Sexual dimorphism is absent. Fertilisation takes place in water. The development may be direct or indirect. If the development is indirect it includes larva stages. In different classes of echinoderms, different types of larvae complete the development. The larval form is bilaterally symmetrical. It undergoes metamorphosis and radial symmetrical adult is developed.

Class of Phylum Echinodermata	**Larval form**
1. Asteriodea	Bipinnaria & Brachiolaria
2. Ophiuroidea	Ophiopkiteus
3. Echinoidea	Echinopkrteus
4. Hobturoidea	Auricularia
5. Crinoidea	Dobolaria & Pentacrinoid

1. Bipinnaria larva :

It is the larva form seen in the life history of Star fish. The fertilised egg is homolecithal. ft undergoes hobblastic cleavage and devebps into blastula and gastrula stages. The gastrula elongates in length and it gives rise to Bipinnaria larva.



1. It is a bilaterally symmetrical free swimming pelagic larva.

2. The pre-oral region is elongated. Post-oral region is broad. The anterior end forms pre-oral lobe.

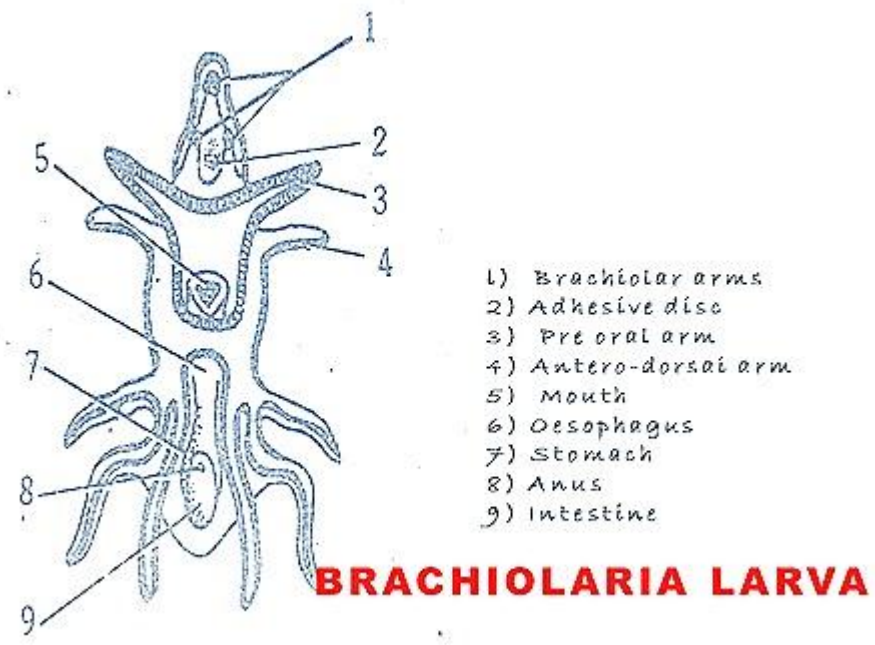
The ciliated band at the pre-iral lobe 'orms into 2 separate bands, Pre-oral band of cilia, and post oral band of cilia. These 2 bands of cilia are drawn into many arms. They are nothing to do with the arms of the star fish. They are,

1) Ventro-median arm.
2) A pair of pre-oral arm.
3) Median dorsal arm.
4) A pair of antero-dorsai arm. 5; A pair of posterio-dorsal arm.
6) A pair of posterio-lateral arm.
7) A pair of post oral arm.
8) The digestive system is developed with mouth and anus. This larva resembles Tomaria larva of Balanoglossus.
This larva slowly grow s into the next larval form called Brachiolaria larva.

2. Brachiolaria Larva :

Bipinnaria larva swims for few weeks in the sea water.lt finally transforms into next larval stage called Brachiolaria larva.

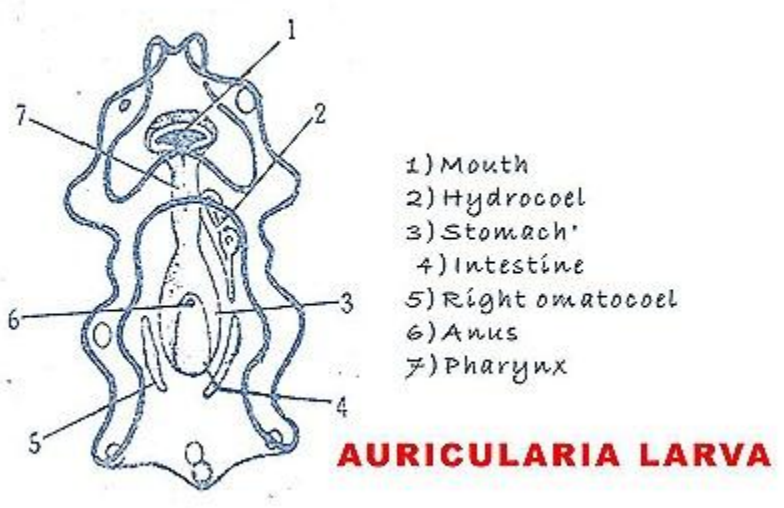
1) It is bilaterally symmetrical larva.
2) It is pelagic larval form, it shows 3 brachiolar arms with suckers. They are one median and two lateral in position.



3) At the tip of brachiolar arms adhesive structures will make their appearance and they are for attachment.
4) The larva shows all the arms that areseen in the Bipinnaria, but these arms are very long and hanging. These ciliated arms will be helpful **for** swimming **in** the water.
5) The digestive system is completely developed with definite stomach and intestine.
This larva after swimming few settle-on a solid object and gets attached to it by its adhesive arms. Posterior end of the larva enlarges and lifts to the right-side. From this rudiments of 5 arms will arise. Thus slowly the larva metamorphosis into an adult.

3. Auricularia Larva : In Holothuroidea this larval form is seen.

1. It is a free swimming pelagic larva.
2. Arms are absent. Alimentary canal is developed. It opens with mouth and ends with anus.
3. Intestine is curved.



4. In Japan and Bermuda very big auricularia larval forms are developed. They are 15 mm in length. Usually this larva is 1 mm in length.
5. Ciliated bands are well-developed. Ciliated band continues through oral loop and anal loop.

PROTOCHORDATES

Protochordates are an informal category of animals (i.e.: not a proper taxonomic group), named mainly for convenience to describe invertebrate animals that are closely related to vertebrates. This group is composed of the Phylum **Hemichordata** and the Subphyla **Urochordata** and **Cephalochordata**.

The Phylum **Hemichordata** consists of marine worms that share some, but not all of the characteristics of chordates. These animals have pharyngeal gill slits and a dorsal nerve cord, which is usually solid. The three body parts are proboscis, collar and trunk. What was once thought to be a notochord is no longer considered homologous. Acorn worms are examples of hemichordates.

The **Urochordates** and **Cephalochordates** are protochordates, but belong to the Phylum **Chordata**. Therefore, these animals will be discussed in the chordate section.

Phylum chordata of animal kingdom is divided into 2 sub-groups Protochordata/acraniata(without brain box or cranium) and **euchordata/craniata**(cranium is present).

- Again **protochordata is divided into two sub-phylum urochordata**/tunicata (notochord is present only in larval tail, eg. Salpa,doliolum) and **cephalochordata** (notochord extends from head to tail region, eg. Branchiostoma)

GENERAL CHARACTERISTICS OF PROTOCHORDATA -

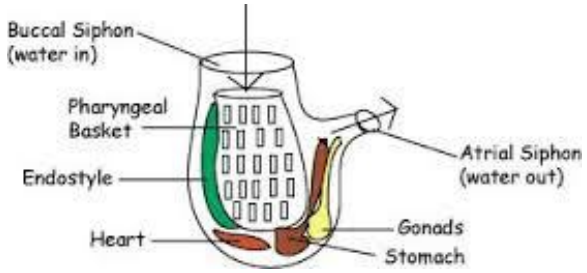
- Elastic, solid, ensheathed rod-like structure of vacuolated turgid cells callled **notochord** is present may be through out the life or only during early embryonic development mentioned above.
- Their central nervous System is dorsal,hollow and single which is different from non-chordata as their CNS is ventral,solid and double.
- Paired pharyngeal gill slits(pharynx is perforated by gill slits) is present which takes part in circulation of water for respiraton and in higher chordates , they occur only in embryonic stage.
- Ventral heart is present and gut lies ventral to nerve cord.
- Post-anal tail is present and if present then it's for balancing.
- They are bilaterally symmetrical, triploblastic, coelomate with organ system level of organisation.

- Urochordata and cephalochordata which are acraniates are considered as primitive and often referred to as protochordates or non-vertebrate chordates.

Subphylum Urochordata

CHARACTERISTICS OF UROCHORDATA:-

1)Possesses a Notochord,a hollow nerve cord and a post anal tail.
2)Body has more than two cell layers and includes tissues and organs.
3)Has a U shaped gut.
4)Body has no coelomic body cavity.
5)Body wholly enclosed in a 'tunic' of secreted protein and cellulose-like material.
6)Are hermaphroditic, normally with only one ovary and testis.
7)Has a nervous system composed of a anterior ganglion from which individual nerves issue.
8)Has no excretory organs.
9)Has a distinct larval stage.
10)All are filter feeders.
11)Live in marine environments.
12)About 2,000 species currently known.



GENERAL CHARACTERS-CEPHALOCHORDATA

Cephalochordata includes two genera, 1. Asymmetron and 2. Branchiostoma (Amphioxus). Cephalochordates are small fish like animals which show Chordate characters. The notochord extends the entire length of the body. They show a dorsal, tubular neural tube without a definite brain.

General Characters:

1. Body is fish -like and is useful for burrowing and swimming.
2. It has a head.
3. It shows a tail.
4. Appendages are absent.
5. Dorsal, caudal and ventral fins are present.
6. Body- wall shows one- cell thick, non-ciliated epidermis, dermis, connective tissue, striated muscle and parietal peritoneum.
7. It has no exoskeleton.

8. Notochord extends from the anterior end to posterior end.
9. Enterocoelic coelom is present. However, reduced in the pharyngeal region by atrium.
10. Alimentary canal is long. It includes a large pharynx with many gill-slits ciliary mode of feeding is developed.
1 1. Gillss will perform respiration.
12. Circulatory system is closed.
13. Heart and respiratory pigments are absent.
14. Hepatic portal system is present.
15. Excretory system shows paired protonephridia with solenocytes.
16. Brain is not present
17. Two pairs of cerebral and several pairs of spinal nerves are present.
18. Sexes are separate. Gonads are metamerically arranged and with out gonoducts.
19. Asexual reproduction will not take place.
20. Fertilization is external.

HEMICHORDATA: CHARACTERS AND CLASSIFICATION (WITH DIAGRAM)GENERAL CHARACTERS OF HEMICHORDATA:

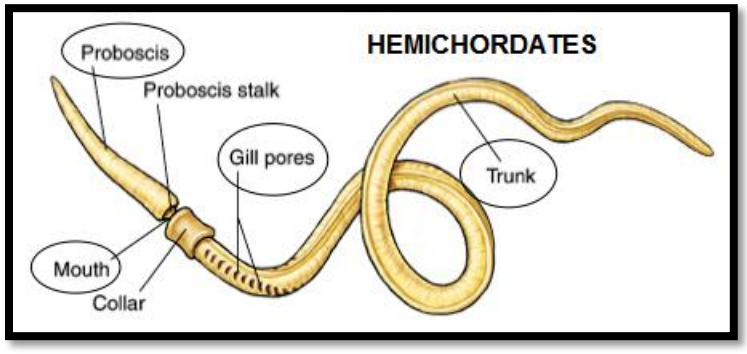
1. Solitary and colonial, mostly tubicolous, exclusively marine.
2. Body soft, fragile, vermiform and divisible into proboscis, collar and trunk.
3. Body wall with a single-layered epidermis.
4. Coelom enterocoelous, divisible into protocoel, mesocoel and metacoel.
5. Buccal diverticulum, earlier considered as notochord, present in the proboscis.
6. Digestive tract complete; in the form of straight or U-shaped tube.
7. Gill-slits, when present, are paired and one to numerous.

CLASSIFICATION OF HEMICHORDATA:

Phylum Hemichrodata has been divided into following four classes:

Class 1. Enteropneusta:

1. Commonly known as **"acorn"** or **"tongue worms."**
2. Solitary and burrowing worm-like marine animals.



PHYLUM CHORDATA

GENERAL CHARACTERS

The chordate animals at some time in their life history exhibit the following diagnostic characters:

1. NOTOCHORD

- It is an elastic, solid, skeletal rod lying below the nerve cord and above the alimentary canal.
- It serves as a primitive internal skeleton and acts as a rigid axis.
- It may persist throughout life or it may be replaced partially or completely by a backbone or vertebral column.

2. DORSAL HOLLOW NERVOUS SYSTEM

- There is a dorsal, hollow, fluid filled nerve cord.
- It is formed by enfolding of a mid-dorsal strip of ectoderm and it generally sinks below the surface.
- It lies above the notochord and outside the coelom.
- It persists throughout life in most chordates, but in a few it degenerates before maturity.

3. GILL CLEFTS

- These are paired openings leading from the Pharynx to the exterior.
- Such gill clefts appear during the development of every chordate, but in many aquatic forms they are lined with vascular lemallae, which forms gills for respiration.
- In terrestrial chordates, which never breath by gills, gill clefts are present during early development but later on, they disappear.

4. PHA-RYNGEAL POUCHES

- All the chordates have paired pharyngeal pouches at some stage of their life cycle.
- These extend from laterally from the anterior part of the digestive tract towards the body wall.

OTHER FEATURES

- Chordates are triploblastic.
- They are bilaterally symmetrical.
- True coelom is found.
- They are found in almost all the habitats of the World.

CHARACTERISTICS OF CHORDATA

Animals in the phylum Chordata share four key features: a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail.

KEY POINTS

- These characteristics are only present during embryonic development in some chordates.
- The notochord provides skeletal support, gives the phylum its name, and develops into the vertebral column in vertebrates.
- The dorsal hollow nerve cord develops into the central nervous system: the brain and spine.
- Pharyngeal slits are openings in the pharynx that develop into gill arches in bony fish and into the jaw and inner ear in terrestrial animals.
- The post-anal tail is a skeletal extension of the posterior end of the body, being absent in humans and apes, although present during embryonic development.

TERMS:

- notochord

a flexible rodlike structure that forms the main support of the body in the lowest chordates; a primitive spine

- nerve cord

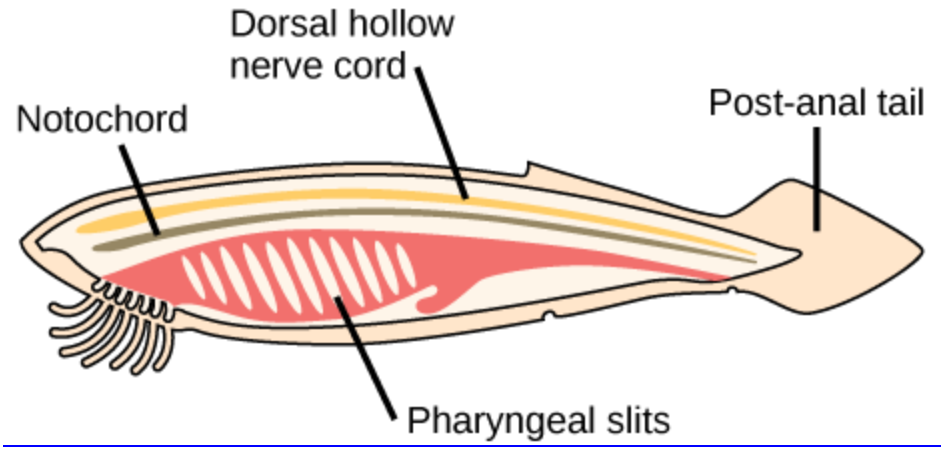
a dorsal tubular cord of nervous tissue above the notochord of a chordate

- pharyngeal slit

filter-feeding organs found in non-vertebrate chordates (lancelets and tunicates) and hemichordates living in aquatic environments

CHARACTERISTICS OF CHORDATA

Animals in the phylum Chordata share four key features that appear at some stage during their development (often, only during embryogenesis) (:



DEFINING CHARACTERISTICS OF CHORDATES

In chordates, four common features appear at some point during development: a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail.

1. a notochord
2. a dorsal hollow nerve cord
3. pharyngeal slits
4. post-anal tail

Notochord

The chordates are named for the notochord: a flexible, rod-shaped structure that is found in the embryonic stage of all chordates and also in the adult stage of some chordate species. It is located between the digestive tube and the nerve cord, providing skeletal support through the length of the body. In some chordates, the notochord acts as the primary axial support of the body throughout the animal's lifetime.

In vertebrates, the notochord is present during embryonic development, at which time it induces the development of the neural tube which serves as a support for the developing embryonic body. The notochord, however, is replaced by the vertebral column (spine) in most adult vertebrates.

Dorsal Hollow Nerve Cord

The dorsal hollow nerve cord derives from ectoderm that rolls into a hollow tube during development. In chordates, it is located dorsally (at the top of the animal) to the notochord. In contrast to the chordates, other animal phyla are characterized by solid nerve cords that are located either ventrally or laterally. The nerve cord found in most chordate embryos develops into the brain and spinal cord, which comprise the central nervous system.

Pharyngeal Slits

Pharyngeal slits are openings in the pharynx (the region just posterior to the mouth) that extend to the outside environment. In organisms that live in aquatic environments, pharyngeal slits allow for the exit of water that enters the mouth during feeding. Some invertebrate chordates use the pharyngeal slits to filter food out of the water that enters the mouth. In vertebrate fishes, the pharyngeal slits develop into gill arches, the bony or cartilaginous gill supports.

In most terrestrial animals, including mammals and birds, pharyngeal slits are present only during embryonic development. In these animals, the pharyngeal slits develop into the jaw and inner ear bones.

Post-anal Tail

The post-anal tail is a posterior elongation of the body, extending beyond the anus. The tail contains skeletal elements and muscles, which provide a source of locomotion in aquatic species. In some terrestrial vertebrates, the tail also helps with balance, courting, and signaling when danger is near. In humans and other apes, the post-anal tail is present during embryonic development, but is vestigial as an adult.

CLASSIFICATION OF PHYLUM CHORDATA

The Phylum Chordata is divided into two groups which are:
1. Acraniata (Protochordata)
2. Craniata (Vertebrata)

1. GROUP ACRANIATA (PROTOCHORDATA)

- They are first or simple Chordates.
- Brain box (Cranium) is absent and hence brain is not prominent.
- Notochord does not transform into vertebral column.

This group is further divided into two sub-phyla, which are as follows:
a) Sub-Phylum Urochordata (Notochord in tail)

b) Sub-Phylum Cephalochordata (Notochord head to tail)

A) SUB-PHYLUM UROCHORDATA (NOTOCHORD IN TAIL)

- They are also known as "Tunicates" because their body is enclosed in a sac called "Tunic."
- All members are marine and sessile.
- Body possesses two openings, an incurrent or buccal siphon and an excurrent or Atrial siphon, through these openings exchange of gases and food or waste material take place.
- As a result of "Retrogressive metamorphosis" the larva loses its tail and most of chordate characters and converts into an adult.

E.g: Ascidia, Herdmania etc.

B) SUB-PHYLUM CEPHALOCHORDATA (NOTOCHORD FROM HEAD TO TAIL)

- This is a small group of marine animals, body with pointed ends.
- Usually live buried in sand, in shallow water with anterior end protruded out.
- They show all typical chordate characters (hollow dorsal nerve chord, pharyngeal gill slits and notochord).
- Only two genera are present around the world.

E.g: Branchiostoma (Amphioxus) etc

2. GROUP CRANIATA (VERTEBRATA)

- In these chordates brain is protected inside a skeletal brain box called "CRANIUM."
- Also known as "Vertebrates" because notochord is replaced by a vertebral column.
- This group is sub-divided into two sub-phyla, which are as follows:

a) Sub-Phylum Agnatha (Mouth without Jaws)
b) Sub-Phylum Gnathostomata (Mouth with Jaws)

A) SUB-PHYLUM AGNATHA (MOUTH WITHOUT JAWS)

- This is a small group of marine vertebrates also known as "Cyclostomes."
- Superficially they resemble the fish but lack the jaw so they are often known as "Jawless Fishes."
- They have rounded suctorial mouth with many rings of teeth.
- Paired fins and scales on body.
- Usually parasitic in nature.

E.g: Hag Fish, Lamprey etc.

B) SUB-PHYLUM GNATHOSTOMATA (MOUTH WITH JAWS)

- It is a large group of vertebrates with both upper and lower jaw.
- Teeth may be present or absent.

Gnathostomata are divided into two super classes, which are as follows:
i) Pisces (Fishes)
ii) Tetrapoda

I) SUPER CLASS PISCES (FISHES)

- This is the largest group of chordates, which includes half of the chordate (25,000 species).
- Study of fishes is called "Ichthyology."
- Body is streamlined with paired fins and covered over by dermal scales.

Super class Pisces is divided into two classes, which are:
i-a) Chondrichthyes (Cartilage Fishes)
i-b) Osteiochthyes (Bony Fishes)

I-A) CLASS CHONDRICHTHYES (CARTILAGE FISHES)

- Alternate name is "Class Elasmobranchi."
- Usually includes marine fishes with endoskeleton of cartilage (soft bone).
- Skin contains sharp tiny enamel coated denticles called "Placoid Scales," which form exoskeleton.
- Mouth is ventral in position and tail fin is "Heterocercal."
- Five exposed gill slits, which are not covered over by a gill cover.
- Common examples are Skates, Sharks, Rays and Scoliodon (Dog Fish)- a small Shark etc.

I-B) CLASS OSTEIOCHTHYES (BONY FISHES)

- Alternate name is "Teleostom," actually the largest class of chordates.
- Includes marine and fresh water fishes.
- Mouth is present at anterior tip.
- Endoskeleton in these fishes is made up of hard bone while exoskeleton is made up of thin bony plates, which are known as "Cycloid" or "Ctenoid scales."

- Gills are covered over on each side by a gill cover called "Operculum."
- An air bladder is present which acts as a hydrostatic organ.
- Tail fin is usually "Homocercal or Diphycercal."
- Common e.g are Eel, Sea-Horse, Flying Fish, Globe Fish etc

LUNG FISHES

- Zoogeographically important fishes, belonging to group "Dipnoi, included in Class Osteiochthyes.
- Only three living genera.
- They respire by gills and by lungs during drought period (Lungs-Modified air bladder).
- Limited distribution in South America, Africa and Australia.

E.g: Protopterus (African Lung Fish)

II) SUPER CLASS TETRAPODA

It includes following classes:

a) Class Amphibia
b) Class Reptilia
c) Class Aves
d) Class Mammalia

A) CLASS AMPHIBIA

- This class includes the animals that came out of the water and established a successful life on land.
- They took advantages of the improved possibilities by remaining close to water, by keeping a soft and moist skin, by developing lungs and by evolving a bony skeleton with a strong vertebral column and four legs.
- They cope with seasonal changes by burrowing during extreme cold and save water by sealing themselves in a mucous envelop on dry land.
- The bony endoskeleton is the main body support.
- The notochord is absorbed during development
- Breathing is mostly by means of skin and also lung, and also by lining of buccal cavity.
- In larva the breathing is mostly by means of external or internal gills.
- The circulatory system shows a three chambered heart, with two atria and one ventricle.
- The amphibians are "Cold Blooded" (Poikilothermic) that is having internal temperature that very with the environment.
- Eggs and sperms are laid in water and fertilization is external.

E.g: Frog and Toads, Salamanders, Newts, Mud puppies etc.

B) CLASS REPTILIA

GENERAL CHARCTERS

The earliest reptiles evolved from the amphibians.

HABIT AND HABITAT

Reptiles are generally well adapted to life on land, in semi-dry, completely dry and even desert habitat.

NATURE

- All reptiles lay their eggs on land.
- They are cold-blooded animals and are less active during low temperature.

STRUCTURAL FEATURES

- They possess dry skin covered with epidermal scales.
- In some lizards and crocodiles, small bony plates develop below the epidermal scales.
- The skeleton is built on the same plane as that of amphibians, but is much stronger to support their body weight.
- Respiration takes place exclusively through lungs.
- Heart is three chambered, two auricles and one incompletely divided ventricle. (In Crocodiles, the ventricle is completely divided into two chambers.)
- The excretion takes place through kidneys. The reptiles secrete much of their waste products in form of non-toxic "Uric-Acid."

REPRODUCTION

- In most reptiles fertilization is internal.
- Eggs are provided with a shell and are laid on land.
- The early development of embryo takes place on the large quantities of yolk and albumin present in the egg.
- Due to the presence of a protective membrane called "AMNION" in the egg, reptiles are included in the "Amniota Group" of Vertebrates.

EXAMPLE

Alligators, Crocodile, Snake, Turtle and Gecko etc.

C) CLASS AVES (BIRDS)

EVOLUTION

- Aves have evolved from reptiles.
- As they acquired the capability of true flight they were able to exploit the aerial environment and became the largest class of terrestrial vertebrates.

CHARACTERS OF CLASS AVES

HABIT AND HABITAT

The birds live from pole to pole in all type of ecological zones. They all breed on land.

FLIGHT AND ADAPTATION

Written by Tahir Habib

- Feathers differentiate birds from all other vertebrates.
- Feathers originated as extraordinary development of Reptilian scales.
- Instead of growing all over the body and spreading evenly, the feathers grow in definite tracts.
- The feathers play an important role in the thermoregulation of birds. They trap air, which is a bad conductor of heat and so prevent loss of body heat.
- To fly efficiently the birds have reduced their body weight in a variety of ways.
- Many bones become hollow, thin and light.
- Synsacrum and pygostyle are formed by the fusion of vertebrae and give strength to skeleton.
- Birds possess strong muscles to control the use of wing in flight.

ADAPTATION FOR COMMUNICATION

- They possess large eyes with well-developed sight.
- The birds communicate with members of their species with sound signals for which the sense of hearing is well developed.

STRUCTURAL FEATURES

- The great mobility of neck is helpful in feeding, nest building, preening and defence.
- There are developed a number of types of bills according to their feeding habits.
- The digestive system of birds is compact and can accommodate large quantity of food.
- The food is stored for a short period in the crop.
- "Gizzard" possess thick muscular wall with horny lining, small stones swallowed by birds are passed on the gizzard for grinding the food.
- The "Syrinx" or sound-producing organ is found in no other vertebrate except the birds. It is located at the junction between the trachea and the paired bronchi.
- The lungs of birds are small, solid, spongy and slightly distensible. They are in contact with a number of air sacs.

MIGRATION IN BIRDS

A large number of species of birds exhibit a deep-rooted phenomenon of migration, during which they travel long distances from their summer breeding homes towards areas of warm climate.

SUB-CLASSES OF AVES

There are two main sub-classes of aves, which are:

i) Sub-Class Ratitae (Flightless Birds)

ii) Sub-Class Carinatae (Free-Flying Birds)

I) SUB CLASS RATITAE (FLIGHTLESS BIRDS)

- This sub-class includes modern big sized flight less birds.
- They comparatively have heavy weight and their wings are either vestigial or rudimentary.
- They have a flat sternum without keel.
- Their flight muscles are poorly developed.
- The distribution of these birds is restricted to few areas of the World.

E.g: Ostrich, Rhea, Emu, Cassowary, Kiwi and Penguin.

II) SUB-CLASS CARINATAE (FREE FLYING BIRDS)

- In this sub-class modern flying birds are included.
- They are usually small, light weight birds with highly developed wings and feathers with interlocking system.
- They possess sternum with a crest like keel to accommodate the hightly developed pectoral flight muscles.
- The flying birds are distributed all around the World.

E.g: Sparrow, Pigeons, Myna, Bulbul, Hoopoes, Crow, Doves, Parrots, Fowls, Cuckoo and Ducks etc.

D) CLASS MAMMALIA

GENERAL CHARACTERS

Early mammals are originated from reptiles. The distinctive characteristic of mammals are at the highest grade of development in animal kingdom.

HABIT AND HABITAT

Mostly terrestrial, a few aquatic.

NATURE

- They are warm-blooded animals.
- They can maintain a fairly high body temperature and so can successfully survive in colder areas of the world

TEMPERATURE REGULATION

- Heat is generated by high metabolic rate of their body and is lost by increasing blood circulation in the skin and evaporation of sweat.
- The mammalian body temperature is maintained at 35˚C-40˚C.

APPARENT FEATURE

- All mammals possess hair on skin.
- Sweat glands and sebaccous glands are present on skin.
- Mammary glands secrete milk in females.
- External ears (Pinna) are present.
- Teeth are heterodont i.e. not uniform. The different types of teeth are: Incisors, Canine, Premolars, Molars.

SKELETAL SYSTEM

- Skull with two occipital condyles is present.
- Lower jaw is composed of single bone on each side.
- Vertebrae are "Gastrocentrous," composed of three pieces i.e. the centrum and two epiphyses.
- Digits of fore and hind limbs are usually five.
- Cervical (Neck) vertebrae are seven.

INTERNAL FEATURES

- A thick muscular septum "Diaphram" is present between abdomen and thoracic cavity.
- Heart is four-chambered.
- R.B.Cs are non-nucleated.
- Brain with four optic lobes.
- Kidney is metanephrous.
- The stomach is simple sac but rarely complicated.

REPRODUCTION

- Mammals give birth to young ones (Viviparous), which are nourished by parents. Except Prototherians that lay eggs.
- Fertilization is internal.
- Development of eggs occurs in the uterus of female, where the developing embryo develops relationship with mother (Placenta).
- After the birth of the child, the mother nourished her young ones.

CLASSIFICATION OF CLASS MAMMALIA

Mammals are divided into three sub-class:

1. SUB-CLASS PROTOTHERIA

Includes the egg laying mammals. For example Duck billed, Echidna (Spiny anteater).

2. SUB-CLASS METATHERIA

CHARACTERISTICS OF VERTEBRATES

Vertebrates (subphylum Vertebrata) are chordates with a spinal column. The name *vertebrate* comes from the individual bony segments called vertebrae that make up the spine. Vertebrates differ from the tunicates and lancelets in two important respects:

1. Vertebral column. In vertebrates, the notochord is replaced during the course of embryonic development by a bony vertebral column.

2. Head. In all vertebrates but the earliest fishes, there is a distinct and welldifferentiated head, with a skull and brain. For this reason, the vertebrates are some- times called the **craniate chordates**.

3. Neural crest. Neural crest cells then migrate to various locations in the developing embryo, where they participate in the development of a variety of structures.

4. Internal organs. Among the internal organs of vertebrates, livers, kidneys, and endocrine glands are characteristic of the group. The ductless endocrine glands secrete hormones that help regulate many of the body's functions. All vertebrates have a heart and a closed circulatory system. In both their circulatory and their excretory functions, vertebrates differ markedly from other animals.

5. Endoskeleton. The endoskeleton of most vertebrates is made of cartilage or bone. Cartilage and bone are specialized tissue containing fibers of the protein collagen compacted together. Bone also contains crystals of a calcium phosphate salt. Bone forms in two stages.

First, collagen is laid down in a matrix of fibers along stress lines to provide flexibility, and then calcium minerals infiltrate the fibers, providing rigidity. The great advantage of bone over chitin as a structural material is that bone is strong without being brittle. The vertebrate endoskeleton makes possible the great size and extraordinary powers of movement that characterize this group

Written by Tahir Habib

CLASS FISH / PICES:

Fishes are oldest aquatic vertebrates found all over the globe. Nearly 500 million years ago the first fish appeared on the earth. Today fishes make up the largest group of vertebrates with 24,000 species. Fishes have their habitats in lakes, streams, oceans, and estuaries. In 1991 it was estimated that 2546 species of fish populated the world. Out of which 969 belong to genera, 254 families, and 40 orders. Around 80% of fish population around the globe was represented by the Indian fishes. Fishes are capable of living in both fresh and marine water.

Fishes are cold blooded animals in the world that are covered with scales and equipped with a pair of fins to swim in the water. Unlike other animals in the world fishes do not have lungs as their breathing organ. Fishes are provided with a special organ called gills which are used for respiration. With the help of gills they draw oxygen from the water and into the blood stream. Fishes reproduce by laying eggs.

To learn more about the characteristic of the fish please refer to: Characteristic of fish

Fish has a streamlined body which helps them to move through the water quickly. To keep them safe from the enemies they have dark color on the top and light color on the bottom. They can change color rapidly and reflective cells in their skin discoloration. The size of the fish ranges from an inch to sixteen feet. To know more about the structure of fish and their activity refer to the FISH ANATOMY.

CHARACTERISTICS OF CLASS PICESES

(AQUATIC ADAPTATIONS IN FISH)

Some live in freezing Arctic seas, others in warm freshwater lakes, and still others spend a lot of time out of water entirely. However varied, all fishes have important characteristics in common:

1. Vertebral column. All fishes have an internal skeleton with a spine surrounding the dorsal nerve cord, although it may not necessarily be made of bone. The brain is fully encased within a protective box, the skull or cranium, made of bone or cartilage.

2. Single-loop blood circulation. Blood is pumped from the heart to the gills. From the gills, the oxygenated blood passes to the rest of the body, and then returns to the heart. The heart is a muscular tube-pump made of four chambers that contract in sequence.

3. Nutritional deficiencies. Fishes are unable to synthesize the aromatic amino acids and must consume them in their diet. This inability has been inherited by all their vertebrate descendants.

The remarkable success of the bony fishes has resulted from a series of significant adaptations that have enabled them to dominate life in the water. These include the swim bladder, lateral line system, and gill cover.

1. Swim Bladder. Although bones are heavier than cartilaginous skeletons, bony fishes are still buoyant because they possess a swim bladder, a gas-filled sac that allows them to regulate their buoyant density and so remain suspended at any depth in the water effortlessly. Gas exchange occurs across the wall of the swim bladder and the blood vessels located near the swim bladder. A variety of physiological factors controls the exchange of gases between the blood stream and the swim bladder.

2. Lateral Line System. Although precursors are found in sharks, bony fishes possess a fully developed lateral line sys- tem. The lateral line system consists of a series of sensory organs that project into a canal beneath the surface of the skin.

3. Gills. Fishes are water-dwelling creatures and must extract oxygen dissolved in the water around them. They are located at the back of the pharynx and are supported by arches of cartilage. Blood moves through the gills in the opposite direction to the flow of water in order to maximize the efficiency of oxygen absorption.

Note: Question may be asked as aquatic adaptation in pieces.

All the species of the fish found in the world are classified into the following three groups. They are:

- Agnatha - jawless fish
- Chrondrichthyes - cartilaginous fish
- Osteichthyes - bony fish
    - Ray finned group
    - Lobe finned group

About 50 species of Agnatha fish, 600 species of Chrondrichthyes fish and 30,000 species of Osteichthyes fish are found in the world. Most of the fishes in the bony group belong to the ray finned group. According to the biologist there are about 70 fish orders are found in the world.

Sharks and rays; sturgeon and gars; herring-like fishes; trout and salmon; eels, minnows, suckers, and catfish; flying fish and relatives; cod-like fish; flatfish; seahorses and relatives; mullets, silversides, and barracuda; and mackerels and tunas are the main group of fishes.

AGNATHAN

Phylum: chordate
Subphylum vertebrata

Agnathan are jawless fish and lack paired fins. They also lack the internal skeleton system. They have a circular tooth mouth (cyclostomic) by which they bore the body of their victim and suck their blood. These are classified in to two major types. They are Hagfish and **Lampreys**.

Characteristic of Agnatha

- Jaws are absent
- Paired fins are absent
- Bony scales and skin plates were present in the ancient species but are absent in the living species
- Gill pouches are present. They have seven or more pouches
- Stomach is absent in the digestive system.

CHRONDRICHTHYES

Phylum: chordate
Subphylum vertebrata

Fearsome predators and harmless mollusc eaters are the members of the Chrondrichthyes. The member of the cartilaginous fish poses true bone and also poses a skeleton made up of cartilage.

Only the teeth of this species and rarely the vertebrae are calcified. Sharks, **Skates**, and **Rays** make up the group of chrondrichthyes

CHARACTERISTICS:

1) These fishes are exclusively marine.
2) The exoskeleton in the form of placoid scales.
3) Their endoskeleton is cartilagenous and are called Cartilage
4) Jaw suspension is amphistylic or hyostylic.
5) 5-7 pairs of gills are present.
6) External gill openings are separate. They are not covered by operculum.
7) Heterocercal caudalfin is seen.
8) Males show claspers for copulation.
9) Air-bladder is absent in these fishes.

OSTEICHTHYES

Phylum: chordate
Subphylum vertebrata

About 30000 species of bony fish are found in this class. Fishes that belong to this species are spindle shaped, oval in section and flattened. Skins are protected by protective scales. Some fishes of this category have actual lungs to breathe and also have sharp eyesight. These bony fishes have a special gas filled chamber called airbladder housed under the skeleton to allow them to remain buoyant. Another adaptation is operculum, a bone on the sides of the fish to protect the chambers that house the gills.

Bony fish are again classified into ray finned and lobe finned fish. Ray finned fish have thin, flexible skeleton rays. Lobe finned fish have muscular fins supported by bones. Bony fish fertilizes either internally or externally. Two types of eggs are laid by the bony fish. They are the eggs that float and the eggs that sink.

CHARACTERISTIC OF OSTEICHTHYES

1. These fishes are marine, fresh water and bracldsh water niem hers.
2. Cycloid, ctenoid or ganoid scales will form the exoskeleton.
3. Endoskeleton bony.
4. Jaws suspension is autostylic
5. Operculum is present.
6. Claspers are absent
7. Usually air bladder is present
   - Have more or less bony skeleton and numerous vertebrae

- Mucous glands and embedded dermal scales are present in the skin
- Have paired fins
- Jaws are present
- Gill arches support the gills and are protected by the operculum

Lungfish, **Eels**, **Acrp**, **Lizardfish**, **Silversides** and **Salmon** form the class of bony fish

CLASSIFICATION OF PIECES

Classes	Cyclostomata	Chondrichthyes	Osteichthyes
Body	Snake like	Fusiform, spindle shaped,	Different types of shapes
Skeleton	Cartilaginous	Cartilaginous	Bony
Scales	Absent	Body is covered with palcoid scales (plate shaped)	1. Ganoid (Smooth & Shinny) 2. Cycliod (Curved) 3. Ctenoid (Comb like)
Mouth Position	Succtorial	Mouth ventral, Nostril does not open in buccal cavity	Jaw bears teeth or may be absent.
Gills slits	6-14 pairs	5-7 pairs	5
Reproduction	Lamprey is bisexual , and Hag fish is unisexual, while fertilization is external	Sexes separate, may be oviparous or viviparous. Fertilization is external.	Unisexual, fertilization is external.
Examples	Lamprey Hag fish	Skate, Electric ray that contain electric organs, and shark.	Trout, Perch, Cod etc.
Importance	Used in Biological Research to study origin of pieces	Used as food	Fish oil is obtain from the liver and it contain vitamin A & D

CLASS AMPHIBIAN

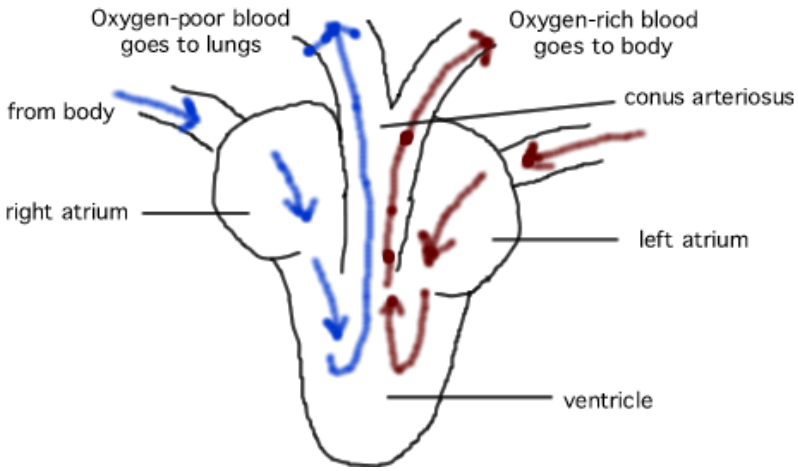
*__Herpetology__ is the study of reptiles and amphibians
What is an amphibian?
- 4000+ species
- Gave rise to modern land vertebrates
- Amphibian means -double life-
- Larvae start life in H2O with gills , adults are terrestrial with lungs

Evolutionary adaptations for life on land:
1. stronger bones
2. lungs and breathing tubes
3. sternum (breastbone) and ribs to protect internal organs

History:
Carboniferous Period = Age of Amphibians, 360-290 million years ago
Climate changes caused habitats to disappear

3 orders of amphibians survive today;
1. Frogs and Toads
2. Salamanders
3. Caecilians

Form and Function in Amphibians
1. Feeding: larvae = herbivore, adults = mostly carnivore
Digestive tract; mouth > esophagus > stomach > small intestines > large intestine (colon) > cloaca
2. Respiration: larva = skin and gills, adult = lungs and some through skin
Many terrestrial salamanders = no lungs at all, through skin and mouth cavity
3. Circulation: double loop system
3 chamber heart right atrium, left atrium, and ventricle

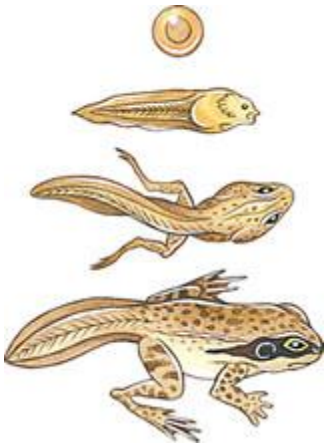


Compare Single to Double Loop Circulation
Single: Heart --> Gills --> Body
Double: Heart --> Lungs --> Heart --> Body

4. Excretion: kidneys filter liquid waste = urine
Kidneys > ureters > small urinary bladder > **cloaca**
5. Reproduction: females lay eggs in water, male deposits sperm over eggs

Tadpoles - Herbivorous, Aquatic, Single Loop Circulation, Gills
Frogs - Carnivorous, Terrestrial or Aquatic, Double Loop, Lungs
Yolk of egg nourishes developing embryo
Larvae commonly called tadpoles, metamorphosis is the process by which tadpoles become adults
A few species will care for their eggs by incubating their young in their mouth, on their back, or stomach!
6. Response: well developed nervous and sensory system

1. Eyes move in socket and have a protective structure = nictitating membrane is a transparent membrane that covers the eye when the frog is in the water
2. Tympanic membrane = eardrums
3. Lateral Line systems = detect water movement (vibrations)



Amphibians characteristics:

To identify an animal as an amphibian, it should have each of these characteristics:

- Amphibians have a backbone. They are vertebrates.
- Amphibians are cold-blooded. They cannot regulate their own body temperature.
- Amphibians spend at least part of their lives in water **and** on land.
- Amphibians do not have scales and their skin is permeable (molecules and gases can pass through).
- Amphibians have gills for at least part of their lives. Some species have gills only as larvae, while others can have gills throughout their lives.
- Most amphibians go through metamorphosis.

Amphibians are frogs, toads, salamanders, caecilians and newts. Some common amphibians are bullfrogs, American toads, mole salamanders and hellbenders.

Written by Tahir Habib

AMPHIBIAN TAXONOMY

Kingdom Animalia
....Phylum Chordata

.....Subphylum Vertebrata
.....Class Amphibia

1:Order Urodela (Salamanders and Newts) long bodies and tails, lives in moist woods
Mud puppy keeps gills and lives in water all their lives
2:Order Anura (Frogs and Toads) hop/jump with legs, adult has no tail
3:Order Apoda (Caecilians) legless with fishlike scales

ORDER 1. ANURA

This order Anura includes frogs and toads.
1) They can live in water and on land.
2) The fore limbs are small, the hind limbs are long.
3) In the adult stage tail is absent
4) They show a pair of eyes. tympanic membranes.
5) Their Life history includes a larval stage called tad-pole larva.
eg:1. Alytes . (Mid wife toad).
2. Cacopus (Burrowing frog).
3. Xenopus (Clawed Toad),
4. Bufo.

ORDER 2. URODELA

This order includes Salamandars and newts. These urodelans are more in North America. Hence North America is called **Head Quarters of Urodela**
1) The body is divisible into head, trunk and tail. Only In these amphibians tail is present. Hence these are called Urodela.
2) The fore limbs and hind limbs are equal.
3) The body's not covered by scales.
4) In some adults the gills are presents
5) Some forms show neoteny and paedogenesis. In North India only one species is available. Tilototriton venvcosa. In South India urodelan animals are absent.
1.Necturus
2. Proteus(Mud puppy).(Blind salamander)
3. Molge (Newt).
4. Amblystoma

ORDER 3. APODA:

1) These animals are limbless. Hence they me called Apoda.
2) The body is long and snake like. Hence it Is called gymnophiona. The body is divisible into head and hunk. Tail is absent

3) On the head two eyes are present. They covered by skin and scales. Hence they are blind (Cecaelians).
4) Lungs are asymetrical.
5) The skin shows minute cycloid scales. in the male apoda animals copulatory organs present.
6) Fertilization is internal.
1. lchthyophis (Limbless amphibian).
2. Gegenophis (Limbless amphibian).
3. Ureotyphlus.

PARENTAL CARE IN THE MEMBERS OF CLASS AMPHIBIA

Amphibian include anurans, urodelans and apodans. In all these groups of amphibians we come across with a great deal of parental care. Amphibians show several mechanisms to protect their eggs and developing young ones because of the they lay few eggs.

Parents protect the eggs and early developmental stages in two ways.
1) They construct nests
2) Direct Nursing.

The female Icthyophis glulinosa will dig a hole in the moist soil near a pond. It will deposit eggs in it. Around this egg mass the mother will coil and. protect the egg mass from the enemies.

2. PARENTAL CARE IN E ORGANISMS CF URODELA:

In some urodela amphibians the eggs are very small. They hatch end directly develop into larvae. In those organisms parental care is not required.

a) Protection by Nests :- Salamandrella keyserlingi will construct a gelatinous bag like structure. It is attached to an aquatic plant below the water. In this bag eggs are stored. Thus they are protected by the Nest.

ii) Autodax will lay eggs in a dry hole on the soil or in a hole on a free. The parents also live in the hole and protect the egg and the larvae developed from them.

b) Direct Nursing by Parents

I) Amphiuma, (Congoeel) The mother will coil around the eggs and protect them.

3. PARENTAL CARE IN ANURA AMPHIBIANS:

In Mura amphibians the parental care is reached its peak. Many organisms will exhibit parental care.

a) **Protection by Nests**:

Many frogs and toads build nests in which the eggs are laid and developed. This is a primitive method of parental care. In these organisms the larva comes out in a very early embryonic stage which requires some kind of protection in the very early stages of development, hence the parent will build nests.

I) **Hyla Faber**:- It is Brazilian free frog. The female will construct the nest in the shallow waters of a pond. The female will dig a hole of 8 to 10cm depth. The mud which comes out of it is used by the female Hyla to construct a wall around the hole. This wall is raisd'above the level of water. Female Hyla will make the inner surface of this Nursery smooth and even the female will lay eggs in this nursery. The eggs and larval forms are protected inside this structure.

ii) **Rhacophorus malabaricus** It is called chunam frog. It lays eggs on the branches or leaves of a tree which will be hanging over a pond. These larvae after hatching from eggs will fall into the pond water and undergo metamorphosis. **Written by Tahir Habib**

CLASS REPTILES

INTRODUCTION

Reptiles do not form a distinct evolutionary group as birds and mammals do. Rather, the Class Reptilia consists of four orders which are very different from each other. For example, lizards are more closely related to birds than to turtles! As a result, reptiles are as easily defined by what they aren't as by what they are.

Living species of the class Reptilia are placed in four orders. The order Testudines includes turtles, the order Squamata includes lizards and snakes, the order Crocodylia contains crocodiles and alligators, and the order Rhynchocephalia contains the lizard-like tuataras.

As opposed to mammals and birds, reptiles have neither fur nor feathers, but scales. Reptiles can not be confused with amphibians because reptiles have dry, water-proof skin and eggs, as well as internal fertilization and more advanced circulatory, respiratory, excretory, and nervous systems.

Reptiles evolved from labyrinthodont amphibians 300 million years ago. The success of this terrestrial vertebrate group is due in large part to the evolution of shelled, large-yolked eggs in which the embryo has an independent water supply. This advance, as well as the development of internal fertilization, enabled reptiles to be the first vertebrates to sever their ties with water. They radiated out across the landscape, diversifying quickly and becoming the dominant life form on the planet during the Mesozoic Era, otherwise known as the age of the reptiles.

CLASS REPTILES

KEY CHARACTERISTICS OF REPTILES

All living reptiles share certain fundamental characteristics, features they retain from the time when they replaced amphibians as the dominant terrestrial vertebrates. Among the most important are:

1. Yolk sac provides food from the yolk for the embryo via blood vessels connecting to the embryo's gut. The **allantois** surrounds a cavity into which waste products from the embryo are excreted. All modern reptiles (as well as birds and mammals) show exactly this same pattern of membranes within the egg. These three classes are called amniotes.

2. Dry skin. Living amphibians have a moist skin and must remain in moist places to avoid drying out. Reptiles have dry, watertight skin. A layer of scales or armor covers their bodies, preventing water loss. These scales develop as surface cells fill with keratin, the same protein that forms claws, fingernails, hair, and bird feathers.

3. Thoracic breathing. Amphibians breathe by squeezing their throat to pump air into their lungs; this limits their breathing capacity to the volume of their mouth. Reptiles developed pulmonary breathing, expanding and contracting the rib cage to suck air into the lungs and then force it out.

4. The circulatory system of reptiles is improved over that of fish and amphibians, providing oxygen to the body more efficiently. The improvement is achieved by extending the septum within the heart from the atrium partway across the ventricle. This septum creates a partial wall that tends to lessen mixing of oxygen-poor blood with oxygen-rich blood within the ventricle. In crocodiles, the septum completely divides the ventricle, creating a four-chambered heart, just as it does in birds and mammals (and probably in dinosaurs).

5. All living reptiles are **ectothermic,** obtaining their heat from external sources. In contrast, **endothermic** animals are able to generate their heat internally. In addition, **homeothermic** animals have a constant body temperature, and **poikilothermic** animals have a body temperature that fluctuates with ambient temperature.

Note: If the Question is asked about the adaptation that makes the life of reptile possible write the detail note of General characteristics of Class reptilian.

REPTILES CHARACTERISTICS:

To identify an animal as a reptile, it should have each of these characteristics:

- Reptiles have a backbone. They are vertebrates.
- Reptiles are covered in scales.
- Reptiles breathe with lungs.
- Most reptiles lay eggs. Some reptiles, like the boa constrictor, give birth to live young.
- Almost all reptiles are cold-blooded. One of the exceptions is the leatherback sea turtle, which can regulate its body temperature to some degree.

Some common reptiles are the American alligator, garter snakes, sea turtles and a monitor lizard.

This cladogram is a very approximate illustration of the complex evolutionary relationships among vertebrates. It shows several things:

- all vertebrates evolved from an amphibian ancestor thought to have been a labyrinthodont
- amphibians diverged from the other vertebrates very early on.
- turtles, crocodiles, and dinosaurs appeared before the other vertebrate taxa.
- dinosaurs, birds, crocodiles, and snakes are more closely related to each other than to turtles or mammals.

Reproduction

While the process of copulation and egg-laying differs slightly among reptiles, they share the ability to produce a large-yolked, shelled egg. This evolutionary innovation allowed them to dominate the terrestrial landscape for 100 million years. Some lizards and snakes have advanced a step further, evolving the ability to retain their eggs internally until they have hatched, and giving birth to fully developed young (this is called vivipary).

Most reptiles, however, lay eggs which have leathery shells which are resistant to drying. Inside, the amnion encloses the embryo in a protected, moist environment in which nourishment is supplied by the yolk sac, and metabolic waste is stored by the allantois. Parental care is very rare in reptiles. In most species, the young are independent from the moment they've hatched.

Poikilothermic

Reptiles are poikilothermic, which means that they can not regulate heat internally (as opposed to birds and mammals which are homeothermic). However, the name "cold blooded" is a misnomer, because reptiles can maintain high body temperatures by relying on external sources of heat. Reptiles bask in the sun to increase their body temperature or hide in their burrows or in water to cool down. At northern latitudes, during cold periods, reptiles are dormant from a few days to several months, their body processes slowed until temperatures increase.

Terrestrial Adaptations:

- **Dry, watertight** skin covered by **scales** made of a protein called **keratin** to prevent **desiccation** (water loss)
- **Toes with claws** to dig & climb
- **Geckos** have toes modified into **suction cups** to aid climbing
- **Snakes use scales** & well developed muscular & skeletal systems to move
- **Lungs** for respiration
- **Double circulation** of blood through heart to increase oxygen to cells
- **Partial separation in ventricle** to separate oxygenated & deoxygenated blood
- **Ectothermic** - body temperature controlled by environment
- May **bask or lie in sun** to raise body temperature or **seek shade** to lower body temperature; known as **thermoregulation**
- **Water conserved as nitrogen wastes excreted in dry, paste like form of uric acid crystals**

Modern Reptiles:

- Only 4 living orders remain
- Found worldwide except in coldest ecosystems

- **Orders include ----- Rhyncocephalia** (tuatara lizard), **Chelonia** (turtles & tortoises), **Squamata** (lizards & snakes), & **Crocodilia** (alligators, caimans, and crocodiles)
-

1. Rhyncocephalia:

Only one living species, Spenodon punctatus, (tuatara lizard)
Live on islands off the coast of New Zealand

- **Spiny crest** running down back
- Grows up to 60 cm in length
- Has 3rd eye on top of head **(parietal eye) that acts as a thermostat**
- Most active when temperatures are low **(nocturnal)**
- Often **burrow during the day**
- Feed on **insects, worms, & small animals at night**

2. Chelonia:

- Includes **turtles and tortoises**
- **Aquatic, but lay eggs on land**
- Body covered with shell composed of hard plates & tough, leathery skin
- **Carapace** or dorsal surface of shell fused with vertebrae & ribs
- **Plastron** is ventral shell surface
- Shape of shell modified for habitat
- **Dome shaped shell** helps to **retract head & limbs in tortoises**

3. Crocodilia:

- Includes **crocodiles, alligators, caimans, & gavials**
- Direct descendants of ***Archosaurs***
- **Carnivorous** (wait for prey to come near & then aggressively attack)
- **Eyes located on top of head** so they can see when submerged
- **Nostrils on top of snout** to breathe in water
- **Valve in back of mouth** prevents water from entering airway when feeding underwater
- **No parental care of young in most species except Nile crocodile** that carry young in their jaws & guards nest
- **Crocodiles** are tropical or subtropical, usually nocturnal, reptiles found in Africa, Asia, South America, & southern Florida

4. Squamata:

- Includes **snakes & lizards**
- **Snakes probably evolved from lizards** during the Cretaceous period

- Snakes have **100-400 vertebrae each with a pair of ribs & attached muscles** for movement
- Interaction of bone, muscles, & skin of snakes allows them 3 ways to move --- **lateral, rectilinear, & side winding**
- ***Lateral undulations:***
  1. Most **common**
  2. **Head moves side to side** causing wave of muscular contractions
  3. Snake uses **sides of its body to push off of ground**
  4. Snake moves forward in **S-shaped path**
- ***Rectilinear Movements:***
  1. **Muscular force applied to belly** & not sides of snake
  2. Scutes or **scales on belly catch on rough surfaces**
  3. Body relaxes & then moves forward slowly
- ***Sidewinding:***
  1. Used by some **desert snakes**
  2. **Sideways movement of body**
  3. **Head vigorously flung from side to side**
  4. **Whiplike motion** moves body along
- **Do not hear or see well** but locate prey using **forked tongue** that gathers chemical scents
- ***Swallow prey whole:***
  1. **Jaws unhinge** for mouth to stretch
  2. **Small teeth used to hold prey** in mouth
  3. **Windpipe thrust into throat** while swallowing so snake can swallow & breathe
  4. **Swallowing may take several hours**
  5. **Saliva begins digestion** during swallowing
- **Constrictors** wrap body around prey & squeeze them to death (boas, pythons, etc.)

- **Snakes may inject venom or poison:**
  1. ***Hemotoxin*** - poisonous proteins attacking red blood cells **(water moccasin & rattlesnake)**
  2. ***Neurotoxin*** - poison that works on nervous system affecting heart rate & breathing **(copperhead)**
- Venomous snakes with 3 types of fangs **--- rear-fanged, front-fanged, & hinge- fanged snakes**
- **Rear-fanged snakes** bite prey & use grooved back teeth to guide venom into puncture **(boomslang)**
- **Front-fanged snakes** inject poison through 2 small front fangs that act like a hypodermic needle **(cobra)**

BITING MECHANISM IN SNAKES

There are altogether more than 2600 species of snakes all over the world including the marine forms, and, out of which only 300 species are poisonous. Number of species diminishes progressively through the polar regions. In India, there are 330 species only and among them only 69 species are poisonous. As per record of the W.H.O., nearly 30000 to 40000 persons die of snake bite in the world every year.

BITING MECHANISM:

The biting apparatus taking part in the biting process are — **1. Poison glands 2.Poison ducts, and 3. Poison teeth or Fangs.**

Now, they are being described below in detail :

There is one pair of poison glands each one is situated on either side of the upper jaw. The poison glands are actually the parotid glands. Each poison gland is sac like in appearance. They are held in position by some ligaments. With the help of anterior ligament, the gland is attached with the maxilla. The posterior ligament is present between the gland and the quadrate. In addition to these, fan-shaped ligaments are also situated between the side walls and squamoso-quadrate junction.

Each poison gland is provided with a narrow duct at its anterior portion which passes along the side of the upper jaw, loops over itself and finally opens at the base of the fang.

There is one pair of fangs in the upper jaw. They are enlarged maxillary teeth which are very sharp and pointed. There is great power of regeneration (when lost for some reason). On the basis of structure and position, the fangs are of the following types :

1) Proteroglyphous type: The fangs are comparatively small and they are present in front of the maxillae. The fang has a groove all along its anterior face. Examples : Cobra, Krait, Sea snakes and Coral snakes.

2) Stenoglyphous type: The fangs are movable and turned inside. Poison canal runs through the fang and opens at the tip. Examples: Vipers and Rattle snakes.

3) Opisthoglyphous type. The fangs are small and lie at the back portion of maxillae. The fang has a groove along its posterior face. Examples : Some colubrid snake (African tree snakes)

4) Aglyphous type: Aglyphous dentition is present in the non- poisonous snakes.

Associated bones and muscles

There are some important bones and muscles which are directly or indirectly associated with the mechanism of biting. In the skull, maxillae, quadrate, pterygoid, squamosals, ectopterygoids and palatines are movably articulated. Premaxillae are very much reduced. Sqamosals are loosely attached tocranium. The joint of quadrate and lower jaws acts as fulcrum. Quadrates are also

loosely articulated with the cranium, pterygoid and lower jaw. Ectopterygoid is a transverse bone.

The important muscles are Digastric muscle, Anterior and Posterior temporalis muscles and Protractor-Pterygoid or Sphenopterygoid muscle. In addition to these, there are two more muscles associated with the poison glands. These are masseter muscle and Mandibular constrictor muscle.

The gastric muscle is attached with the squamosal bone anteriorly and with the base of the lower jaw (articular) posteriorly.

The Sphenopterygoid muscle is attached to the Sphenoidal region anteriorly and dorsal surface of the Pterygoid posteriorly. Anterior and Posterior temporalis muscles are attached to the side walls of the cranium and the lower jaw.

Opening and Closing of Mouth (Process of biting)

(i) When the digastric muscle contracts, the mandible is lowered and the skull alongwith the upper jaws goes up. As a result, the mouth opens.

(ii) The distal end of the quadrate is pushed forward which thrusts the pterygoid, palatine and transverse bar.

(iii) Contraction of the Sphenopterygoid muscle also contributes to the above process and Pterygoid is pulled forward and ectopterygoid is pushed upward.

(iv) The upward movement of ectopterygoid brings about a rotation of maxilla on its own axis and as a result fangs are erected.

(v) The mouth closes by the contraction of anterior temporalis and pterygoid muscles. Fangs pierce into the skin of the victim.

(vi) Muscles associated with the poison gland (masseter and mandibular) contract and the poison is squeezed into the body of the victim through the poison ducts and fangs.

Snake Poison (Venom)

Snake venom is complicated mixture of many organic compounds, for example — Protcolysins, Cardiotoxins, Haemorrhagin, Neurotoxins and Antibactericidum etc.

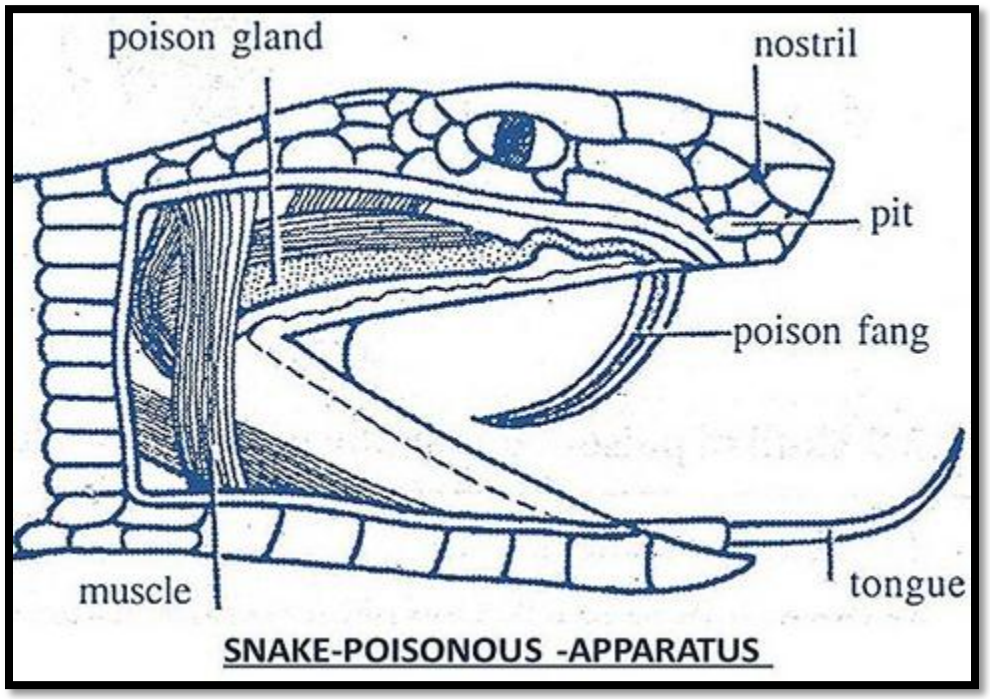
Various symptoms are shown by the victim of snake bite by different snakes. In the cobra bite the victim feels pain, weakness and difficult breathing. There is profuse salivation and frequent vomiting. The victim also becomes much lethargic. There is nervous breakdown also. In Krait venom the victim feels pain in abdomen, rest symptoms are like cobra. In the case of viper poison, swelling at the place of biting is very common, also rupture of endothelium, hemorrhage

and blood clotting are very common signs. Low blood pressure and heart failure are also common.

SOME COMMON POISONOUS SNAKES 1. *Naja tripudians* 2. *Naja bungarus* (*Naja naja*) 3. *Bungarus fasciatus* 4. *Bungarus niger*

SOME COMMON NON POISONOUS SNAKES :

However, many harmless-to-humans snakes, like **Hognose** snakes, **Garter snakes** and Rat snakes for example, do produce toxins that are scientifically or technically venomous. **Boas**, **pythons**, bull snakes and **king snakes** are examples of truly non-venomous snake species.



SNAKE-POISONOUS -APPARATUS

Written by Tahir Habib

WHAT ARE THE ADAPTATIONS FOR REPTILES TO LIVE ON LAND?

Reptiles separated from their water-dwelling ancestors and climbed onto land during the Paleozoic era, over 280 million years ago. When that era gave way to the Mesozoic, following a mass planetary extinction, reptiles survived and continued to evolve. They dominated the earth between 248 and 213 million years ago and live on today as modern-day snakes, turtles, lizards, crocodiles and even birds.

Reptile skin : Reptile skin contains keratin, a water-resistant substance that maintains hydration. Reptiles also have scales to keep in moisture and help avoid skin damage, though the scales are sometimes too small to be visible. This feature is most evident in turtles, whose scales fuse to form a shell, while you can see a bird's scales on its feet and in the form of feathers.

Kidney: Living on land means limited access to drinking water, so reptiles' kidneys have adapted. They conserve water by producing less urine in more concentrated forms.

Reproduction: Laying soft-shelled eggs is safe in water, but land-dwelling creatures require a different reproductive strategy. Scientists think this is why reptiles evolved a hard shell around their eggs, and why some no longer lay eggs at all. In many types of snakes the eggs hatch internally, and babies are born live.

Adapting lungs: in place of gills was a significant step in reptiles' migration to land. While amphibians all have gills at some stage in their development, either temporarily during the larval stage or permanently through adulthood, reptiles are born with fully developed lungs.

Basking : For cold-blooded creatures on land, survival requires more than just physical changes. Since a reptile's temperature depends on its surroundings, it basks on rocks to warm its blood for hunting. Without a place to bask, reptiles can't get enough blood flow, as anyone who keeps reptiles as pets can verify. Reptiles kept in captivity must have access to warming lights and heat-absorbent surfaces to substitute for a natural basking environment.

Legs: Not all reptiles have legs now, but they all needed them to become land-dwelling creatures. This was once a topic for debate due to the legless nature of snakes. Though scientists knew that snakes once had legs, they could not determine whether they lost their limbs before or after migrating to land. Scientists at Penn State resolved this issue in 2004 by comparing DNA between snakes and their closest genetic relatives. They determined that snakes lost their legs after they left the water, possibly to enable their burrowing habits, but that snakes, like all reptiles, initially required legs to relocate to land habitats.

CLASS AVES (BIRDS)

- presence of feather, beak and forelimb in form of wing.
- Hind limb adapted to clasping, walking and swimming.
- No glands on skin (only oil gland at tail base).
- Hollow bones (pneumatic).
- Air sacs connected to lungs to supplement respiration.
- Crop and gizzard are additional chambers in digestive system.
- Warm blooded.
- Heart four chambered.
- Sexes separate.
- Fertilisation internal and development direct.
- eg. *Columba, Psittacula* etc.

CLASSIFICATION OF AVES

(Girish Chandra)

Subclass ARCHAEORNITHES (Ancient birds)

Order **Archaeopterygiformes,** *Archaeopteryx; Archaeornis.* **Extinct**.

Fossil birds as connecting link between reptiles & birds. Skull rounded like birds; feathers on wings and tail; pelvis and fore and hind limb bones bird-like. Tail long, without pygostyle; bones not pneumatic; thecodont teeth; amphicoelous vertebrae; ribs without uncinate process; tibia and fibula separate; all digits with claws.

Subclass NEORNITHES (True birds)

Superorder ODONTOGNATHAE (Toothed birds)

1. Order **Hesperornithiformes,** ex. *Hesperornis.* **Extinct**.

Duck like, flightless swimming birds with webbed toes and thecodont teeth in jaws; keel and furcula absent; skull bones fused; heterocoelous vertebrae; wings reduced, incapable of flight; found in cretaceous period; body 90 cm long.

2. Order **Ichthyornithiformes,** ex. *Ichthyornis; Apatornis.* **Extinct**.

Gull-like flying birds with few teeth and fish-catching beak; keel and furcula present; vertebrae amphicoelous; carpometacarpus formed in fore limb; body 20 cm long.

Superorder PALEOGNATHAE (=RATITAE)

1. Order **Struthioniformes,** African ostrich, *Struthio camelus.*

Head and neck without feathers; feet with two toes; height up to ten feet and weight up to 150 kg; male incubates eggs.

2. Order **Rheiformes,** South American ostrich, *Rhea americana; Pteronemia pennata.*

Head and neck feathered; feet with 3 toes, webbed at base; smaller than African ostrich; eggs lemon yellow, incubated by male.

3. Order **Casuariformes,** Emu *(Dromaeus novehollandae),* Cassowary*(Casuarius casuarius),* found in Australia and New Guinea. 4 species.

Brownish colour; 180 cm tall; aftershaft on feathers; monogamous; cassowaries are brightly colored with horny helmet on the head.

4. Order **Apterygiformes,** Kiwi *(Apteryx australis; A. hoasti; A. oweni).* New Zealand.

Feathers hair-like; wings reduced; tail absent; long beak with nostrils at the tip; acute sense of smell; nocturnal and burrowing birds; lay one egg at a time in burrows.

5. Order **Tinamiformes,** Tinamous *(Eudromea elegans; Crypturellus variegatus);* found in South America, south of Mexico; 50 species.

Partridge-like birds, cryptically coloured; not tail; can fly short distances; keel present; palate paleognathous; male incubates eggs which are laid in a nest on ground.

6. Order **Dinornithiformes,** Moa *(Dinornis).* **Extinct** in 13th century in New Zealand.

Twelve feet tall; stout birds with long neck and legs; wings rugimentary; 3 clawed digits on feet.

7. Order **Aepyornithiformes,** Elephant birds *(Aepyornis; Mullerornis).* **Extinct.**

Lived in Madagascar nearly 2000 years ago; height 7-10 feet; body heavily built; legs long and stout with 4 toes; wings rudimentary; eggs 30 cm long.

8. Order **Diatrymiformes,** *Diatryma.* **Extinct** in USA, France, Britain.

Seven feet tall birds with massive head and sharp tearing beak; hallux small; pelvis large; preyed upon small mammals that they ran down.

Superorder IMPENNAE

1. Order **Sphenisciformes,** Penguins *(Spheniscus; Aptenodytes; Eudyptes),* **15**species.

Found in southern hemisphere and Antarctica; body streamlined; feather compact, scale-like; fatty insulating layer under the skin; air sacs absent; wings modified, paddle-like for swimming; toes webbed for swimming; beak fish-eating; one egg laid at a time which is incubated on the feet; gregarious.

Superorder NEOGNATHAE (=CARINATAE)

1.Order **Gaviiformes,** Divers and loons. Aquatic birds that catch fish and crustaceans by diving; toes webbed; legs short and set far back; migratory. There are two species, *Gavia arctica* and *G. stellata* recorded in India.

2. Order **Podicipitiformes,** Grebes *(Podiceps, Podilymbus).* **17** species. Aquatic birds with rudimentary tail; bill compressed, pointed; front toes wsdith broad lateral vane-like lobes; nails broad and flattened; feed on fish and crustaceans. Migratory.

3. Order **Procellariformes,** Albatross *(Diomedea),* Shearwater *(Puffinus).* 81 species. Ocean birds with a wing span up to 11 feet; beak long, hooked at tip; wings narrow, long and pointed; feet webbed with strong hind claw; tail short and rounded; hallux reduced or absent; soaring and migratory birds.

4. Order **Pelecaniformes,** Pelicans, cormorants, frigate birds. **50** species. Large birds with short legs and large webbed toes; upper mandible flattened and hooked at tip; lower mandible has a pouch of loose skin; tail short; food mainly fish.

5. Order **Ciconiiformes,** Herons, Egrets, Storks, Flamingos. **117** species. Long legs and long slender, flexible neck; bill long straight, sharp and dagger-like; middle and outer toes webbed at base; many migratory.

6. Order **Anseriformes,** Ducks, Swans, Geese, Teels, Pochards. **149** species. Large conspicuous water birds; bill broad, flat with comb-like margin for straining food particles; wings usually narrow and pointed; tail short; feet webbed; tongue thick and fleshy; migratory.

7. Order **Falconiformes,** Vultures, Kite, Eagle, Buzzard, Hawk, Falcons. **274**species. Birds of prey; beak short, upper mandible longer and hooked at tip for tearing flesh; feet strong and powerful, with hooked claws; hallus strong; predators or scavengers.

8. Order **Galliformes,** Game birds, Megapods, Patridge, Quail, Turkey, Hoatzins, Guinea Fowl, Fowls, Peacocks, Pheasants. **240** species. Terrestrial; legs stout and unfeathered; hind tarsus with a spur in male; claws short, strong and blunt; beak short and stout; legs adapted for running.

9. Order **Gruiformes,** Crane, Rail, Bustard. 185 species. Small to large ground birds or shore birds; hallux absent; keel is reduced, have weak power of fight; slight web on toes; feed on fish, reptiles and mollusks.

10. Order **Charadriiformes,** Plovers, Lapwings, Sandpipers, Pranticole, Gulls, Terns. **293** species. Waders and good fliers; beak variously modified; hallux small or absent; anterior toes webbed; terns have forked tail and short legs; feed on fish.

11. Order **Columbiformes,** Pigeons, Doves, Sandgrouse, Dodo. **301** species. Grain or fruit-eating birds; slender beak; legs for perching; eggs pure white; youngs are fed on milky food produced in crop; base of beak covered with a soft swollen membrance in which lie the nostrils.

12. Order **Psittaciformes,** Parrots, Macaws, Cocatoo, Parakeet. **317** species. Fruit eating birds; bills stout and strongly hooked; upper mandible movable; tongue thick and fleshy; feet zygodactylous; tail pointed.

13. Order **Cuculiformes,** Cuckoo, Koel, Brainfever bird, Crow-pheasant. 143 species. Feet zygodactylous; young do not grow down feathers; brood parasitic, lay their eggs in the nest of other birds; wings long and pointed; migratory;

14. Order **Strigiformes,** Owls *(Bubo, Strix, Nyctea, Tyto).* **132** species. Nocturnal birds of prey hunting small mammals and reptiles; eyes large, directed forward; upper eyelid large; beak short and hooked, sharp; ear opening large; neck highly flexible; fight soundless.

15. Order **Caprimulgiformes,** Nightjars, Oil birds, Frogmouths. **92** species. Bill short, flexible with enormous gape; wings long; bristles around nostrils; nocturnal birds, feeding on insects on wing; eggs are laid on ground in a bush.

16. Order **Apodiformes (=Micropodiformes),** Swifts, Hummigbirds. **388**species. Gregarious, insectivorous birds, adapted for rapid flight; wings long and narrow; tail short and deeply forked; gape of mouth very large; beak short and hooked; feet with 4 toes, all directed forward; legs weak; capable of flying backward.

17. Order **Coliiformes,** Mouse birds of South Africa. Short legs with sharp claws for climbing on trees. Crest on head. Feathers hair-like. Gregarious. **6**species.

18. Order **Trogoniformes,** Trogons of Asia and Africa. Zygodactylous. Insectivorous, Solitary. Base of beak hairy. **35** species. Bill short, strong and wide; base of nostrils covered with bristles; tail long.

19. Order **Coraciiformes,** Kingfishes, Bee-eaters, Rollers, Hoopoe, Hornbill. **192**species. Three front toes are joined at base; beak long heavy and sharply pointed; nest is built in tree hole; highly variable species.

20. Order **Piciformes,** Woodpeckers, Honey guide, Toucans. **377** species. Insectivorous.birds, adapted for climbing on tree trunks; feet zygodactylous; beak strong adapted for wood cutting; tongue very long, armed with spines at tip; tail feathers strong to support the body; eggs are laid in tree hole.

21. Order **Passeriformes,** Perching birds. Pitta, Flycatchers, Lyre-birds, Skylarks, Swallows, Wagtails, Shrikes, Bulbul, Wren, Babblers, Warblers, Tailor-birds, Nightingale, Tit, Nuthatch, Sunbirds, Tanager, Starlings, Grackle, Oriole, Drongo, Magpie, Jay. **5,110** species. More than half of total number of bird species are included in this order. Feet adapted for perching; front toes are free and hallux long and movable; highly variable species, adapted for various habitats.

HOW BIRDS FLY- FLIGHT - ADAPTATIONS IN BIRDS:

One of the requirements for heavier-than-air flying machines is a structure that combines strength with light weight. This is true for birds as well as planes. Birds have many physical features, besides wings, that work together to enable them to fly. They need lightweight, streamlined, rigid structures for flight. The four forces of flight – weight, lift, drag and thrust – affect the flight of birds.

Physical features

Flying birds have:

- lightweight, smooth feathers – this reduces the forces of weight and drag
- a beak, instead of heavy, bony jaws and teeth – this reduces the force of weight
- an enlarged breastbone called a sternum for flight muscle attachment – this helps with the force of thrust
- light bones – a bird's bones are basically hollow with air sacs and thin, tiny cross pieces to make bones stronger – this reduces the force of weight
- a rigid skeleton to provide firm attachments for powerful flight muscles – this helps with the force of thrust
- a streamlined body – this helps reduce the force of drag
- wings – these enable the force of lift.

Wings

The shape of a bird's wing is important for producing lift. The increased speed over a curved, larger wing area creates a longer path of air. This means the air is moving more quickly over the top surface of the wing, reducing air pressure on the top of the wing and creating lift. Also, the angle of the wing (tilted) deflects air downwards, causing a reaction force in the opposite direction and creating lift.

Larger wings produce greater lift than smaller wings. So smaller-winged birds (and planes) need to fly faster to maintain the same lift as those with larger wings.

Wing loading tells you how fast a bird or plane must fly to be able to maintain lift: wing loading = weight/wing area (kilograms per square metre).

A smaller wing loading number means the bird/plane can fly more slowly while still maintaining lift and is more manoeuvrable.

Gliding

When a bird is gliding, it doesn't have to do any work. The wings are held out to the side of the body and do not flap. As the wings move through the air, they are held at a slight angle, which deflects the air downwards and causes a reaction in the opposite direction, which is lift. But there is also drag (air resistance) on the bird's body, so every now and then, the bird has to tilt forward and go into a slight dive so that it can maintain forward speed.

Soaring

Soaring flight is a special kind of glide in which the bird flies in a rising air current (called a thermal). Because the air is rising, the bird can maintain its height relative to the ground. The albatross uses this type of soaring to support its multi-year voyages at sea.

Flapping

Birds' wings flap with an up-and-down motion. This propels them forward. The entire wingspan has to be at the right angle of attack, which means the wings have to twist (and do so automatically) with each downward stroke to keep aligned with the direction of travel.

Different birds have different adaptive features to meet their flight needs:

- Some birds are small and can manipulate their wings and tail to manoeuvre easily, such as the fantail (pīwakawaka).
- The hawk, with its large wingspan, is capable of speed and soaring.
- Gannets and seabirds are streamlined to dive at high speeds into the ocean for fish.
- Godwits, although small, are equipped to fly long distances.

More Adptations:

Light in weight , light bones.
Feathers , wings for flight .
Hollow bones.
Streamline body.
No urinary bladder.
Air Sacs ,, respiratory adaptations.

ANATOMICAL ADAPTATIONS

BODY SHAPE

Birds have short, light and compact body as compared to other animals.

Most organs and large muscles are located near the center of gravity, which is slightly below and behind the wings to provide better balance during flight.

FEATHERS

Contour feathers cover the body and make it streamlined and decrease drag. Down feathers and soft and meant for insulation. Primary feathers are on the wings and are also called remiges, which help in flight and also provide wing shape. Tail feathers are called rectrices which stretch sideways so that tail can be used like a rudder for turning and balancing.

SKELETON

The evolution of flight has endowed birds with many physical features in addition to wings and feathers. One way to reduce weight in birds is by the fusion and elimination of some unnecessary bones and the "pneumatization" of the remaining ones. Not only are some bones of birds hollow but many of the larger ones are connected to the air sacs of the respiratory system.

METABOLISM

Birds have high metabolism and endothermy for quick generation of power and for maintenance of high body temperature. Birds require large amounts of energy for flight, and need efficient oxygen circulation in high altitudes. The highest flight recorded for a bird was 11,274 m (37,000 ft.) when a Ruppell's griffon vulture collided into a commercial airline over western Africa (Martin, 1987).

Birds normally maintain a body temperature of 38.0C to 42.0C (100.40F-107.60F) (Brooke and Birkhead, 1991).

RESPIRATORY SYSTEM

The respiratory system of birds is adapted to the energy demands of flight. A bird's respiratory system is proportionately larger and much more efficient than in other animals, since flight is a more demanding activity than walking or running. An average bird's respiratory system occupies about one-fifth of its body volume, while in an average mammal it is only about one-twentieth. Lungs of birds are less flexible, and relatively small, but they are interconnected with a system of large, thin-walled air sacs in the front and in the posterior portions of body.

BIRD MIGRATION

Bird migration refers to the regular (and often seasonal) journeys to and from a given area undertaken by all or part of a bird population. Not all bird species (or even populations within the same species) are migratory. In contrast to more irregular movements such as emigration, nomadism, and invasion, which are made in response to changes in food availability, habitat, or weather, bird migration is marked by its cyclical pattern.

The most common pattern among the migratory birds of Europe and North America involves flying north to breed in the temperate or arctic summer and returning to wintering grounds in warmer regions to the south. However, other patterns of migration have been observed: In tropical regions, for example, some species migrate in response to the cycle of wet and dry seasons. In mountainous areas, like the Himalayas, vertical movements may occur from higher breeding grounds to lower altitudes with less exposure to harsh winter weather.

Why Do Birds Migrate? **Written by Tahir Habib**

Birds migrate to move from areas of low or decreasing resources to areas of high or increasing resources. The two primary resources being sought are food and nesting locations.

Birds that nest in the Northern Hemisphere tend to migrate northward in the spring to take advantage of burgeoning insect populations, budding plants and an abundance of nesting locations. As winter approaches and the availability of insects and other food drops, the birds move south again. Escaping the cold is a motivating factor but many species, including hummingbirds, can withstand freezing temperatures as long as an adequate supply of food is available.

Different Types of Bird Migration

While the exact birds that participate in different migration patterns can be subject to interpretation and may gradually change as migration patterns evolve, the most common migrations include:

- **Seasonal**: This well-known and widespread migration is predictable based on seasonal changes, as birds move between breeding and non-breeding ranges. The height of these migration periods are during spring and fall, though in some areas the change between wet and dry seasons are migration indicators.
- **Latitudinal**: This migration is between areas of different latitudes from north to south and vice versa. This is the most common migration type with many neotropical migrants.

The exact direction of migration is often determined by geographic features, however, such as mountain ranges and available habitats.

- **Longitudinal**: Similar to latitudinal migration, this type of movement is a change between different longitudes from east to west or west to east. This is a common type of migration for many birds in Europe, where geographic features encourage birds to move longitudinally rather than latitudinally.
- **Altitudinal**: Birds that breed in tall mountains often exhibit altitudinal migration. This type of migration is the move to lower elevations in winter, when harsh weather and deep snowfall may make staying at upper elevations impossible. Birds that use altitudinal migration may not venture far in terms of overall mileage, but just a few hundred feet of elevation can make a great difference in habitats.
- **Loop**: Birds that follow an annual circle are loop migrants. This migration includes two distinctly different routes to and from breeding grounds, often taking advantage of varied resources at different times of the year. For example, rufous hummingbirds follow a coastal route in spring on their way from Mexico to Alaska, but take advantage of mountain wildflowers on an interior southbound route in autumn. Loop migration is also common with many seabirds and shorebirds as they use seasonal variations in wind patterns to aid their flight.
- **Nomadic**: This movement is less predictable and can be erratic depending on available food and water resources. Nomadic birds tend to stay within the same range but may be completely absent from parts of that range when resources are scarce, but will return when the habitat becomes more suitable. Types of birds that migrate nomadically include waxwings, phainopeplas, zebra finches and black swans.
- **Irruptive**: Bird irruptions are highly unpredictable but spectacular migrations that bring large numbers of birds into unusual areas, most often in winter. Unlike nomads, irruptive birds may be found far outside their expected ranges during this type of migration, but the reason is the same – the search for suitable food and water resources. Types of migrating birds that exhibit irruptive patterns include redpolls, varied thrushes, evening grosbeaks, crossbills and snowy owls.
- **Dispersal**: While not always considered a true migration, bird dispersal is nonetheless relatively predictable and seasonal, though only once a year. In this migration, juvenile birds are forced away from their hatching grounds and must seek out their own territories as their parents continue to use the same range. This is more common among birds that are year-round residents of the same range and will defend their territories throughout the

year, such as woodpeckers.

ADVANTAGES OF MIGRATION IN BIRDS:

FOOD:

There are many reasons for participating in game farming. It can be an enjoyable hobby and means of increasing bird population (Ralpha et al., 2007). Wild game may have a different flavor and texture than domestic meat. But wild game can be delicious if properly prepared.

Ornament:

Neaderthals exploited birds for the use of the feathers or claws as personal ornaments (Finlayson et al., 2012). Many bird species display elaborate ornaments including feather structures such as facial plumes, crests, and tail streamers and bare part ornaments such as bill plates, knobs and wattles during their breeding seasons.

Recreation and Tourism

Nature based tourism and recreation, such as the viewing of wildlife, is popular and often occurs in protected areas (Newsomeal., 2002; Higginbottom, 2004). This is a common benefit of birds. Game viewing attracts people to conservation areas for complete relaxation. Many migratory birds.

Production of oil:

Production of oil Game birds are capable of synthesizing oil. Nutritional Information for 3 ounces of raw wild game reviewed that game bird ranging from 103 to 188 calories is capable of producing 2- 9g fat and 1-2g saturated fat (Nash, 2003).

CONCLUSION:

Birds form one of the common examples of migratory animals. In turn the huge numbers of migratory birds represent an important component of the food chain whether, native or non-native species. Their beautiful plumage, crests, tail streamers, bill plates and wattles contributes to uniqueness of birds‟ existence during breeding seasons making, bird species an excellent source of recreation that is capable of generating millions of dollars for nations due their diverse nature and distribution.

THE ORIGINS OF BIRDS (BIRDS ARE GLORIOUS REPTILES)

Introduction

Have you ever really looked at a bird's feet? Most birds have clawed toes and scales covering their feet. Birds also lay eggs in nests. These three traits are found in reptiles as well. However, birds have many other traits, such as feathers and warm-bloodedness,

that are not found in modern reptiles. One of the most famous fossils ever found is *Archaeopteryx*, a small animal with clawed toes, scaly legs, teeth, and feathered wings. *Archaeopteryx* was found in rocks dating from the Jurassic Period, 150 million years ago. Many scientists classify *Archaeopteryx* as a bird. Other scientists point out that, if you took away the feathers, this fossil would look just like *Deinonychus*, a small theropod dinosaur. Scientists agree that *Archaeopteryx* wasn't able to fly, partly because it had a flat sternum (breastbone). Birds have a keeled sternum to which flight muscles are attached. Yet *Archaeopteryx* clearly had feathers. Was this fossil a dinosaur or a bird? This is only one of the many questions paleontologists struggle with when they study the evolution of birds.

One of the first people to make a connection between dinosaurs and birds was Thomas Huxley, a contemporary of Charles Darwin in the 1800s. In 1916, a Danish doctor named Heilmann wrote a book titled *The Origin of Birds*, in which he listed the similarities between the skeletons of theropod dinosaurs and modern birds. Later fossil discoveries made these similarities more striking. In the 1960s, an American named John Ostrom found 22 features in theropods and birds that could not be found in any other animal groups. However, new fossils of birds and birdlike dinosaurs are being discovered every year. Some of these fossils are changing perceptions of the origins of birds. Did birds evolve from theropods or another group of dinosaurs? Or did birds and dinosaurs evolve from a common ancestor much earlier in geologic time? Is *Archaeopteryx* the first bird? When did feathers evolve and how? Which came first, feathers or flight?

ARCHAEOPTERYX:
AN EARLY BIRD

Paleontology has helped us understand the unique evolutionary history of birds.

A particulary important and still contentious discovery is **Archaeopteryx lithographica,** found in the Jurassic Solnhofen Limestone of southern Germany, which is marked by rare but exceptionally well preserved fossils. Archaeopteryx is considered by many to be the first bird, being of about 150 million years of age. It is actually intermediate between the birds that we see flying around in our backyards and the predatory dinosaurs like Deinonychus. In fact, one

skeleton of Archaeopteryx that had poorly preserved feathers was originally described as a skeleton of a small bipedal dinosaur, Compsognathus. A total of seven specimens of the bird are known at this time.

It has long been accepted that **Archaeopteryx** was a transitional form between birds and reptiles, and that it is the earliest known bird. Lately, scientists have realized that it bears even more resemblance to its ancestors, the Maniraptora, than to modern birds; providing a strong phylogenetic link between the two groups. It is one of the most important fossils ever discovered.

Unlike all living birds, Archaeopteryx had a full set of teeth, a rather flat **sternum** ("breastbone"), a long, bony tail, **gastralia** ("belly ribs"), and three claws on the wing which could have still been used to grasp prey (or maybe trees). However, its feathers, wings, **furcula** ("wishbone") and reduced fingers are all characteristics of modern birds.

As you can see, *Archaeopteryx* certainly had feathers, although whether these feathers were used for regulating its body temperature or for flight is a matter still open for debate. Feathers may have originally evolved for insulation and then been co-opted into flight. The origin of flight, and the actual flight capabilities of *Archaeopteryx*, are debated. Two models of the evolution of flight have been proposed: in the "trees-down" model, birds evolved from ancestors that lived in trees and could glide down, analogous to today's flying squirrels. In the "ground-up" model, the ancestors of birds lived on the ground and made long leaps. For more information, see our new exhibits on vertebrate flight and avian flight.

CLASS MAMMALIA

(Dr. Girish Chandra)

Mammals are defined as vertebrates that possess hairs and mammary glands for feeding young. They also possess a four-chambered heart, a large cerebral cortex, three distinctive bones: incus, malleus and stapes in the middle ear, a diaphragm for breathing, heterodont and thecodont dentition, limbs attached under the body, dicondylic skull and acoelous vertebrae. The class Mammalia is classified into three subclasses, 28 Orders, 161 Families, 747 Genera and 4939 Species

Main Characteristics of mammals:

- **Endothermy** - maintain high, constant body temperature through their metabolism
- **Pelage** - hair or fur made of protein called keratin covering all or part of the body for insulation & camouflage
- **Four chambered heart** (two atria & two ventricles) keep oxygenated & deoxygenated blood from mixing; double circulation
- **Mammary glands** in females are modified sweat glands that make **milk** containing sugars, proteins, & fats to nourish young
- **Single jawbone**
- **Specialized teeth** for biting, cutting, & chewing
- **Highly developed brain** (large cerebrum)
- **Diaphragm** - muscle below lungs that aids respiration
- Most are **viviparous** (live birth)
- **Uterus** in females where young develop
- **Placenta** lines uterus & provides nutrients and gas & waste exchange for developing young
- Have **sweat glands** for cooling & **scent glands** for attracting mates & marking territories

Classification of Mammals

Mammals are the largest class in the animal world. Mammals are of different types and can be distinguished up into marine mammals, smaller mammals and larger mammals. Mammals belong to the class mammalia.

Since mammals are of different types they are classified into three subclass based on their reproduction. They are Eutheria, Metatheria and Prototheria.

Eutheria

Mammals that give birth to their young ones directly belong to the subclass Eutheria. The young ones form as an embryo in the mother stomach and grow there for a certain period of time. This subclass consists of 19 orders. Best example and well known of this class are humans, dogs and cats.

- Insectivora (moles, shrews)
- Dermoptera (flying lemurs)
- Chiroptera (bats)
- Cetacea (whales)
- Carnivora (cats, bears, dogs, otters, seals, sea lions)
- Tubulidentata (aardvarks)
- Proboscidea (elephants)
- Hyracoidea (hyraxes)
- Primates (monkeys, lemurs, bush babies, aye-ayes)
- Xenarthra or Edentata (armadillos, anteaters, sloths)
- Pholidota (pangolins)
- Lagomorpha (rabbits, hares, pikas)
- Rodentia (mice, rats, squirrels, porcupines, beavers, voles, hamsters)
- Sirenia (manatees, dugongs)
- Perissodactyla (horses, donkeys, zebras, rhinoceroses, tapirs)
- Artiodactyla (pronghorns, deer, camels, gnus, goats, giraffes, hippopotami, pigs,
- peccaries, chevrotains, musk-deer, cows)
- Scandentia (tree shrews)
- Macroscelidea (Elephant Shrews)

Metatheria

Mammals that belong to this subclass also give birth to their young ones but the young ones are born immature. So they jump into their mother pouch and stay their till they are mature. Metatheria subclass contains seven orders with 250 species. Marsupials and kangaroo are the best example for this subclass.

- Didelphimorphia (New World opossums)
- Paucituberculata (South American rat opossums)
- Microbiotheria (colocolo)
- Dasyuromorphia (dasyurids, thylacines)
- Peramelemorphia (bandicoots)
- Notoryctemorphia (marsupial moles)
- Diprotodontia (kangaroos, koalas, wombats, possums)

Prototheria

Prototheria consists of egg laying animals and are also known as monotremes. This subclass consists of six species all in one order.

- **Monotremata (platypus and echidna)**

Although mammals are classified in to class, subclass, and order the scientist have classified on the general basis. This general classification makes it easy to learn about the mammals class and their distinguished features.

General classification of Mammals
Animals

- Lion
- Tiger
- Dog

Order Marsupials:

- Found in **New Guinea, Australia, & the Americas**
- **Dominate animal in Australia due to lack of competition from placental mammals**
- Known as pouched animals
- Pouch called **marsupium**
- **Viviparous** (live birth)
- Tiny, immature young must crawl to mother's pouch after birth
- Young **attach to mammary gland nipple** to nurse until able to survive outside of pouch
- Includes opossum, kangaroo, wombat, & koala
- Kangaroo
- Koala
- Tasmanian devil
- Womba

Order Primates

- Chimpanzee
- Gorilla
- Monkey
- Organqutan
- Lemur

Order Rodents

- **Largest mammal order** (40% of all species)
- Found everywhere **except Antarctica**
- Includes **squirrels, chipmunks, gophers, rats, mice, & porcupines**
- Have **two** instead of four **incisors**
- **Teeth continue to grow throughout their life**

- Feed on hard seeds, twigs, roots, & bark
- **weGnawing** keeps incisors sharp
- **High reproductive capacity**
- Guinea pig & capybaras are two rodents found in South America
- Squirrels
- Mice
- Porcupines

Order Lagomorphs

- includes rabbits, hares, & pikas
- Found **worldwide**
- Have a **double row of upper incisors & two large front teeth** backed up by two smaller teeth
- Continuous growing teeth
- **Herbivores**

Order Cetaceans

- Whales
- Dolphins

Order Carnivora:

- Found worldwide
- Includes **cats, dogs, raccoons, bears, hyenas, & otters**
- Meat eaters **(carnivores)** mainly
- Many feed on both plants & animals **(omnivores)**
- Have **long canine teeth** & strong jaws
- **Clawed toes** for seizing & holding prey
- Keen sense of sight & smell
- Long limbs for running fast

Order Primates:

- Includes 2 main groups --- **Prosimians & Anthropoids**
- Most are **omnivores**
- Have **teeth suitable for a varied diet**
- **Prosimians** include **lemurs, tarsiers, & lorises**
- **Anthropoids** include **monkeys, apes, & humans**
- Anthropoids have a larger brain
- Show **more complex behaviors** than other animals
- Highly organized **social groups**
- Gorilla is the largest primate

- Have 2 forward-facing eyes for depth perception
- Have grasping hands & most with grasping feet
- Some have a grasping tail for life in trees
- Live in a variety of habitats

Other mammals

- Seals
- Seal lions
- Warlus

MAMMALIAN FAUNA OF BALOCHISTAN

Sr. Nos	Species	Common name	Preferred Habitat	IUCN Status
1	*Crossodura zarudnyi*	Desert shrew	Dry beds with vegetation	Lower Risk (lc)
2	*Paraechinus hypomelas*	Migratory Hedgehog	Around the human settlements	Lower Risk (lc)
3	*Hemiechinus collaris*	Hedgehog	Small dry Hillocks near patches of vegetation	Lower Risk (lc)
4	*Pipisttrellus kuhlii*	Kuhl's Pipistrelle	Agricultural areas	Lower Risk (lc)
5	*Canis lupus*	Indian wolf	Hilly tracts	Lower Risk (lc)
6	*Canis aureus*	Asiatic Jackal	Agricultural areas near settlements	Lower Risk (lc)
7	*Felis margarita*	Sand Cat	Sand dune areas	Near Threatened
8	*Vulpes rueppelli*	Sand Fox	Sand dune areas	Data Deficient (DD)
9	*Vulpes vulpes*	Common Red Fox	Hilly tracts	Lower Risk (lc)
10	*Vulpes cana*	King Fox	Hilly areas around the settlements	Data Deficient (DD)
11	*Gazella subgutterosa*	Goitred Gazelle	Narrow valleys in barren mountain ranges	Endangered
12	*Lepus capensis*	Cape hare	Vegetation patches along dry rivulets	Lower Risk (lc)
13	*Salpingotus*	Balochistan	Sand dune areas	Lower Risk (lc)

MAMMALS & BIRDS IN HINGOL PARK (BALOCHISTAN)

Mammals in the park include Sindh Leopard, Indian Fox, Jungle Cat, Jackals, Sind Wild Goat, Blandford's Urial, Chinkara Gazelle, Honey Badger, Indian Pangolin, Hedgehog, Porcupine, Indian Grey Mongoose, Cairo Spiny mouse and the Rock Mouse. As for the birds, Houbara Bustard, Dalmatian and Spot-billed Pelican, Lagger Falcon, Red-headed merlin, Kestrel, Grey Partridge, See See Partridge, , Eagle owl , Sind pied woodpecker, Hume's chat, Brown rock pipit, Striped Buning, Finche Larks, Hoopoe, Shrikes and Wheatears. Beside Bonnelli's, Imperial Tawny and Golden Eagle are also found here. There are three varieties of vultures, namely Eurasian Griffon Vulture, Egyptian Vulture and the Cinereous Vulture. As for sand grouse, there are many varieties like Stone Curlew, Indian, Coroneted, Painted and Close-Barred Sand Grouse.

Written by Tahir Habib

COELOM

A **coelom** (Greek: ***coel*** = hollow cavity) is a fluid-filled cavity between the alimentary canal and the body wall lined on all sides by mesoderm. The peritoneal cavity in our abdomen is one part of our coelom and there are similar spaces around our heart and lungs. However, the type of coelom (or even its existence) differs among groups of animals both in its structure and mode of development. There are three *structural* types of body plans related to the coelom.

1. **Acoelomates**, in which no coelomic cavity exists. Examples are flatworms (Platyhelminthes), coelenterates and sponges. Only a gut, coelenteron or spongocoel exists in these animals and there is no other cavity.

2. **Pseudocoelomates**, in which a body cavity exists in addition to alimentary canal, but it is lined by mesoderm only on the outer body wall side and not around the gut. Examples are round worms (Nemathelminthes) and some minor phyla grouped under Aschelminthes.

3. **Coelomates or Eucoelmates.** They are true coelomates in which the coelom is lined both on the inside of the body wall as well as around the gut by mesoderm. Animals with a true coelom also have **mesenteries**, which suspend the body organs within the coelom. Animals higher to round worms such as annelids, arthropods, mollusks, echinoderms and chordates fall in this category. Tue coelomates are of the following types.

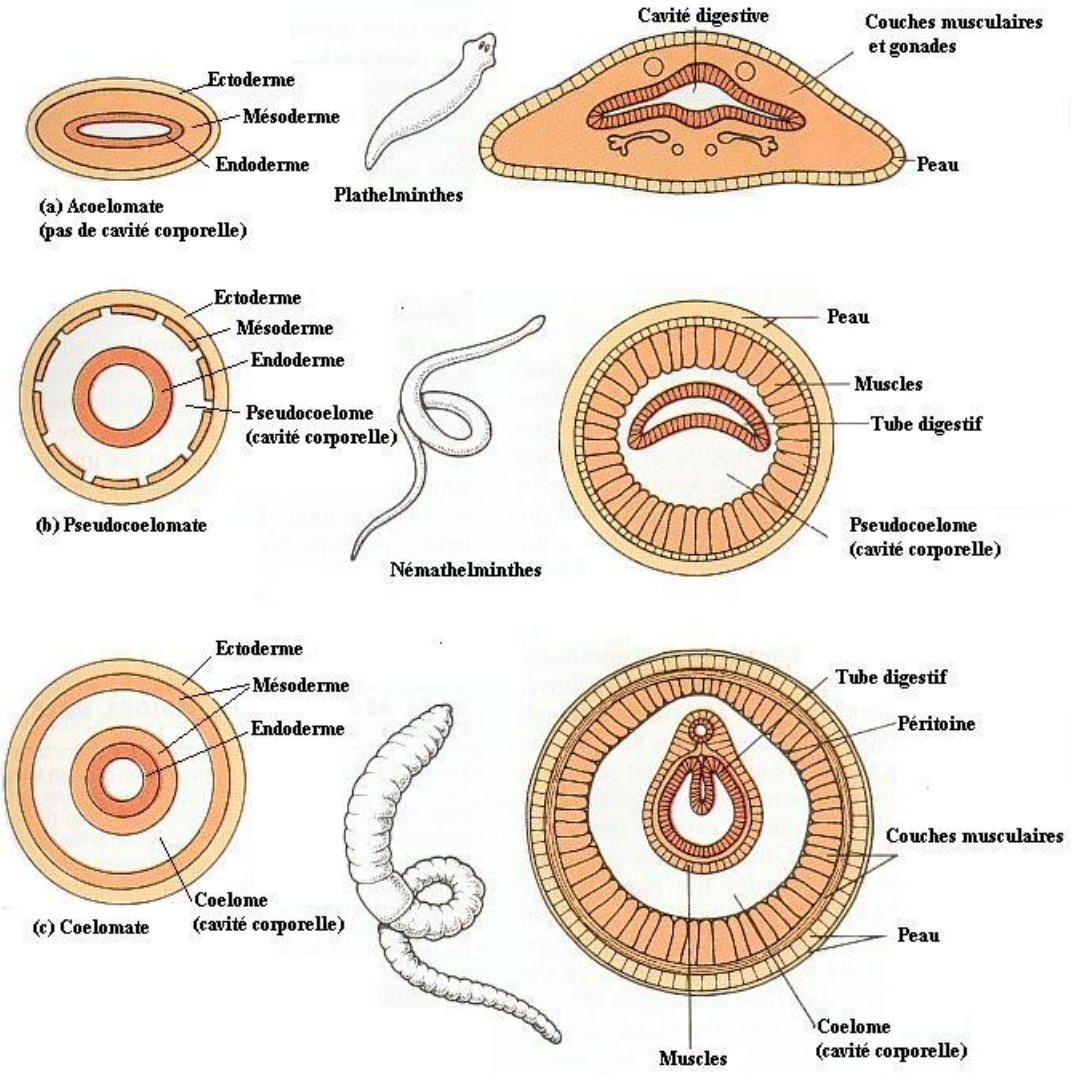
(i) Schizocoelomates are true coelomates in which the body cavity originates by splitting of mesodermal tissue at the time of gastrulation. This method of coelom formation is called **schizocoelous** (Greek: ***schizo*** = split), and occurs in animals like annelids, arthropods and mollusks. Sometimes the schizocoelom is filled with blood and is called **haemocoel** as in arthropods and mollusks.

(ii) Enterocoelomates. In most deuterostomes, such as chordates and echinoderms, the coelom originates by out-pouching of the archenteron during gastrulation. Each pouch then expands and its mesoderm lines the gut on the inner side and body wall on the outer side. This method of coelom formation is called **enterocoelous**.

Segmentation, Cephalization and Tagmosis

Segmentation, also known as metamerization, is the structural grouping of parts of an animal body into discrete segments. **Cephalization** means that there is a head, and therefore a concentration of sensory organs, feeding organs, and centers of neural integration near the anterior end of the animal. While at first seeming a bit simplistic, cephalization has tremendous implications for animals. **Tagmosis** occurs in segmented animals where groups of segments are

organized into functional units. A good example is in arthropods, where segments are grouped into body regions like the head, thorax, and abdomen, each having its own suite of functions.



WRITTEN BY TAHIR HABIB

EVOLUTION OF THE HUMAN HEART

The current human heart is a large muscular organ with four chambers, a septum, several valves, and other various parts necessary for pumping blood all around the human body. However, this amazing organ is a product of evolution and has spent millions of years perfecting itself in order to keep humans alive.

Invertebrate Hearts

Invertebrate animals have very simple circulatory systems. Many do not have a heart or blood because they are not complex enough to need a way to get nutrients to their body cells. Their cells are able to just absorb nutrients through their skin or from other cells. As the invertebrates become a little more complex, they use an open circulatory system. This type of circulatory system does not have any blood vessels, or has very few. The blood is pumped throughout the tissues and filters back to the pumping mechanism.

Like in earthworms, this type of circulatory system does not use an actual heart. It has one or more small muscular areas capable of contracting and pushing the blood and then reabsorbing it as it filters back. However, these muscular regions were the precursors to our complex human heart.

Fish Hearts

Of the vertebrates, fish have the simplest type of heart. While it is a closed circulatory system, it has only two chambers. The top is called the atrium and the bottom chamber is called the ventricle. It has only one large vessel that feeds the blood into the gills to get oxygen and then transports it around the fish's body.

Frog Hearts (Amphibian heart)

It is thought that while fish only lived in the oceans, amphibians like the frog were the link between water dwelling animals and the newer land animals that evolved. Logically, it follows that frogs would therefore have a more complex heart than fish since they are higher on the evolutionary chain. In fact, frogs have a three chambered heart. Frogs evolved to have two atria instead of one, but still only have one ventricle. The separation of the atria allows frogs to keep the oxygenated and deoxygenated blood separate as they come into the heart. The single ventricle is very large and very muscular so it can pump the oxygenated blood throughout the various blood vessels in the body.

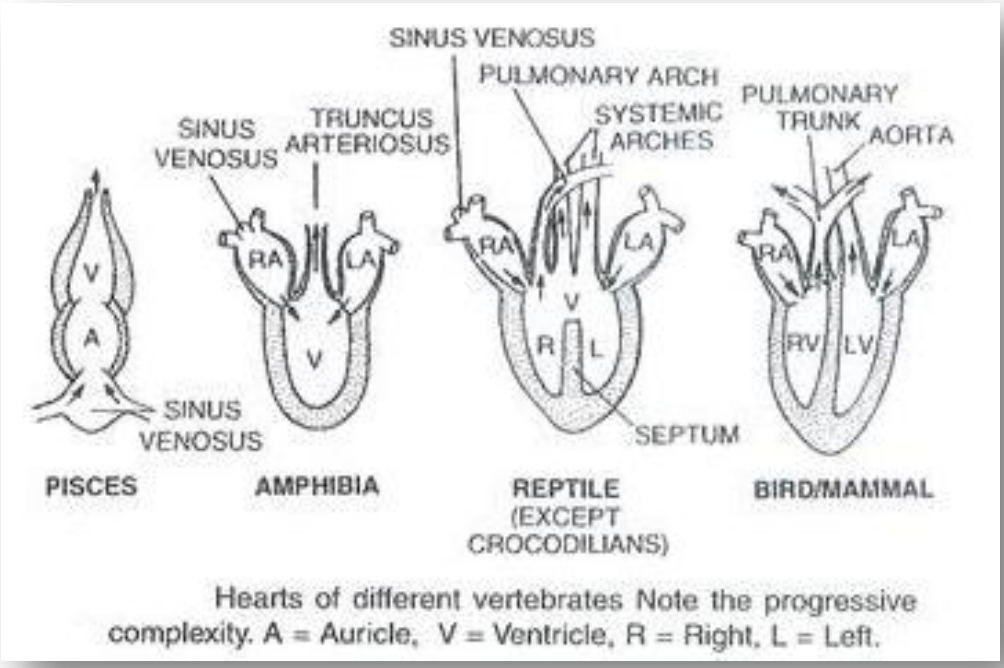
Turtle Hearts (Reptile)

The next step up on the evolutionary ladder is the reptiles. It was recently discovered that some reptiles, like turtles, actually have a heart that has a sort of a three and a half chambered heart. There is a small septum that goes about halfway down the ventricle. The blood is still able to mix in the ventricle, but the timing of the pumping of the ventricle minimizes that mixing of the blood.

Human (Mammal) Hearts

The human heart, along with the rest of the mammals, is the most complex having four chambers. The human heart has a fully formed septum that separates both the atria and the ventricles. The atria sit on top of the ventricles. The right atrium receives deoxygenated blood coming back from various parts of the body. That blood is then let into the right ventricle which pumps the blood to the lungs through the pulmonary artery. The blood gets oxygenated and then returns to the left atrium through the pulmonary veins. The oxygenated blood then goes into the left ventricle and is pumped out to the body through the largest artery in the body, the aorta.

This complex, but efficient, way of getting oxygen and nutrients to body tissues to billions of years to evolve and perfect.



Hearts of different vertebrates Note the progressive complexity. A = Auricle, V = Ventricle, R = Right, L = Left.

WILDLIFE OF PAKSIATN

EXISTING WILDLIFE IN PAKISTAN

The mountainous areas embracing the Himalayan, Karakorum and Hindukush Ranges are rich in fauna and flora, as compared to other parts of the country. These areas provide an excellent habitat for wildlife in the form of alpine grazing lands, sub-alpine scrub and temperate forests. These habitats support a variety of wild animals. The areas are difficult for human beings to access, hence, most wildlife is present in reasonable numbers though some are endangered for other reasons. Some of the main wildlife species are the snow leopard, the black and the brown bears, otter, wolf, lynx, Himalayan ibex, markhor, bharal, Marco Polo's sheep, shapu, musk deer, marmots, tragopan and monal pheasants. The snow partridge and snowcock reside at higher elevations. The Rhesus monkey, common langur, red fox, black bear, common leopard, a variety of cats, musk deer (over a limited area), goral, several species of flying squirrels, chakor, partridge and pheasants (koklass, kaleej and cheer) live in the lower elevations. Amongst these the snow leopard, musk deer, Marco Polo's sheep, and the brown bear are endangered. The Tibetan wild ass and the blue sheep populations have been reduced drastically. The cheer pheasant is reported to be extinct from within Pakistan's boundaries, and is included in the IUCN Red Data Book. The western horned tragopan was reported to have disappeared from within Pakistani territory, but has now been relocated to Indus Kohistan, although its numbers are low.

The main threats to the population of wild animals in the northern mountainous regions include, the competition with domestic livestock for existing natural forage, increasing human interference in the form of cultivation, the construction of roads, and hunting.

The Himalayan foothills and the Potohar region, including the Salt Range and Kala Chitta Range, are covered with scrub forests, which have been reduced to scanty growth in most places. Medium-sized animals like the Punjab urial, barking deer, goral, chinkara, partridges (grey and black), seesee and chakor are supported in these habitats. A variety of songbird fauna also occurs in these areas.

Vast Indus flood plains have been cleared of natural vegetation to grow crops. Very little wildlife habitat has been left untouched. Only animals like the jackal, mongoose, jungle cat, civet cat,

scaly anteater, desert cat and the wild hare occur in these areas. Hog deer is found in riverine tracts. The crop residues and wild growth support reasonable populations of black and grey partridges.

Little vegetative cover, severity of climatic conditions and the great thrust of grazing animals on the deserts have left wild animals in a precarious position. Parts of Thall and Cholistan are now being irrigated, with the situation almost identical to that of the flood plains. Chinkara is the only animal, which can still be found in average numbers in Cholistan, but rarely in Thall. The blackbuck, once plentiful in Cholistan has now been eliminated. However, efforts are being made to reintroduce them back into the country. A small number of blue bulls are found along the Pak-Indian border, and some parts of Cholistan. Grey partridge, species of sand grouse and the Indian courser are the main birds of the area. Peafowl occur in some areas in Cholistan.

The Thar Desert supports a fair population of the Chinkara gazelle. Peacocks are only found in the wild, mainly because of the protection they enjoy in Hindu communities. The wild ass migrates from the Indian part of the Rann of Kutch to the Pakistani part in search of food.

The Houbara bustard is a regular winter visitor to the desert. Visiting diplomats have hunted and reduced their numbers. The great Indian bustard is sporadically sighted. The imperial sandgrouse is another migrant visiting these areas. Grey partridges are frequently sighted. The python is also threatened with extinction.

The Sulaiman and Kirthar Ranges present habitats manifesting unique characteristics. The former supports the straight-horned markhor, chinkara and urial, whereas Sindh ibex, urial, chinkara and common leopard occupy the latter. The straight-horned markhor, which is almost extinct from within settled boundaries of Pakistan, occurs in somewhat fair numbers in the Tribal Areas. The chakor, seesee and grey partridge are birds commonly found in the tracts.

The reed beds and tamarisk bushes along the rivers support hog deer and black partridge populations. However, due to occasional heavy floods their numbers have also been reduced. The Indus dolphin, fishing cat, and smooth otter are found in the Indus River waters below the Chashma Barrage. The gavial has become extinct in Pakistan. The crocodile is found in small numbers in lower Sindh. Wild boar numbers have increased because of the immunity they enjoy in a Muslim society that forbids its consumption by humans.

The animals found in the south-western mountains of Balochistan are: Sindh ibex, Chiltan markhor, straight horned markhor, wild sheep, leopard, marbled pole cat, Blandford's fox, chinkara, goitered gazelle and the marsh crocodile. The cheetah, is believed to be extinct and the Makran (baluchistan) bear critically endangered. The Houbara bustard (migratory), sandgrouse, black and grey partridges, and the chakor and see see partridges are also found here.

Irrigated forest plantations have emerged as the prevailing land use practice for the last 100 years. These ideally provide excellent habitat for chinkara, hog deer and blue bull. Forest

management does not cater to the needs of these wild animals. This, coupled with the poor implementation of laws has resulted in the extinction of species in the irrigated plantations. Due to habitat disturbances, the ungulates have failed to establish themselves, whereas the partridges have flourished well.

The striped hyena and the wolf are widely distributed in the sparsely populated parts of the country. However, information about them is scanty. Information about carnivores in general is difficult to obtain because of their nocturnal mode of life and high mobility. The black bear and brown bear populations are also not understood completely.

Birds of prey like the peregrine, cherrug or saker falcons, tawny eagle, imperial and greater spotted eagles, osprey, shikra, and the black-winged kite occur throughout Pakistan but their population statuses are unknown.

Pakistan's coastline of 1,050 km consists of a variety of habitat types, supporting a wide range of animals, of which over 1000 are fish species. Pakistan's marine flora and fauna have not been studied properly. Hence, detailed information on these species is deficient. Along the shores, there are four species of marine turtles: the ridley, green, leather back and hawksbill turtle, which are of high economic importance. Due to loss of habitat and human disturbances, their population is also decreasing.

About eight species of freshwater turtles are found in Pakistan. Sand lizards, monitors, geckos, agamas, diamond snakes, sand snakes, vipers, cobras, kraits and the famous Indian python constitute the other reptilian fauna.

Large water bodies in the country support a variety of waterfowl both resident and migratory. The extent of wetlands is constantly being changed. On one hand, swamps and marshes are being drained to reclaim land, whereas on the other hand, new dams (large water bodies) have been created for irrigation purposes. Canal irrigation through seepage has also contributed towards increasing the land area under water in the form of water logging. Such areas support a great number of waterfowl by providing them with an excellent habitat. The wetlands are one of the most important wintering areas and "green routes" of Asia. The important waterfowl in Pakistan are the ducks (mallard, pintail, shoveler, pochard, gargeny, ruddy shellduck, teals, tufted and gadwall), geese (grey lag, bar-headed), coots, flamingoes, pelicans, spoon bills, storks, ibises, plovers, curlews, sand pipers, snipes, and herons. The marbled teal and white-headed duck have decreased in number and now visit the wetlands infrequently. Among the waterfowl are (resident) gallinules, moorhens and rails, gulls, terns, water cock, grebes, cormorants, egrets, bitterns, and jakanas. The spot-billed lesser whistling teal and the cotton teal are resident ducks. A rich wader fauna visits the coastline during the winter.

Efforts have been made to document the status of wildlife and in some cases, the correct status is known, whereas most of the information about their populations is sketchy. With the strengthening of wildlife organisations in the country more reliable information can be obtained.

BIODIVERSITY IN PAKISTAN

Flora/Fauna	Number of Species		
	In World	In Pakistan	Endemic
Plants	25,000 to 75,000 species	6,000 species 5,000 wild)	372 species
Mammals	18 orders	10 orders	IndusDolphin. ChiltanMarkhor. Pakistan Sand Cat. SuleimanMarkhor. PunjabUrial. Baluchistan Bear.
	4,100 species	188 species of which: 63 rodents 39 carnivores 38 bats 25 hoofed animals 11 insectivores 9 aquatic animals, 3 primates,	

		1 pholidota	
Birds	8,600 species	666 migratory & resident species	
Reptiles	6,500 species	174 species of which : 88 lizards 72 snakes 10 turtles (2 marine, 8 freshwater) 2 tortoises 1 crocodile 1 Gavial	
Amphibians		16 species	
Fishes	2,600 species	525 species of which: 400 marine fish 125 freshwater species	
Insects/ Invertebrates	750,000 species	20,000 species 700 marine	

Written by Tahir Habib

DISTRIBUTION AND STATUS OF WILD LIFE OF PAKISTAN (BALOCHISTAN)

The Wild life of the Pakistan is mainly known different distribution notes representing zoogeographical observations appearing from time to time.

MAMMALS (MAMMALIAN FAUNA)

A. Wild Sheep and Goats:

1. Markhor (*Capra falconeri)*

Two varieties of Markhor (Goat) are distributed widely on Steep Mountain slopes of northern parts of Balochistan, Pakistan.

a) Suleiman Markhor (*Capra falconeri jerdoni*)

b) Chiltan Markhor (*Capra falconeri chialtanensis)*

Distribution of Chiltan Markhor (*Capra falconeri chialtanensis)* Chiltan Wild Goat or Chiltan Markhor has restricted distribution limited to Chiltan hills and is still challenge for the taxonomist. Massive hunting had reduced its numbers to less than 75 heads in 1960s. Chiltan National Park Hazargangi was created to provide protection to this endangered ungulate. Strict protective measures taken through the dedicated efforts of the National Park increased its number to about 300. **Distribution of Suleiman Markhor** (*Capra falconeri jerdoni)* Straight-horned Markhor or Suleiman Markhor has though a wider distribution throughout the Toba Kakar ranges along with hills around Quetta. Yet its status is largely endangered. The present reports (WWF) indicated that its population has riskily declined due to massive harvesting pressure. Now hardly an animals can be seen own in its previous strongholds.

2. Gazelle (Hiran)

There are two varieties of Gazelle are found in Pakistan.

a) Chinkara or Indian Gazelle (*Gazella bennettii*)

b) Goitered Gazelle (*Gazella subgutturosa)*

Chinkara or Indian Gazelle (*Gazella bennettii*)

3. Balochistan Urial (*Ovis orientalis blandfordi*)

Common Name: Wild Sheep

Distribution Balochistan Urial are distributed in all the mountains of the region with comparatively gentlers slopes through these are present now in small numbers in Toba Kakar ranges Maslakh, Chiltan hills, Takatu ranges of Quetta, Kharan and Makran areas. In 1995, it has estimated that some 2,500-3,000 heads are still surviving in this region. The specie is regarded as vulnerable in the region because of its competition with the grazing sheep and presence in small isolated populations.

4. Sindh-Ibex (*Capra aegagrus blythi*)

Common Name: Pahari Bakra or wild Goat

Distribution It is widely distributed in a comparative habitat condition in almost all the mount ranges present in southern parts of the Balochistan through the recent record suggested that its population is estimate in Kirthar national park (located north east of Karachi) is around 13,000.

B. PRIMATES Two varieties of Primates Monkey and Langur are distributed widely on Mountain slopes of the Pakistan.

a) Rhesus Macaque (*Macaca mulatta*)

b) Hanuman or Grey Langur (*Semnopithecus entellus*)

- **Rhesus Macaque** (*Macaca mulatta*) Common Name: Bandar

Distribution Rhesus monkeys are mainly found in the northern hill regions of Murree, Swat, Khagan, Azad Kashmir and Chitral. This animal occurs throughout the high hills of Hazara and Malakand civil divisions. It is also found in Sakra mountain range in Mardan civil division. They are also found in the Margalla Hills.

- **Hanuman or Grey Langur** (*Semnopithecus entellus*) Common Name: Langur

C. Lagomorph

Two species of the Lagomorph are still fairly common in suitable conditions of this region.

- **Cape hare** (*Lepus capensis*)

Identification Cape hares have a typical hare-like body shape with long ears, long well-developed hind legs, a short fluffy tail and a characteristic hopping gait. The body hair is fine and soft; the upperparts vary in color from light brown to black. Their coloration is so variable that it is difficult to give a precise description. The belly is white. The head is a lighter yellowish color on the nose and the cheeks. Most animals have a distinct white patch on the forehead just above the eyes. The tail is black above and white underneath. The females are larger and heavier than the males. **Distribution** It is widely distributed almost though out the Balochistan, especially in large patches in Nushki, Dalbandin and Chagai Districts of Balochistan. Further, it is also found in the Azad Kashmir.

- **Afghan Pika** (*Ochotona rufescens*)

Identification These lagomorphs are small and oval-shaped, with males and females similar in size and weight. Its body is generally grey and brown, with tinges of cream coloring during summer months and heavy brown fur in winter. Eyes are widely set to offer a broad field of vision. The average weight is less than 500 grams, while average length ranges from 4.7 to 11.8 inches. Ears are round and large for its body. In contrast, both its head and legs are short and its tail hardly visible. **Distribution** It is still fairly common in the high altitude of juniper forest of Ziarat Valley of Balochistan.

D. Wild Cats

In Pakistan, a number of wild cat are distributed in different region, although few has been discussed here: **Sand Cat** *(Felis margarita)*

Common Leopard *(Panthera pardus)* Common name: Guldar, Teendwa, Chita

- **Leopard Cat** *(Prionailurus bengalensis)* Common name: Chita Billi (Urdu

Distribution Leopard cats can live close to rural settlements, occasionally raiding poultry. In Pakistan this cat is found in the Murree hills and the Kaghan valley. It is also found in Azad Kashmir. Further west it is found in Swat, Dir, and lower Gilgit. It is also reported from Chitral in few numbers. Record about the overall population is unknown.

- **Common Leopard** *(Panthera pardus)* Common name: Guldar, Teendwa, Chita

Distribution The leopard is found in the Kirthar Mountain Range of Sind and the Toba Kakar, the Mekran and the Suleiman Range of Baluchistan. It is also found in the Kaghan valley and the Margalla Hills. In Azad Kashmir it is found around the hill ranges of Muzaffarabad and the Neelum Valley. Beside, the total population in Pakistan is unknown.

- **Snow Leopard or Ounce** *(Uncia uncia)*

Common name: Barfani Chita

Distribution In Pakistan the Snow Leopard is found in the high mountains of the Karakoram and the Hindukush. There are mainly found in Baltistan, Chitral, Gilgit, Upper Swat Valley and the Slopes of Nanga Parbat. The total population of the snow leopards in Pakistan is 100-200.

- **E. Wild Dogs**

In Pakistan, a number of wild cat are distributed in different region, although two verities are has been discussed here: **Red Fox** *(Vulpes vulpes)* Common name: Loomari

- **Bengal Fox** *(Vulpes bengalensis)*

Common name: Loomari

Name of Mammals	Common Name	Zoological Name
Wild Sheep and Goats:	Suleiman Markhor	*Capra falconeri jerdoni*
	Chiltan Markhor	*Capra falconeri chialtanensis*
	Chinkara or Indian	*Gazella bennettii*
	Goitered Gazelle	*Gazella subgutturosa*
	Balochistan Urial	*Ovis orientalis blandfordi*
	Sindh-Ibex	*Capra aegagrus blythi*
Primates	Rhesus Macaque	*Macaca mulatta*
	Grey Langur	*Semnopithecus entellus*
Lagomorph	Cape hare	*Lepus capensis*
	Afghan Pika	*Ochotona rufescens*
Wild Cats	Sand Cat	*Felis margarita*
	Leopard Cat	*Prionailurus bengalensis*
	Common Leopard	*Panthera pardus*
	Snow Leopard	*Uncia uncia*
Wild Dogs	Red Fox	*Vulpes vulpes*
	Bengal Fox	*Vulpes bengalensis*

MAMMALIAN FAUNA OF BALOCHISTAN

Sr. Nos	Species	Common name	Preferred Habitat	IUCN Status
1	*Crossodura zarudnyi*	Desert shrew	Dry beds with vegetation	Lower Risk (lc)
2	*Paraechinus hypomelas*	Migratory Hedgehog	Around the human settlements	Lower Risk (lc)
3	*Hemiechinus collaris*	Hedgehog	Small dry Hillocks near patches of vegetation	Lower Risk (lc)
4	*Pipisttrellus kuhlii*	Kuhl's Pipistrelle	Agricultural areas	Lower Risk (lc)
5	*Canis lupus*	Indian wolf	Hilly tracts	Lower Risk (lc)
6	*Canis aureus*	Asiatic Jackal	Agricultural areas near settlements	Lower Risk (lc)
7	*Felis margarita*	Sand Cat	Sand dune areas	Near Threatened
8	*Vulpes rueppelli*	Sand Fox	Sand dune areas	Data Deficient (DD)
9	*Vulpes vulpes*	Common Red Fox	Hilly tracts	Lower Risk (lc)
10	*Vulpes cana*	King Fox	Hilly areas around the settlements	Data Deficient (DD)
11	*Gazella subgutterosa*	Goitred Gazelle	Narrow valleys in barren mountain ranges	Endangered
12	*Lepus capensis*	Cape hare	Vegetation patches along dry rivulets	Lower Risk (lc)
13	*Salpingotus*	Balochistan	Sand dune areas	Lower Risk (lc)

MAMMALS & BIRDS IN HINGOL PARK (BALOCHISTAN)

Mammals in the park include Sindh Leopard, Indian Fox, Jungle Cat, Jackals, Sind Wild Goat, Blandford's Urial, Chinkara Gazelle, Honey Badger, Indian Pangolin, Hedgehog, Porcupine, Indian Grey Mongoose, Cairo Spiny mouse and the Rock Mouse. As for the birds, Houbara Bustard, Dalmatian and Spot-billed Pelican, Lagger Falcon, Red-headed merlin, Kestrel, Grey Partridge, See See Partridge, , Eagle owl , Sind pied woodpecker, Hume's chat, Brown rock pipit, Striped Buning, Finche Larks, Hoopoe, Shrikes and Wheatears. Beside Bonnelli's, Imperial Tawny and Golden Eagle are also found here. There are three varieties of vultures, namely Eurasian Griffon Vulture, Egyptian Vulture and the Cinereous Vulture. As for sand

grouse, there are many varieties like Stone Curlew, Indian, Coroneted, Painted and Close-Barred Sand Grouse.

REPTILES (REPTILIAN FAUNA) In the wild fauna of Reptilian possesses about one species of crocodilian, two chelonian, 72 snakes and 63 species of lizards. There are many species of sea snakes in coastal areas of Balochistan.

1. Marsh Crocodile (*Crocodylus palustris*) Common Name: Mugger Much

Distribution Out of three species of crocodilian in Indian Sub-Continent, only one known as mugger or marsh crocodile is found in Pakistan. The major population of crocodiles is found in Sanghar, Khairpur and Nawabshah districts in Sindh while in Balochistan in four major rivers including Dasht, Hingol, Nari and Hub. Overall more than five hundred species has been reported from Sindh and Balochistan Provinces.

2. Green Sea Turtle (*Chelonia mydas japonica)*
Common Name: Sabaz Kachwa

3. Lizards:
Overall, 63 species are found in Pakistan; Two varieties of lizards are widely distributed i.e. Monitor Lizard and Spiny Tail Lizard are more common in Pakistan.
a. Monitor Lizard (Varanus)
Common name: Goa

4. Snakes

Snakes can be divided into two categories one is poisonous and other is non-poisonous. Moreover, due to their distribution they are further classified into as Terrestrial and Sea snakes. There are around 55 species of sea snakes, which are found in the seas of the world but in the coastal waters of Pakistan, only 14 species have so far been recorded. In Pakistan, total of the 72 snake species are found and 12 terrestrial snake species are poisonous. Most common snakes are Bengarus, pit viper, leafnose viper, viper labitina etc.

A. Non-poisonous Terrestrial Snake
Indian Python (*Python molurus*) Common name: Azdaha

B. Poisonous Terrestrial Snake
Indian or Spectacled Cobra (*Naja naja*) Common name: Sheesh Nag, Kala Nag.

Distribution: *N.n.naja* is found In Sindh, Balochistan and Punjab (Usually absent at desert or rainforest area). *N.n.oxiana* is rare in Pakistan and restricted in few places of Balochistan and KPK.

Reptiles of Pakistan

Name of Reptiles	Common Name	Zoological Name
Crocodile	Marsh Crocodile	*Crocodylus palustris*
Turtle	Green Sea Turtle	*Chelonia mydas japonica*
Lizard	Monitor Lizard	Varanus Monitor
	Spiny Tailed Lizard	*Uromastix harwichii*
Non-poisonous Terrestrial Snake	Indian Python	*Python molurus*
Poisonous Terrestrial Snake	Indian or Spectacled Cobra	*Naja naja* *naja naja naja* *naja naja oxiana*
Sea Snakes	Persian Gulf sea snake Toothed sea snake Yellow Sea Snake Common small headed sea snake	Nil

BIRDS

(Avian Fauna) The avifauna of Pakistan includes more than 700 species, of which 39 are rare or accidental. A great variety of bird species exploit the area either as residents or migrants. This famous route from Siberia to various destinations in Pakistan over Karakorum, Hindu Kush, and Suleiman Ranges along Indus River down to the delta is known as International Migratory Bird Route Number 4. It is also called as the **Green Route** or more commonly **Indus Flyway**. The birds start on this route in November. February is the peak time and by March they start flying back home. These periods may vary depending upon weather conditions in Siberia and or Pakistan. Here three verities of migratory and three residents birds are discussed.

1. Siberian Crane (*Grus leucogeranus*) Common name: Safed Koonj

Distribution Due to over hunting limited population of Siberians is reported annually in the Sindh province. It is declared as endangered species by WWF and Wild life department of Pakistan.

2. Houbara Bustard (*Chlamydotis undulate*)
Common Name: Tiloor
Distribution This migratory bird arrives every year in Pakistan in November and December from Mongolia, Siberia and central Asian republics. Besides, its population is rapidly declining in Pakistan. Overall, population estimation has not been recorded in last 5 years. Although their breeding is take place in different areas of Pakistan especially funded by Arabs in Punjab and Balochistan.

3. Saker Falcons (*Falco cherrug*)
Common Name: Charagh

4. Chakor (*Alectoris chukar)*
Common Name: Chakor

Avian Fauna of Pakistan

Name of Birds	Common Name	Zoological Name
Siberian Crane	Safed Koonj	*Grus leucogeranus*
Houbara Bustard	Tiloor	*Chlamydotis undulate*
Saker Falcons	Charagh	*Falco cherrug*
Shaheen Falcon	Shaheen	*Falco peregrinus peregrinator*
Chakor	Chakor	*Alectoris chukar*
Grey Francolin	Teetar	*Francolinus pondicerianus*

Fishes Fauna of Pakistan

Fishes	Common Name	Zoological Name
Marine water Fishes	Great Hammer Head Shark	*Canis aureus*
	Spanish Mackeral	*Scomberomorus maculatus*
	Swordfish	*Xiphias gladius*
Fresh Water Fishes	Golden Mahseer	*Tor putitora*
	Rohu	*Labeo rohita*
	Indian Carp	*Catla catla*

Avian Fauna of Pakistan

Name of Birds	Common Name	Zoological Name
Siberian Crane	Safed Koonj	*Grus leucogeranus*
Houbara Bustard	Tiloor	*Chlamydotis undulate*
Saker Falcons	Charagh	*Falco cherrug*
Shaheen Falcon	Shaheen	*Falco peregrinus peregrinator*
Chakor	Chakor	*Alectoris chukar*
Grey Francolin	Teetar	*Francolinus pondicerianus*

National Symbols

Title	Symbols
National Animal	Markhor
State Animal	Snow Leopard
National Bird	Chukar
State Bird	Shaheen
National Aquatic Animal	Indus River dolphin
National Fish	Mahseer
National Reptile	Mugger Crocodile
National Amphibian	Indus Valley Toad

WILD LIFE RULES AND REGULATION IN PAKISTAN OR CONSERVATION STRATEGIES OF WILDLIFE IN PAKISTAN

During the British rule about a century ago a criminal procedure code 1898, banned the killing or injury to any animal. By the twentieth century British government improve the wild bird and animal protection act 1912. This act was further improved in 1940. The British wild bird and animal protection act 1940 was updated again in 1959 and followed as "the west Pakistan wildlife protection Ordinance". Later Government of Pakistan constituted National Council for Conservation of wild life in 1974 to formulate policies, coordination and promote their implementation and collaborate with all province non-government societies and international agencies for conservation of wildlife. National council helped the provincial and Federal government in formulation of rules and regulation of wildlife protection, preservation conservation and management act. **Wild life Acts** Following acts have been enforced in all provinces including Azad Kashmir and Northern areas.

1. The Sind Wildlife Protection ordinance, 1972.

2. The K.P.K Wildlife Protection act 1975-1977.

3. The Punjab Wildlife act and rule, 1974.

4. Northern Areas wildlife Preservation act, 1975.

5. Azad Jammu and Kashmir wildlife Rules 1985.

6. Balochistan Wildlife act 1974-1975.

Silent Feature of the Act

1. **Killing or Hunting wildlife:** No person shall kill or possess any wild bird animal or meat trophy thereof, or attempt to kill except a permit of Government Rule.

2. **License:** No person shall use hawks for hawking or dogs not be possessed for killing wild birds or animals without special license.

3. **Wild animal is Government Property:** Any dead animal or dying or which has been killed, its meat and trophy will be the government property.

4. **Ban on animal transfer:** Restriction of the transfer of the animals, trophies or meat to other countries or inside the country. Same in the manner persons are not allowed to receive the trophy, meat as a gift without prior license.

5. **Sanctuary:** Government may, by notification in the official Gazette, declare any area to be wild life sanctuary and may demarcate it in such manner as may be prescribed.

6. **National Park:** With view to the protection and preservation of scenery, flora and fauna in natural state, government can declare any area as National Park .

7. **Game Reserve:** The Government may declare any area to be a Game Reserve, where hunting, shooting any wild bird or animals in the first schedule except under a special permit is prohibited.

8. **Punishment:** Violation of any wildlife rule shall be punished with custody of about one year with a specific amount as a fee punishment to be punished.

9. **Management Board:** Government shall establish wild life management board which is consists of a chairman and other members.

10. **Self Defence:** For any person to kill any wild animal by any means in the immediate defence of his own life or that of any other person. It shall not be an offence.

11. **Officer Violation:** An abetment (violation) of any offence under the act should be banished.

12. **Authority of Wildlife Officer:** An officer has the authority to arrest any person without orders from a Magistrate and without a warrant, arrest any person against whom found guilty to violet or breaks the laws. Officer has also the power to issue a search warrant under the court of criminal procedure 1898 (Act V-1898)

13. **Special Killing:** In the interest of scientific or public purpose government can allow killing or capturing of wild animals.

14. **Revise the Rules:** Government make rules or revise rules from time to time to carry out the provision into effect in this ordinance.

Along with these rules three schedules have been issued which are as under;

1. **Schedule I:** It include list of animals which may be hunted on an ordinary shooting license with the beg limit per day. No animal can be hunted during breeding season.

2. **Schedule II:** It include list of animals for the control of transfer or export of which from the respective provinces require certificate of lawful possession (control).

3. **Schedule III:** It includes list of those animals which are protected and neither the can be killed nor be captured.

Provisional Rule: The provisional Governments have also formulated rules as

1. Hunting fee for ordinary shooting license, generally for birds and small game is Rs. 1000 per anum.
2. Hunting fee for schedule hunting permit for big game in Rs. 500/= per anum (Annual).
3. Hunting fee for single animal per head i.e.

a. Maricopa Sheep (Mountain Goat) is Rs. 40,000/= each animals.
b. Himalayan Ibex Rs. 3,000/=
c. Markhor Rs. 20,000/=

Although fully restriction or hunting of animals like Markhor is banned in Balochistan.

PHILOSOPHY OF WILD LIFE CONSERVATION OR IMPORTANCE OF WILD LIFE CONSERVATION OR MULTIPLE USE OF THE WILDLIFE.

Wildlife is beneficial to the nation as a whole and to the member of public, individually in many ways. The term wildlife is used with reference to mammals, birds and reptiles having values of food, sport, fur, skin, trade etc. Conservation of wild life is necessary because of the following reasons.

1. Balance in Nature

Wild life is an important part of an ecosystem with which man himself as animal interrelated and interdependent for his survival. It plays a significant role in food chain be converting plant material into meat which is an important source of protein. The wild life help us in maintaining the balance of nature e.g. the destruction of carnivores life lion, tiger, jackals etc would only increase the number of herbivores which may eat up most of the vegetation.

2. Aesthetic values

The wildlife has an excellent aesthetic value. The richness variety and fascination of life on this planet diminish with every space that disappears. When wild specie becomes extinct every one of us suffers as aesthetic loss. Without Chinkara, Markhor and beautiful snow leopard, these are the things which really matter in life and the thing of beauty of them appeal to the mind

3. Scientific Values

Wildlife provides gene pool for improvement in domesticated species of livestock, poultry and crops for higher production and efficiency. The wild flora and fauna are such source of genes which can be used in breeding new forms of plants and animals for characters life disease resistance, faster rate of growth, higher yield and other ecological amplitude. Some wildlife species act as biological controller against insects and vertebrate pests of crops and forests. Many wildlife species help in keeping the environment clean by acting as scavenger i.e. crows, eagles, vultures etc.

4. Economic Values

Proper management of wildlife can bring economic returns through sport hunting, trade and tourism. It helps ruler economy by generating jobs opportunities. We can strengthen our economy by the breeding of different animals. Beside, France and Switzerland are the countries which are at the peak in the import of the Wildlife. In Kenya wildlife ranks the third industry after coffee. By controlled management and conservation techniques we can get food, fur musk, skin and valuable trophies from wildlife.

5. Food Values

All game mammals and birds as well as wild fishes are a valuable source of food supply in the form of meat, egg and fishes for human beings.

6. Cultural values

Wildlife tourism helps in establishing relationships among people at national and international level. It thus introduces the local culture and traditions to the outer world.

7. Sport and recreational values

Wildlife provides best means of sport and recreation. The beautiful life animals and birds and their voice aids in the beauty of nature and thus in a source of attraction for anesthetists.

8. Shooting

Shooting and fishing are useful source of income for the state as income from the import of arms, ammunition, fees from gun license and fishing permits.

9. Plant helper

Wildlife animals and birds are also a source of pollination and seed dispersal of many valuable plants and trees.

10. Public interest

Less fertilizer soil can be made beneficial by using it for wildlife purposes that is fees constructing zoos, wildlife parks, sanctuaries etc.

Overall, we can say that In Zoological point of view wildlife is an important element because without wildlife the subject of Zoology will be irrelevant.

WILDLIFE CONSERVATION OR EXTINCTION OF WILDLIFE

Wildlife conservation is the practice of protecting endangered plant and animal species and their habitats. The primary goal of wildlife conservation is to ensure that nature will be around for future generations to enjoy and to recognize the importance of wildlife and wilderness lands to humans. Around the globe many different agencies are working under government polices to help to implement the policies for the protection of wild life. Beside numerous independent nonprofit organizations also promote various wildlife conservation causes. Wildlife conservation has become an increasingly important practice due to the negative effects of human activity on wildlife. The science of conservation biology plays a part in wildlife conservation. The ethic of conservation, in addition to lobbying by conservationists, has made it an important environmental issue. **Major threats to wildlife (biodiversity)** Major threats to wildlife can be categorized as below:

1. **Deforestation:** Destruction of forests for want of timber, fuel and inhibition is the main sources of extinction of wildlife forest are actually the natural home of animals.

2. **Spot hunting and poaching:** Hunting for fur has led to extinction of some animals since long time e.g. tigers, lions etc are killed for spots only.

3. **Hunting for food:** The herbivore animals are indiscriminately destroyed for want of meat e.g. birds, deer, wild cows etc.

4. **Climate change:** Animals required specific environment, climate change could cause disastrous loss of wildlife species. Wildlife is sensitive to moisture change so, they will be harmed by any change in moisture level.

5. **Pesticides and toxic chemical:** Widely used, making the environment toxic to certain plants, insects, and rodents.

6. **Natural phenomena:** due to natural disasters like Floods, earthquakes, volcanoes, lightning, forest fires can be affected to decline the numbers of wildlife.

7. **Pollution:** Pollutants released into the environment can cause diseases in animals to cause a decrease in the number of a wide variety of organisms.

8. **Over-exploitation of resources:** Exploitation of wild populations for food has resulted in population crashes (over-fishing, for example).

9. **Accidental deaths:** Few wildlife species can lead to death due to different accidental condition like car collisions, air collisions (birds), collisions with ships (whales), etc.

Conservative measures for Wildlife The extinction of our resources, forest is wildlife is not only disturbing the integral part of our ecosystem bit also snatching from us the natural glories. So our main task is to conserve and protect the biotic communities of plants and animals. The following methods shall be enforced in this regard.

1. Checking of the deforestation: Forest should be conserved and extended, because they provide shelter and source and food for wildlife.

2. Conservation of soil: It includes soil erosion, control, plantation and preservation.

3. Zoological Garden: It should be built on natural environment to build the areas.

4. Extensive Research: Research should be conducted to get better understanding of animals to preserve their natural habitat.

5. Awareness plans: Workshop, exhibition and seminar for public awareness should be arranged for the protection and conservation of animals.

WILDLIFE MANAGEMENT

Wildlife management is term very often used by the environmentalists all around the globe and Aldo Leopold was the pioneers of wildlife management. The best way to define wildlife management would be to say that "wildlife management is all about finding the balance between the needs of wildlife and the needs of people by using different scientific methods". Wildlife management is these days mostly focused on wildlife conservation, and this requires help of many other scientific disciplines such as chemistry, biology, ecology, climatology and geography to get the best possible results.

Major Goals of the Wildlife Management

1. halt the loss of Earth's biodiversity

Biodiversity loss is huge problem around the globe, and we already know many plants are at the brink of the extinction. To halt the loss of earth's biodiversity can be manage through ecological principles like geography, pedology (soil study), hydrology, succession etc.

2. Reinstatement of the habitat

Many animals are in trouble due to habitat loss, and some are threatened with the invasive species. Improving animal habitat is the key to success and this can be achieved with several different techniques such as reforestation, pest control, nitrification and denitrification, irrigation, hedge laying, etc.

3. Balance Between Species

Wildlife management also needs to find balance between the species, and ensure the perfect food chain functioning. Achieving this delicate balance sometimes even involves using certain unpopular methods such as hunting and culling that are criticized by environmentalists.

4. Management Units

Wildlife management is multidimensional task that needs to view things from many different perspectives before choosing the perfect technique for given wildlife habitat. This makes wildlife management very complex science, which makes things very

5. Farmer subside

In UK, government has given the former subsides (improvement of the farmland) through developing the Countryside Stewardship Scheme. This scheme is based on the restoring and recreating traditional walls and ditches (making holes in the land), wildlife corridors in arable areas using uncropped margins in arable fields for maintaining and increasing biodiversity).

6. Wildlife Act

Legislation has also been passed to protect the animals like the Wildlife act of Pakistan 1973 and Wildlife and countryside act of UK 1981.

7. Game keeping

Game keeping includes the killing of animals which share the common niches or to kill the predators to maintain a high population of the more profitable species, such as pheasants. Game keeping is performed by Game keeper in the globe.

8. Pest Control

Pest control is used to control the pests which have diverse affect on the economy, human health and ecology. Pest control is at least as old as agriculture. A number of pest control techniques are used like field burning, traps, fumigation etc. Among all the types and verities of the pest control the Biological Control is the most save method to active the goal without harming the environment e.g. different bacterial colonies are used to control the mosquito larva to grow.