process of using chromosomes in taxonomy.

Karyotypes within interbreeding populations of a species are usually constant. Between species there may be variation in chromosome number and size. Final stages of chromosomal aberrations such as inversions and translocations can give clues regarding intermediary stages.

1.1.4 Chemotaxonomy

Chemotaxonomy refers to the use of information about small molecules produced by the action of enzymes. Protein fractions in electrophoretic techniques, identification of amino acids in chromatography, prevalence of isoenzymes in tissue materials are all tools employed in chemotaxonomy. The occurrence of specific pheromones, colour pigments, toxins also help as keys in taxonomy.

1.1.5 Palaeotaxonomy

This method depends on identification and dating of fossils. Availability of a good complete fossil provides better chance for identification. In several fossils, their sections taken through laboratory processes have provided the identification features.

The fossils are normally studied along with other accompanying fossils, its geographic location and other factors. Even though it is possible to assign a fossil to a genus or other higher level, fixing the species is not always possible.

1.1.6 Nomenclature methods

Nomenclature forms the basis by which scientists can name and cross refer to organisms. It is an integral part of taxonomy. In fact, modern taxonomy started in 1753 with the publication of first part of ***Systema*** by **Linnaeus**. According to Linnaeus a Species is specified by the combination of both its specific and generic names. Since it requires two names, it is referred to as the **binomial system**. This system is now firmly established in Biology.

In modern times International Commissions are responsible for naming each major group of organisms. There are several such commissions. These commissions authorize the usage of scientific names in biology. Naming of animals is monitored by **International Code of Zoological Nomenclature** (ICZN) (International Commission of Zoological Nomenclature, 1985).

The rules are set out in the ‘codes’. The codes are modified by occasional science congresses.

The key may be either **bracketed** or **indented**. In a **bracketed key** alternative contrastive characters are used for identification. The number on the right side indicates the next alternative character for consideration.

In an **indented key** a series of choices are provided for identifying a taxon. The user should choose from among the choices.

The following examples provide the keys for identification four species of frogs in Tamil Nadu, namely ***Rana hexadactyla***, ***R. tigrina***, ***R. cyanophlictis*** and ***R. limnochoris***.

The Bracketed key (Genus : Rana)

(1) Large size, snout - vent 100 - 200mm 3

(1) Small size,snout to vent less than 100 mm 2

(2) Pointed snout ....***R. limnochoris***

(2) Obtusely pointed snout ....***R. hexadactyla***

(3) 4th toe longer than others .....***R. tigrina***

(3) 4th toe not longer .... ***R. cyanophlictis***.

The Indented key (Genus : Rana)

Large sized body

skin smooth ..... ***R.hexadactyla***

skin with folds ..... ***R. tigrina***

Small size

blunt snout ..... ***R. cyanophlictis***

pointed or round snout ..... ***R. limnochoris***

1.2 Animal groups

1.2.1 Methods of grouping animals

There are several ways of grouping animals. In all these methods the basic Taxon remains without any change. However the taxa are rearranged in different groups. All these groupings are mostly provided for the convenience in identifying similar taxa.

I. One of the earliest method of grouping the animals could be dividing the Animal kingdom into two assemblages called **Invertebrata** and **Vertebrata**.

1. All of them have three layers in the body wall. They are named as outer ectoderm, middle mesoderm, and inner endoderm. Thus they are called as ***Triploblastic*** *animals.*

2. The body is bilaterally symmetrical.

Phylum: Platyhelminthes :-

This phylum includes flatworms. These are acoelomates, without a body cavity called **coelom**. The alimentary canal is either absent or very simple. Excretion and osmoregulation occur through **flame cells**.These worms are mostly hermophrodites, having both male and female reproductive organs in a single individual. Most of the members are parasites. It is divided into three classes, namely **Turbellaria**, **Trematoda** and **Cestoda**.

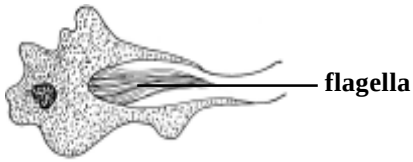


Fig. 1.2.7 A flame cell

Class Turbellaria :- These are free living aquatic flatworms. The Planaria of this class shows characteristic regeneration.

Class Trematoda :- These are flukes living as parasites inside a host (endoparasites). A protective **cuticle** covers the outer surface of the body. Flukes have **suckers** for attachment to the host tissues. The examples are ***Fasciola*** (liver fluke), ***Schistosoma*** (blood fluke).

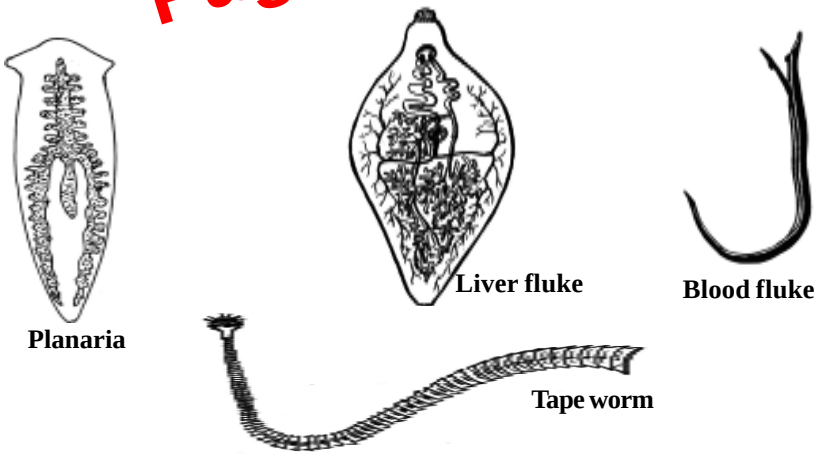


Fig. 1.2.8 Platyhelminth worms

2. Dorsal tubular nerve cord

The nerve cord lies just above the notochord and remains entirely outside the coelom. It is a tubular structure having a small hollow canal running from one end to the other. The dorsal hollow nerve cord persits throughout the adult life of almost all chordates.

3. Gill slits or Pharyngeal clefts

These are paired lateral clefts leading from the pharynx to the exterior. They are present throughout life in fishes and a few tailed amphibians. In amphibians, like frogs and toads it is found only in the larval stages. In higher vertebrates (reptiles, birds and mammals) they are embryonic and non-functional.

4. Ventral heart

The heart is chambered. It is located ventral to the alimentary canal.

5. Closed blood vascular system

In chordates, the blood passes through a continuous system of tubes namely arteries, capillaries and veins.

6. Hepatic portal system

In chordates, the food laden blood from the digestive tract passes through the capillary network in the liver, before reaching the heart. Thus the veins originating from the digestive tract as capillaries and ending in the liver again as capillaries constitute the hepatic portal system.

Classification.

The Phylum Chordata is classified into four sub phyla:

Sub phylum 1. Hemichordata,

Sub phylum 2. Cephalochordata

Sub phylum 3. Urochordata

Sub phylum 4. Vertebrata.

First three sub phyla are collectively known as **Protochordates**. Since the members of these sub phyla do not have a cranium or skull they are also referred to as **Acrania**.

The sub phylum vertebrata may be classified into two groups (i) **Pisces** and (ii). **Tetrapoda**.

Class : Pisces

Fishes are **poikilothermic**, aquatic vertebrates with jaws. The body is streamlined. It is differentiated into head, trunk and tail. Between head and trunk, the neck is absent. Locomotion is effected by **paired** and **median fins**.

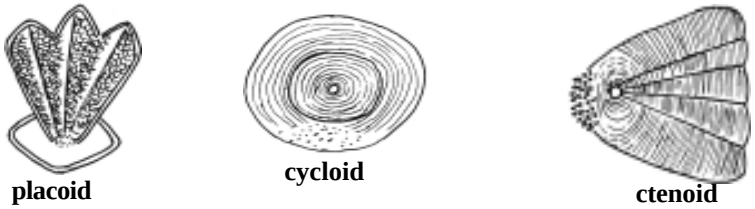


Fig. 1.2.22 Scales

The body has a covering of **scales**. They are of various types like **placoid**, **cycloid**, **ctenoid** and **ganoid** scales. The body muscles are arranged into segments called **myotomes**.

The Alimentary canal consists of a distinct **stomach** and **pancreas** and terminates into **cloaca** or **anus**. Respiration is performed by **gills**. Gill slits are 5-7 pairs. They may be naked or covered by an **operculum**. The **heart** is two chambered (an auricle and a ventricle).

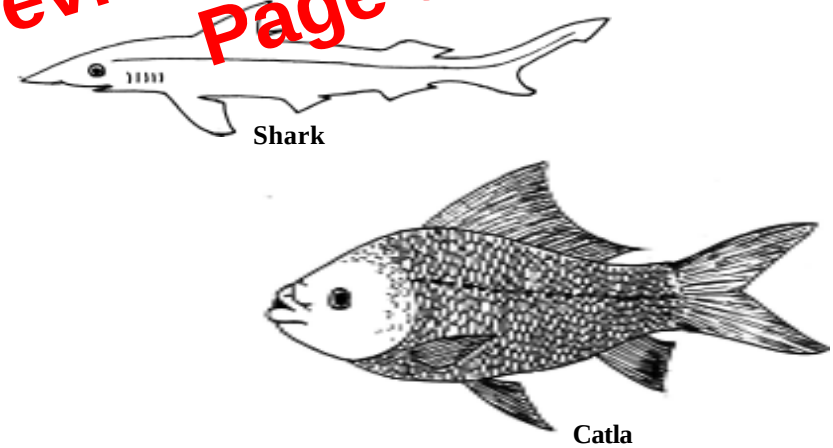


Fig. 1.2.23 Fishes

Pre-erythrocytic cycle:

The pre-erythrocytic cycle comprises the asexual reproduction of the parasite in the liver. When an infected female Anopheles mosquito bites a person, thousands of slender, sickle shaped nucleated **sporozoites** are injected in the blood. The sporozoites first enter the capillary vessels of the skin and then enter the general circulation. These parasites circulate in the blood for about 30 minutes and enter into the pre-erythrocytic cycle in the **reticuloendothelial cells** of the **liver**.

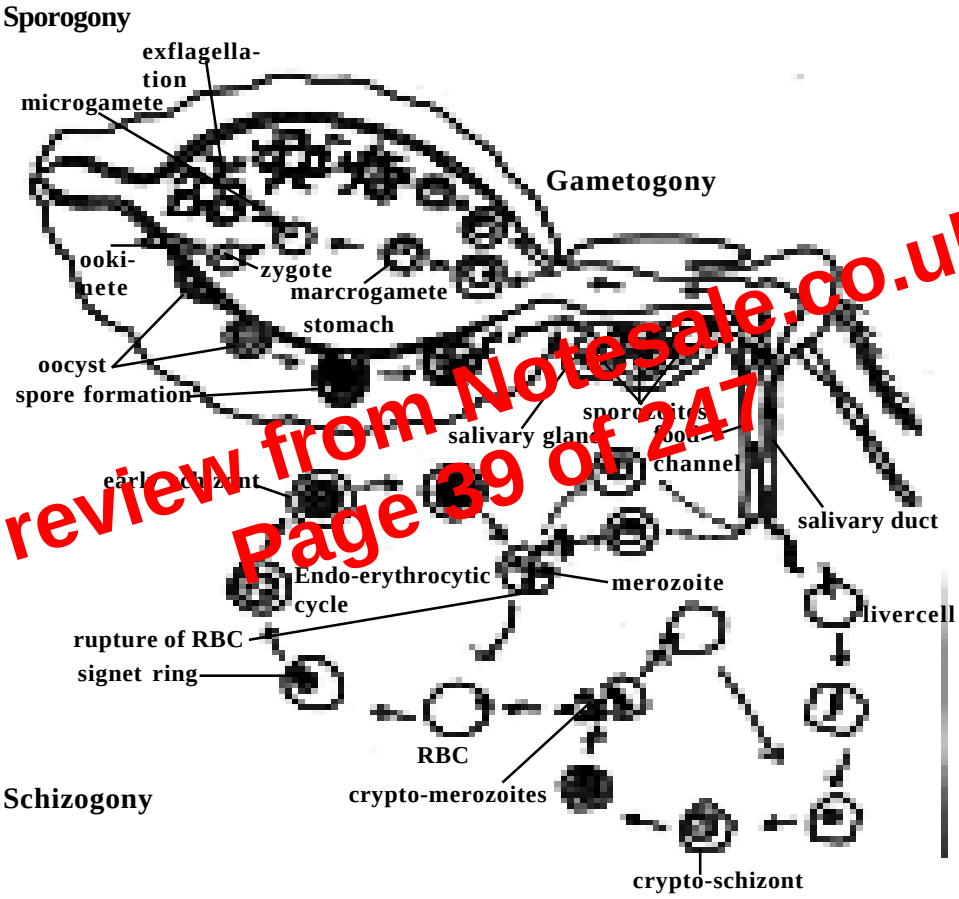


Fig. 1.3.1 Life cycle of malarial parasite

The sporozoites penetrate the liver cells and develop into forms known as **cryptozoites**. A cryptozoite has a compact nucleus and no pigment or

febrile condition in man is due to toxins liberated into the blood along with the merozoites when the corpuscle is ruptured at the end of schizogony.

There are four species of ***Plasmodium*** known to cause malaria in man. The commonest and most widely distributed species is ***P. vivax*.** It causes **benign tertian malaria** in which the fever recurs every third day (every 48 hours). ***P.falciparum*** is largely limited to the tropics and subtropics and causes the **malignant tertian** or **subtertian malaria.** This type of malaria has a high death rate. Blood corpuscle parasitised by this species tend to clump together and block up small blood vessels and damage the essential organs. It is a dangerous species and the disease often appears in an epidemic scale. ***P. malariae*** causes **quartan malaria** with feverish fits every fourth day (every 72 hours). The fourth species is ***P. ovale.*** It is principally found in west Africa but occassionally in S. America, Russia and Palestine. It causes **benign tertian malaria** in which the fever recurs every third day (every 48 hours).

These four species differ from each other in the details of structure, time needed to complete the schiogzony, the incubation period, number of merozoites released and duration of sexual cycle.

Control of Malaria

The control measures fall under the following three categories.

Treatment of infected patient

(1) Plasmodium does not produce antitoxins or antibodies in human blood. Therefore malaria cannot be treated by inoculation or vaccination with immune sera. It can only be treated with drugs that may kill all stages of the parasite without poisoning the patient.**Quinine**, which is extracted from the bark of **cinchona** trees, had been used effectively for the past 300 years to cure malaria. The various synthetic drugs, such as Paludrine, Atabrin, Camoquin, Chloroquine, Resochin, Pamaquin etc are used as suppressants of various stages of the parasites.

(2) **Prevention of infection** :

It can be effected in two ways.

(i) using protective measures such as mosquito nets, anti-mosquito creams (repellants) and coils.

(ii) use of the prophylactic drugs; small daily dose of anti-malarial drugs will kill the parasite either in the sporozoite or merozoite stage.

(3) **Control of vector**

It is perfectly clear that if the vector is completely exterminated the infection cannot be transmitted from one person to another. It is the most effective and surest way of controlling malaria. It is achieved by using effective insecticides and by draining swamps. It destroys the breeding places of mosquitoes.

Adult mosquito can be most effectively controlled by spraying DDT, malathion or any other insecticide in the houses; fumigating pyrethrum cresol and other compounds of naptha; sterilization of male mosquitoes. The young stages of mosquito can be controlled by introducing larvivorous fishes like Gambusia and Lebistes in ponds, lakes, canals and tanks.

Type study - 2. Earthworm

Phylum - **Annelida**

Class - **Chaetopoda**

Order - **Oligochaeta**

Type - ***Lampito mauritii***

Earthworms are nocturnal animals. They lie in the burrows during the day and come out at night for food. Earthworms leave the burrow only during the rainy season when their burrows are flooded with water.

External features

Lampito (Megascolex) ***mauritii*** is a common earthworm found in South India. The body is long, slender, cylindical and bliaterally symmetrical. It is about 8 to 21 cm long and 3 to 4 mm in thickness. The dorsal surface is dark purplish brown, and the ventral surface is paler in colour. It is marked by a series of segments. The segments are separated from one another by intersegmental grooves. The division is both external and internal. Inside the body, each cavity of the segment is separated from the next, by a thin partition called the **septum**. All the segments look alike. This kind of repetitive arrangement of the segments is called **metamerism**.

The **mouth** is found in the centre of the first segment of the body, called the **peristomium**. Overhanging the mouth is a small flap called the **upperlip** or **prostomium**. The last segment has the anus. It is called the **pygidium**. In mature worms, segments 14 to 17 may be found swollen with a glandular thickening of the skin called **clitellum**.

essential for respiration. The coelomic cavity communicates to the exterior through reproductive and excretory apertures. The germ cells are budded off from the wall of this cavity.

Locomotion :

Earthworms move about by contraction and expansion of its body wall. When the circular muscles of the body wall contract, the body becomes thin and elongated. This process results in the forward extension of the body. Then it fixes itself firmly to the ground with help of the body setae and mouth. Subsequently when the longitudinal muscles contract, the body becomes thick and shortened. As a result, the body is drawn forward towards the anterior end which is already fixed to the ground. Thus by a repeated process of alternate contraction and expansion of muscular body wall locomotion is effected.

Digestive System :

The digestive system runs as a straight tube from mouth to anus. The **mouth** is situated in the first segment. The mouth opens into the **buccal cavity** which occupies segments 1 and 2. The buccal cavity in turn leads into a thick muscular **Pharynx**. The pharynx occupies segments 3 and 4 and is surrounded by the **pharyngeal glands.** The oesophagus is a short narrow tube lying in 5th segment. It leads into the gizzard lying in the 6th segment. Its inner surface has a chitinous lining. The intestine is a large tube extending from the gizzard to the anus. The intestine upto the 14th segment is narrow and the remaining part is sacculated. The dorsal wall of the intestine is folded into the cavity as the **typhlosole**. This fold contains blood vessels. It increases the absorptive area of the intestine. The inner epithelium consits of columnar cells and glandular cells.

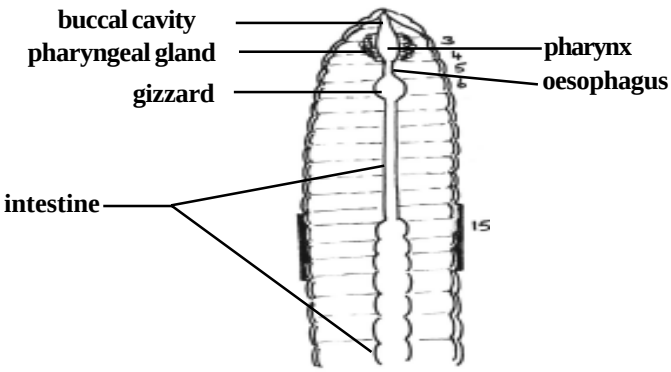


Fig. 1.3.4. Earthworm-Digestive system

deferens. The secretion of the prostate glands help to arrange the sperms into bundles called **spermatophores**.

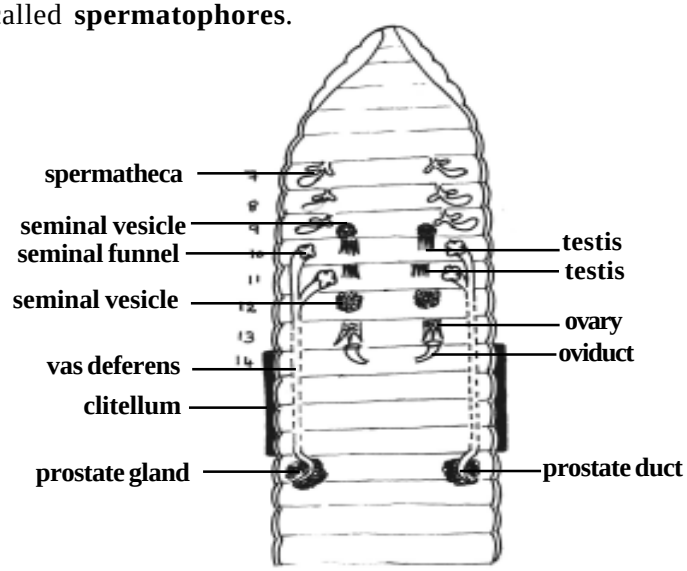


Fig. 1.3.8. Earthworm - Reproductive system

Female reproductive organs.

A pair of **ovaries** are found lying in segment 13. They are attached to the anterior septum of the 13th segment. Each ovary is a flat structure with a number of finger like processes. The ova are arranged in a linear order in the ovaries. There are a pair of **oviducts**. They open internally into the 13th segment and externally on the ventral surface of the 14th segment. Three pairs of **spermathecae** are present in segments 7, 8 and 9. These external openings are situated in the intersegmental grooves of segments 6 and 7, 7 and 8, and 8 and 9. The spermatozoa received from another individual during copulation are stored in **spermathecae** .

Copulation :

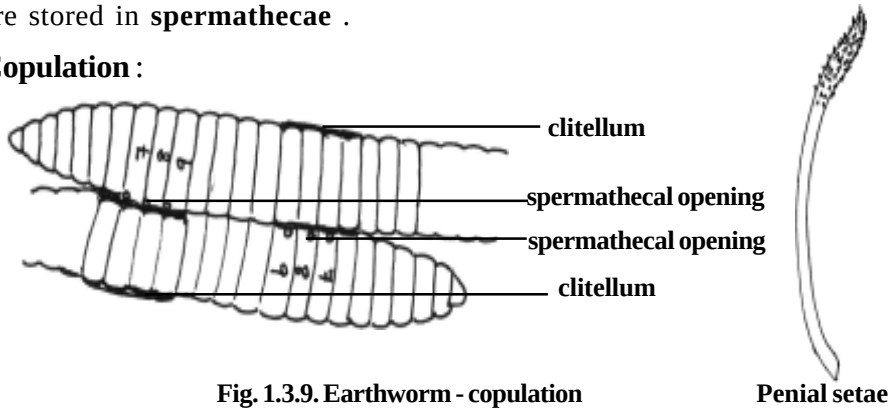


Fig. 1.3.9. Earthworm - copulation

During copulation the head ends of the two worms are directed in the opposite directions and the clitellum of one worm is opposite to the spermathecal segments of the other. The spermatozoa of one worm pass into the spermathecae of the other worms. The worms separate after the mutual exchange of spermatozoa.

Later the glandular cells of the clitellum secrete a thick fluid which hardens into a **girdle** surrounding the clitellum.

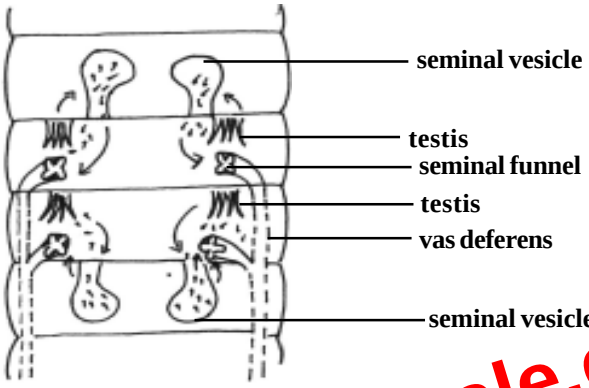


Fig. 1.3.10. Earthworm - Sperm transfer, storage and fertilization

The girdle is moved forward by the wriggling movements of the body. As the girdle is moved forwards it receives the ova and spermatozoa. The girdle containing the germ cells (ova and sperms) and the nutrient albuminous fluid is slipped off at the anterior end and it becomes a closed sac called the **cocoon**. Fertilization and the development of the eggs into worms takes place within the cocoon. Young worms come out of the cocoon after complete development.

Type study - 3. Pigeon

Sub phylum	-	**Vertebrata**
Class	-	**Aves**
Order	-	**Columbiformes**
Type	-	***Columba livia***

Birds are easily recongnised group of vertebrates. In birds every part of the body is modified to suit their aerial mode of life. Birds possess feathers, beak and feet modified in relation to their aerial life.

The Pigeons are flying birds(carinate). They are known both as wild and domesticated forms. The Pigeons are seen both in tropical and temperate

Quill feather :

Each quill feather has a central **stem** or **scapus**. It is divided into lower hollow part called the **quill** or **calamus** and a solid upper part termed **rachis**. The quill has at its lower end an opening called **inferior umbilicus**, through which vascular processes or papilla of the dermis project into the growing feather. Another opening the **Superior umbilicus** occurs at the junction of quill and the rachis on the inner face of feather. Close to this opening, there is a small tuft of soft feathers called **aftershaft**. Attached to the rachis are small **filaments** or **barbs**. The rachis with the barbs constitute the **vane** or **vexillum**. Each barb is provided with **barbules** and **hooklets**. The barbs remain attached with one another to form a continuous blade for striking the air in flight.

There are twenty three quill feathers or **remiges** in each wing. Eleven of these known as **primaries**. are attached to the hand. The remaining twelve fixed on the forearm are called **secondaries**. Attached to the thumb is a small tuft of feathers known as **ala spuria** or **bastard wing**. The tail bears twelve **tail feathers** or **rectrices** which are arranged in the form of a fan.

The **contour feathers** are soft and the barbs are plume like with no interlocking mechanisms. These help to keep the body warm and lock air pockets. The **filoplumes** have delicate hair like long axis and a few barbs devoid of barbules. **Down feathers** have small axis and a few barbs devoid of locking structures at the distal end. Nestlings are covered with down feathers.

Endoskeleton :-

The endoskeleton of pigeon is strong but lightly built. The texture of the bone is often spongy. Bone marrow is absent. The air spaces from the lungs may continue into the bones, making them light. The bones are more or less devoid of bone marrow. These are called **Pneumatic bones**. Most of the bones except those of the tail, forearm, hand and hind limb contain air spaces. In general there is a tendency for the reduction and fusion of bones. It gives rigidity to the skeleton.

Flight muscles :-

The wings are the modified forelimbs. They are organs of flight. The musculature of the forelimbs are greatly modified in response to the function they perform. Flight is the coordinated effort of a number of paired muscles of which the following are most important.

ward through the neck. On entering the thoracic cavity, the trachea expands into a **syrinx** or **voice box.** Later it divides into two **bronchi**, one for each lung. The walls of tracheal and bronchial tubes are supported by a series of closely set cartilagenous rings. Each bronchus enters a bright red lung. The bronchus divides and subdivides into smaller branches, ultimately ending in fine air capillaries. **Lungs** are solid spongy organs. They do not hang freely in the thoracic cavity but are lodged firmly in the ribs. Some of the branchial tubes pass through the lungs and communicate with the air cavities in the bone. There are nine **air sacs**. They are a median interclavicular, a pair of cervical, two pairs of thoracic and a pair of abdominal air sacs.

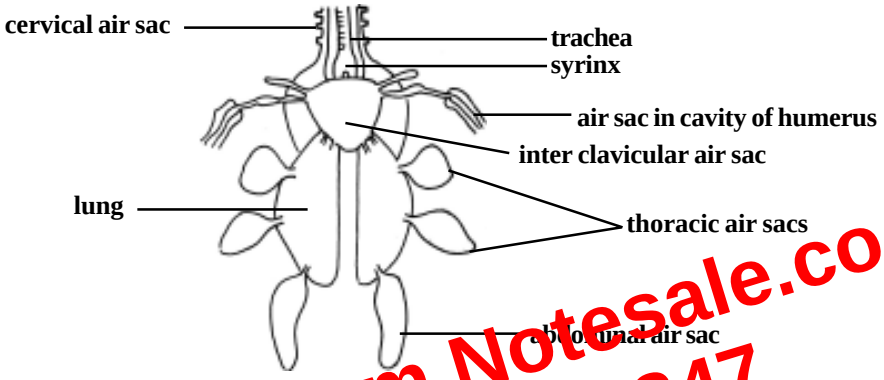


Fig. 3.15. Pigeon - Lungs and air sacs

The air sacs help to maintain high body temperatures. They make the body lighter and help in flight.

Mechanism of Respiration :-

In birds the expiration is an active process. The process of inspiration is passive. In a resting bird, the sternum is moved up and down with the help of **intercostal** and the **abdominal muscles**.

During flight, the **sternum** is rendered immovable due to the support of wings, but the body cavity is raised and lowered by the action of wings and by the lowering of the vertebral column.

Circulatory system :-

The **heart** is four chambered, with two **auricles** and two **ventricles**. There is complete separation of the oxygenated and non-oxygenated blood. Birds have two distinct circulations as **arterial** and **venous** systems.

Arterial system :-

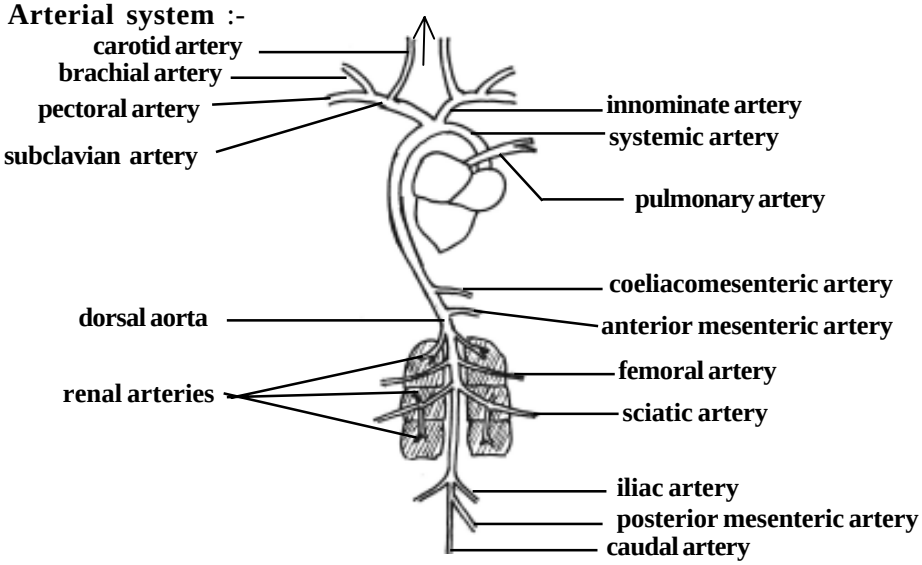


Fig. 1.3.17. Pigeon - arterial system

From the right ventricle arises the **pulmonary artery** carrying deoxygenated blood to the lungs for purification. An **aorta** arises from the left ventricle (right systemic). It carries oxygenated blood to various regions of the body through several arteries.

Venous system :

The deoxygenated blood from various regions of the body are collected by several veins. Finally these veins take the blood to the right auricle through the two **precaval** and a single **postcaval** veins.

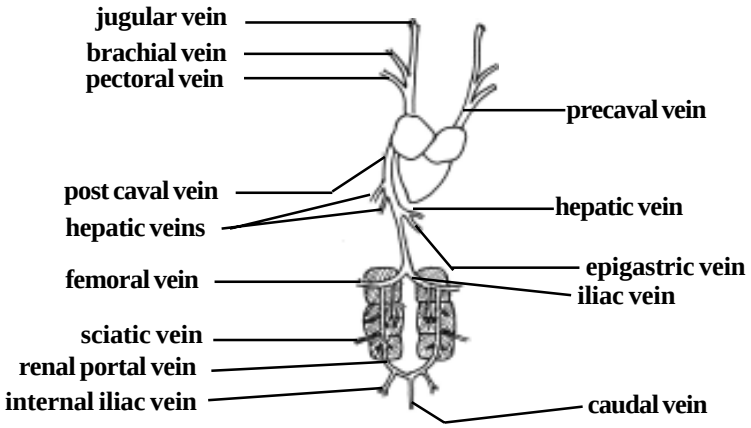


Fig. 1.3.18. Pigeon - venous system

Part D

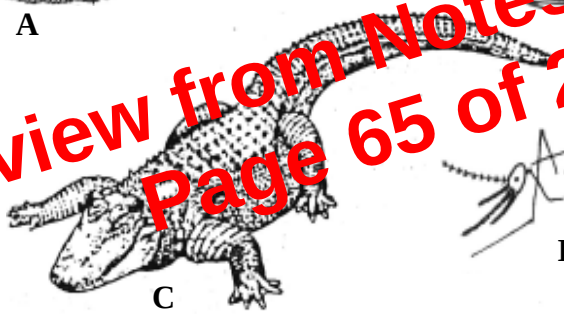
Answer in detail

1. Define species and provide an account on various animal groups.
2. Write an essay on the various methods of taxonomy.
3. Give a detailed account on the general characters chordates.
4. Explain the life cycle of Plasmodium in man.
5. Describe the external features of *Columba livia*.
6. Give a detailed account on the reproductive system and the process of reproduction in earthworms.

Classify giving reasons.

A

B



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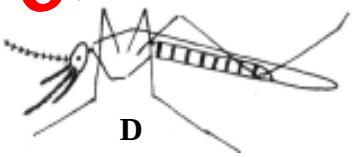

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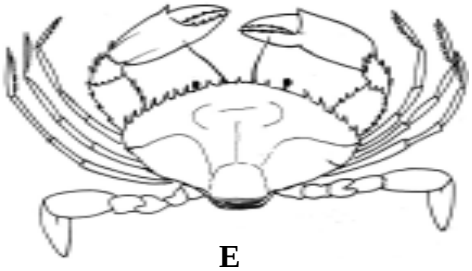

E

F

2.2.4 Endoplasmic Reticulum. (ER)

Electron microscopic study of sectioned cells has revealed the presence of a three dimensional network of sac-like and tubular cavities called **cisternae** bounded by a unit membrane inside the cell. Since these structures are concentrated in the endoplasmic portion of the cytoplasm, the entire organisation is called the **endoplasmic reticulum**. This name was coined by **Porter** in 1953.

The occurrence of ER varies from cell to cell. They are absent in erythrocytes, egg cells and embryonic cells.

The ER is the site of specific enzyme controlled biochemical reactions. Its outer surface carries numerous ribosomes. The presence of ribosomes gives a granular appearance. In this condition ER is described as **rough endoplasmic reticulum** (RER). RER is the site of synthesis of proteins. Ribosomes are absent on **smooth endoplasmic reticulum** (SER). SER is concerned with lipid metabolism.

Morphologically ER may occur in three forms namely 1. Lamellar form 2. Vesicular form and 3. Tubular form.

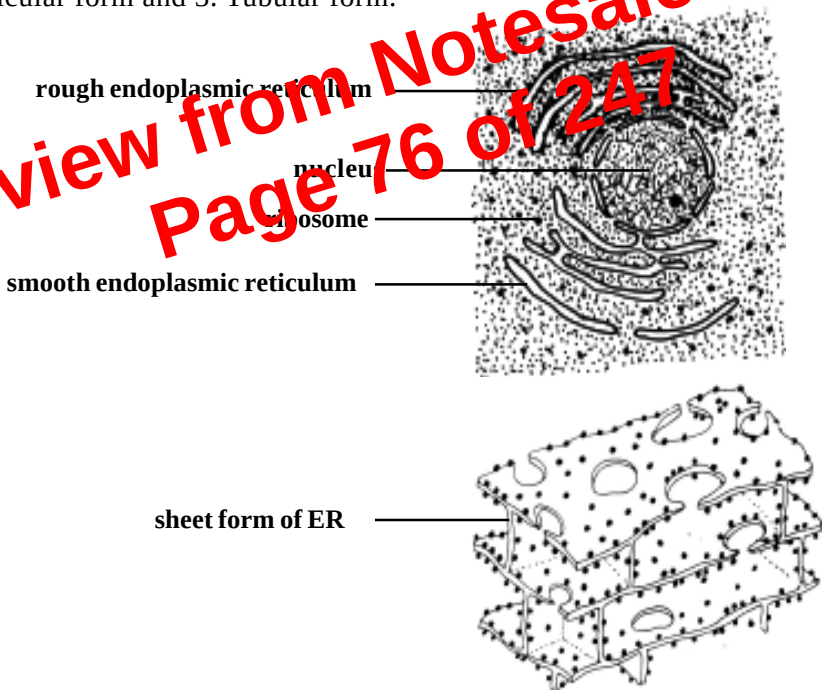

Fig.2.2.6. Endoplasmic recticulum

play chromosomal abnormalites such as duplication, deletions and translocations. Thus such alterations in gene arrangement can lead to generation of oncogenes.

Oncogenes of human tumours

Oncogene	Type of cancer	Activation mechanism
hox11	Acute T-cell leukemia	Translocation
erbB-2	Breast and ovarian carcinomas	Amplification
L-myc	Lung carcinoma	Amplification
ret	Thyroid carcinoma DNA	rearrangement.

A distinct mechanism by which oncogenes are activated in human tumors is **amplification**. It results in elevated gene expression. Gene amplification is very common in cancer cells. It occurs a thousand times more frequently than in normal cells. Molecular biologists are now working on the products of oncogenes.

2. The growth of normal cells is controlled by **suppressor genes**. In cancer, parts of the genome functioning as the suppressor genes are either lost or inactivated. Hence, negative regulators of cell proliferation are removed. It contributes to the abnormal proliferation of cells.

Gene	Type of cancer
APC	Colon / rectum carcinoma
BRCA 1	Breast and ovarian carcinoma
1 NK 4	Melanoma, lung carcinoma, brain tumors, leukemias, lymphoma
Rb	Retinoblastoma
PTEN	Brain tumors, kidney and lung carcinomas.

The protein products of the tumor suppressor genes normally inhibit cell proliferation. Inactivation of such genes therefore leads to tumor development.

The complete sequence of events required for the development of any human cancer is not yet known. But it is clear that both the **activation** of **oncogenes** and the **inactivation of tumor suppressor genes** are critical steps in tumor initiation and progression. Simultaneous effect on both the genes

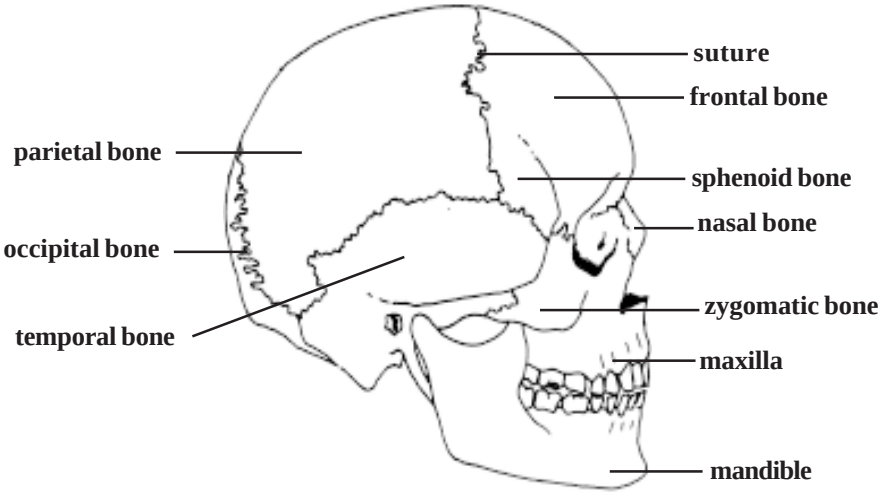

Fig.3.2.4. Skull - Lateral view

In the front there are 14 facial bones. Of these **maxilla**, **zygomatic**, **palatine**, **lacrymal**, **nasal** and **inferior nasal konchа** remain as pairs. **Mandible** or **lower jaw** and **vomer** are unpaired bones.

The **parietal** and **occipital** bones are major bones on the posterior side of the skull. The parietal bones are joined to the occipital bone at the back. The side of the head is formed of the parietal and the **temporal** bones. The large hole in the temporal bone is the **external auditory meatus**. This opening is meant for transmitting sound waves towards the eardrum. On the lateral side immediately anterior to the temporal, the **sphenoid** bone is seen. Anterior to the sphenoid bone is the **zygomatic bone** or **cheek bone**. It is a prominent bone on the face. The upper jaw is formed of the **maxilla**. The **mandible** constitutes the lower jaw.

The major bones seen from the frontal view are the **frontal bone**, **zygomatic bone** the **maxillae** and the **mandible**. The most prominent openings in the skull are the **orbits** and the **nasal cavity**. The two orbits are meant for accommodating the eyes. The bones of the orbits provide protection for the eyes and attachment points for the muscles that move the eyes. The bones forming the oribits are the **frontal**, **sphenoid**, **zygomatic**, **maxilla**, **lacrymal**, **ethmoid** and **palatine**. The head region also contains 6 ear ossicles. They are Maleus (2), incus (2) and stapes (2).

Wrist - This short region is composed of eight **carpal bones**. These are arranaged into two rows of four each. The carpals along with accompanying ligaments are arranged in such a way that a tunnel on the anterior surface of the wrist called the **carpal tunnel** has been formed. Tendons, nerves and blood vessels pass through this tunnel to enter the hand.

Hand - The bony framework of the hand is formed of five **metacarpals**. They are attached to the carpals in the wrist. The concave nature of the palm in the resting position is due to curved arrangement of metacarpals.

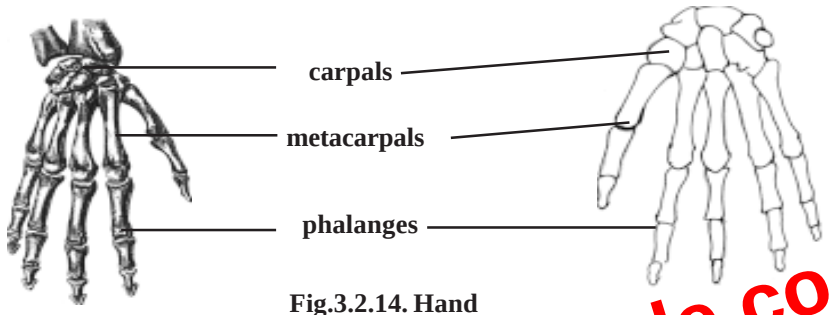

Fig.3.2.14. Hand

Each hand has five digits. They include one thumb and four fingers. Each digit has small long bones called **phalanges**. While the thumb has two phalanges other fingers have three each.

Lower limb or Leg : The general pattern of the lower limb is similar to that of the upper limb.

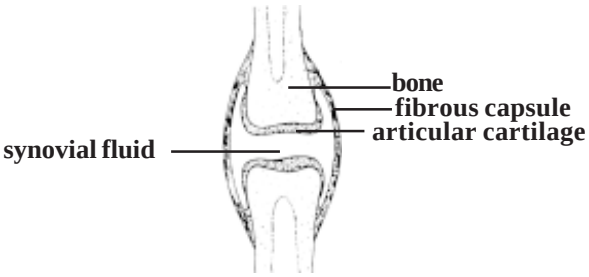

Fig.3.2.15. A Synovial joint

3.3. Muscular System

Locomotion and bodily movements are characteristic features of the animals. The movements are effected by various cell organelles such as cilia, flagella and organs like muscles. Muscular movements are more powerful and energetic. The skeletal muscles apart from their role in smarter movements, provide beautiful shapes to the body. The inner smooth muscles of the visceral organs make them work like machines all through the life period. The muscle cells function like small motors to produce the forces responsible for the movement of the arms, legs, heart and other part of the body. Thus the highly specialized muscle tissues are responsible for the mechanical processes in the body.

Based on structure, functioning and occurrence three different types of muscle tissues have been identified. They are the **skeletal**, **visceral** and **cardiac** muscles.

1). **Skeletal muscles or striped muscles** : These muscles are attached to the bones. The muscle cells are long and cylindrical. These voluntary muscles cause body movements.

2). **Visceral muscles or Nonstriated muscles** : These are found in the walls of the inner organs such as blood vessels, stomach and intestine. The muscle cells are spindle shaped. These are involuntary in nature.

3). **Cardiac muscle** : These are found in the wall of the heart. The muscle cells are cylindrical and branched. The muscles are involuntary in nature.

Skeletal muscles

The skeletal muscles are attached to bones by **tendons**. The tendons help to transfer the forces developed by skeletal muscles to the bones. These muscles are covered by sheets of connective tissue called **fascia**.

Tendons : These are connective tissue structures showing slight elasticity. They are like cords or straps strongly attached to bones. The tensile strength of tendons is nearly half that of steel. A tendon having 10 mm diameter can support 600 - 1000 kg.

Fascia : These are assemblages of connective tissues lining skeletal muscles as membranous sheets. The fascia may be superficial or deep. The superficial fascia is a layer of loose connective tissue found in between skin and muscles. The deep fascia are collagen fibres found as a tough inelastic sheath around the musculature. They run between groups of muscles and connect with the bones.

III. Muscles of the Trunk region.

The muscles of the vertebral column help to bend and rotate the body. These are strong back muscles that help the trunk to maintain erect posture. The most prominent muscles of this region are the **erector spinae**, **longissimus** and **spinalis**.

Four important thoracic muscle groups are associated with the process of breathing. While the process of inspiration is due to **scalene** and **external intercostal muscles**, the expiration is performed due to **internal intercostals** and transverse **thoracis.** Major breathing movement is due to **diaphragm,** a curved musculofibrous sheet that separates thoracic and abdominal cavities.

Abdominal muscles can aid in forced expiration, vomitting, defaecation, urination and childbirth.

The inferior opening of the pelvic bone is covered by **pelvic diaphragm** muscles. Below these muscles **perineum** is pressent. The perineum and other "subfloor" muscles form the **urogenital diaphragm**. Pelvic and urogenital diaphragm may get strecthed in pregnancy due to weight of the foetus. However by specific exercises they can be strengthened.

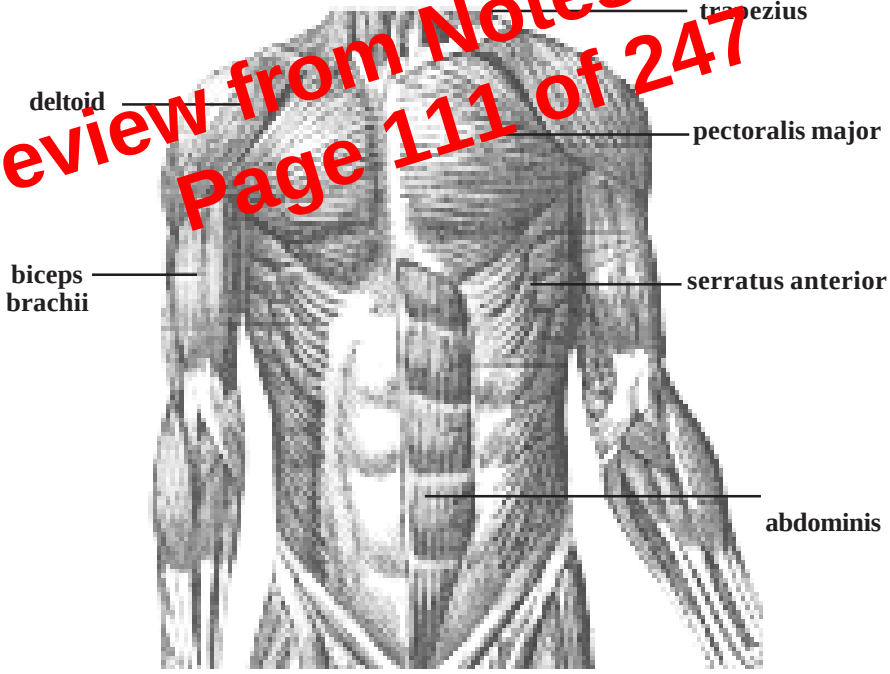

Fig.3.3.2. Muscles of the Trunk

Systemic and Pulmonary circulations

The most important component of this system is the **heart**. It is a large, muscular, valved structure having four chambers. The chambers are the **right atrium**, **left atrium**, **right ventricle** and **left ventricle**. Each atrium opens into a corresponding ventricle. The right and left chambers are separated by **septa**.

Systemic circulation :- The left atrium receives oxygenated blood from the lungs, through the pulmonary vein. When the atria contract, blood from the left atrium is forced into the left ventricle. Later by a contraction of the ventricle, the blood leaves the heart through the aorta. The aorta is the single systemic artery emerging from the heart. By successive branchings, the aorta

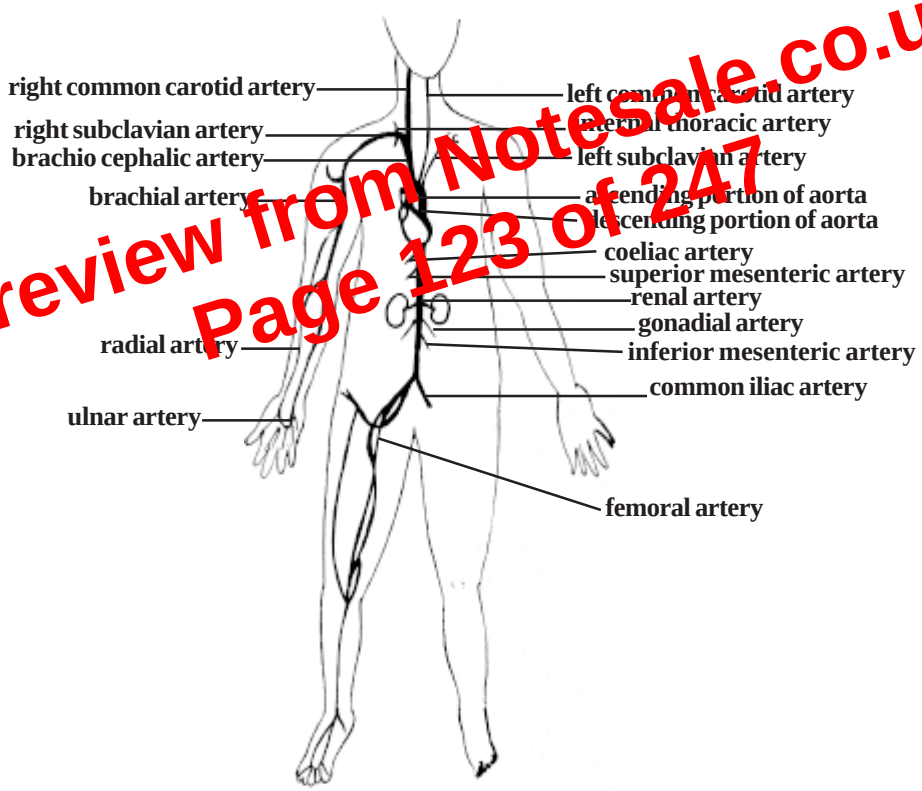

Fig. 3.6.2 Human - Arterial system

2. **Muscular arteries** :- There are larger and smaller muscular arteries. The larger muscular arteries are inelastic and they have thick walls. The wall has 30-40microns in diameter in the layers of smooth muscles. Since they regulate blood supply, they are called **distributing arteries**. The small muscular arteries are capable of vasodilation and vasoconstriction.

3. **Arterioles** :- They conduct blood from the arteries to the capillary bed. These are small vessels capable of vasodilation and vasoconstriction.

4. **Capillaries** :- These are fine vessels found between arterioles and venules. They measure 5-8micron in diameter.

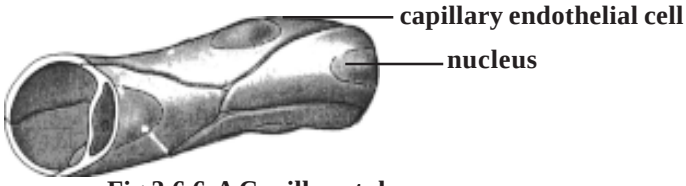

Fig.3.6.6. A Capillary tube

5. **Venules** :- These are tubes of flat, oval or polygonal endothelial cells. Each venule is formed by the convergence of two or more capillaries. Its diameter ranges upto 30micron.

6. **Veins** :- Veins seen in anatomy are **medium veins**. They run in between venules and **large veins**. Large veins transport blood to the heart.

Veins with diameter above 2 mm have valves. They are of semilunar type. They allow movement of blood towards the heart. There are several valves in the medium veins.

Branching of blood vessels :- When an artery divides into two equal branches, the original artery ceases to exist. Hence the branches are called **terminal branches**. The smaller branching vessels formed on the sides are called the **collateral branches**. When arteries are joined to each other it is named as **anastomosis**.

Blood supply to blood vessels :- As any other region, the cells and tissue on the wall of the blood vessel require nourishment. Some amount can diffuse from blood in the lumen. For vessels having diameter greater than 1 mm, diffusion of nutrients may not be possible. Such vessels have very minute vessels called **vasa vasorum** spread over them. They penetrate into the wall of the blood vessels.

The structure of a peripheral nerve

A nerve is made up of several nerve fibres. A nerve fibre contains axons with their coverings called **schwann cells**. The fibres are grouped into **fasciculi**. The number and pattern of fasciculi vary in different nerves. Thus a nerve trunk possesses many such fasciculi. Such a trunk is surrounded by an **epineuruium**. The individual fasciculi are enclosed by a multilayered **perineurium**. The perineurium surrounds the **endoneurium** or intra fascicular connective tissue.

In a peripheral nerve the epineurium constitutes 30 -70 % of the total cross sectional area of the nerve bundle. The thickness is more when there are more fasciculi. A layer of fat in the epineurium provides a 'cushion' effect to the nerve.

The perineurium contains alternating layers of flattened polygonal cells. The endoneurium remains condensed around axons. The components of the endoneurium remain bathed in endoneurial fluid.

The fasciculi of the nerve are supplied blood by **vasa nervosum**. These minute blood vessels radiate upto the endoneurium.

Nervous system

The organs of the nervous system are continuous in nature. However, for study purposes it can be divided into systems and organs.

A. **Central nervous system** (C N S)

This system includes the **brain** and the **spinal cord** or medulla spinalis. They are protected by surrounding bones. While the brain is located within the **cranium,** the spinal cord is placed within the **vertebral canal** of the vertebrae. Through an opening called **foramen magnum**, the spinal cord descends down from the brain.

B. **Peripheral nervous system**.

It consists of nerves and ganglia. The nerves that are formed from the brain are called the **cranial nerves**. There are 12 pairs of cranial nerves and 31 pairs of spinal nerves.

C. **Autonomous nervous system**.

The nerves in this system transmit impulses from the C N S to smooth muscles, cardiac muscles and glands. It is also called the **involuntary nervous system**. It is subdivided into sympathetic and parasympathetic divisions.

column. There are two enlargements in the spinal cord. They are the **cervical** and **lumbar** enlargements. Below the lumbar enlargement the spinal cord tapers to form a cone like region called the **conus medullaris**. A connective tissue filament called the **filum terminale** extends inferiorly from conus medullaris to the coccyx. The conus medullaris and the nerves extending below resemble a horse's tail. Hence it is called **cauda equina**.

A cross section of the spinal cord reveals a central grey portion and a peripheral white portion. The white matter consists of nerve tracts and the grey matter consists of neuron cell bodies and dendrites.

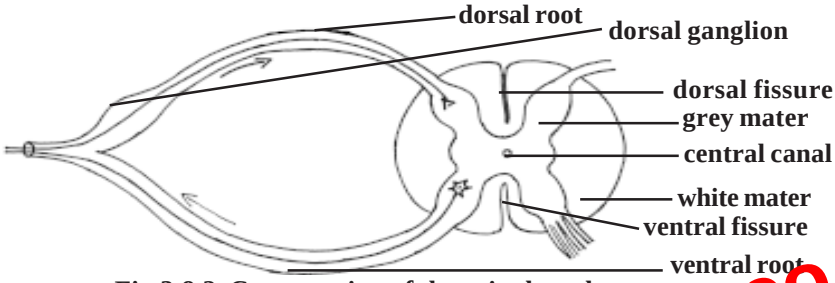

Fig.3.8.2. Cross section of the spinal cord

The dorsal and ventral sides have long fissures. There are 31 pairs of spinal nerves arising from the spinal cord. Each nerve has a **dorsal root** and a **ventral root** from the spinal cord. The dorsal roots have **dorsal root ganglia**.

Ventricles

The entire CNS remains as a hollow tube. The tube inside the adult brain forms ventricles.

Each cerebral hemisphere contains a large cavity called the **lateral ventricle**. It corresponds to the hypothetical first and second ventricles. The two lateral ventricles communicate with the third ventricle located in the centre of the diencephalon. This connection is made through two **interventricular foramina** (**foramen of Monro**). The *third ventricle* inturn opens into the **fourth ventricle** found inside the medulla oblongata. This communication happens through a narrow canal called the **cerebral aqueduct** (aqueduct of sylvius). The fourth ventricle is continuous with the **central canal** of the spinal cord. The central canal extends nearly to the full length of the cord.

Cerebro-spinal fluid (CSF)

This fluid fills the ventricles of the brain and the central canal of the spinal cord. About 80-90 % of CSF is produced by specialized cells called

ependymal cells within the lateral ventricles. Remaining 10-12 % is produced by similar cells in the 3rd and 4th ventricles. These ependymal cells, their supportive tissue and the associated blood vessels together are called **choroid plexuses**. The plexuses are formed by invagination of the vascular piamater into the ventricles.

3. 9. The Sensory Organs.

Living organism respond to several stimuli such as light, heat, sound, chemicals, pressure, touch, stretch and orientation. These stimuli are felt by specific receptors. The receptors convert the stimuli into impulses in the nervous systems.

The **touch receptors** in the skin are the simplest receptors. Such receptors are single nerve cells responding directly to the stimulus. Other receptors are complex s**ense organs**. On these organs the stimulus is channelled into a receptive region of the organ. Among the several organs, the most important are the **eyes** and **ears**.

The eye

The eye is formed of 3 coats or tunics.

Coats or tunic	Region
1. Outer or fibrous	- **sclera** & **cornea**
2. middle or vascular	- **choroid**, **ciliary body** & **iris**
3. inner or nervous	- **retina**

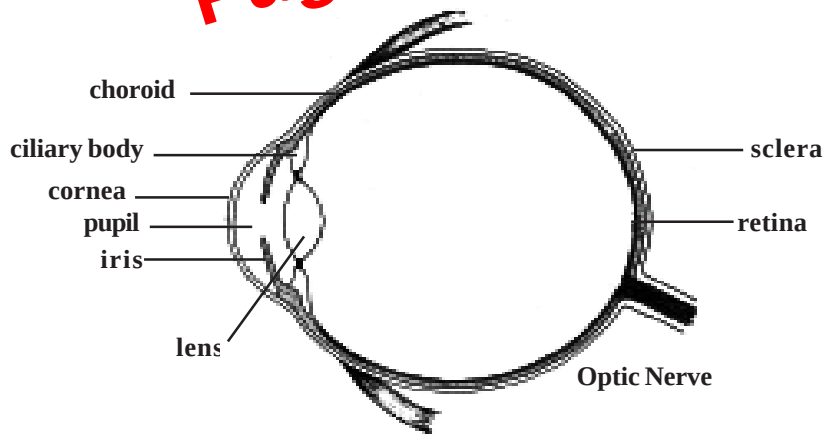

Fig.3.9.1. C.S. of human eye

Pituitary gland (or) Hypophysis

It is an organ, that secretes eight major hormones. These hormones regulate numerous body functions and controls the secretory activities of several other endocrine glands. The **hypothalamus** of the brain is connected to the pituitary. The posterior pituitary is an extension of the hypothalamus.

Structure of the pituitary gland.

This gland is approximately 1 cm in diameter. It weighs 0.5-1g. It is placed in a region called the **sella turcica** of the sphenoid bone in the floor of the skull. It is placed inferior to the hypothalamus. It is connected to it by a stalk of tissue called the **infundibulum**.

Based on origin and function the pituitary is divided into two parts. They are the **posterior pituitary** or **neurohypophysis** and **anterior pituitary** or **adenohypophysis**.

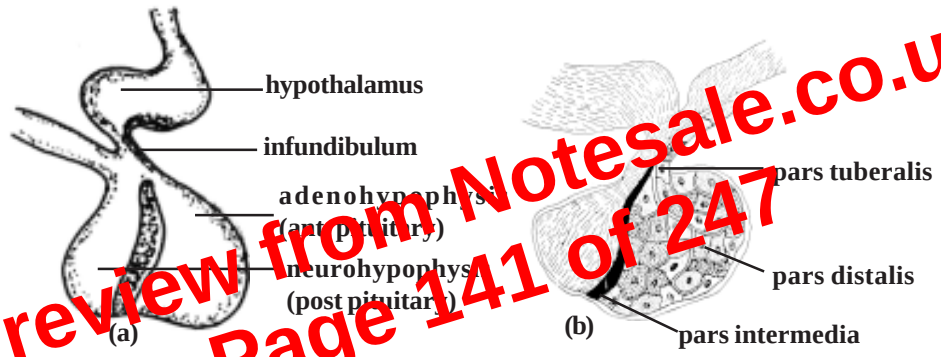

Fig.3.10.2. (a) Entire (b) L.S. of the pituitary gland

Posterior pituitary or Neurohypophysis.

The posterior pituitary is continuous with the brain. Hence it is called the **neurohypophysis**. During embryonic development, it is formed as an outgrowth of the inferior part of the brain in the area of the hypothalamus. The outgrowth of the brain, forms the **infundibulum**. The distal end of the infundibulum enlarges to form the **posterior pituitary**. Since this part of the pituitary is an extension of the nervous system, its secretions are known as **neurohormones**.

Anterior Pituitary or Adenohypophysis

During embryonic development an outpocketing of the roof of the oral cavity arises. It is called as the **Rathke's pouch**. This pouch grows

Most nephrons measure 50-55 mm in length. 15% of the nephrons are larger and they remain near the medulla. These are called the **juxtamedullary nephrons**. They have larger loops of Henle.

The renal corpuscle of the nephron consists of a **Bowman's capsule** and a bunch of capillaries called the **glomerulus**.

In the Bowman's capsule the outer and inner layers are called **parietal** and **visceral layers** respectively. The outer parietal layer is composed of simple squamous epithelium. The inner visceral layer surrounds the glomerulus. It consists of specialized cells called **podocytes**. The walls of the glomerular capillaries are lined with endothelial cells. There is a basement membrane between the endothelial cells of the glomerular capillaries and the podocytes of Bowman's capsule. The capillary endothelium, the basement membrane and the podocytes of Bowman's capsule make up the **filtration membrane**.

The glomerulus is supplied with blood by an afferent arteriole. It is drained by an efferent arteriole.

The cavity of Bowman's capsule opens into the proximal tubule. The proximal tubule is also called the **proximal convoluted tubule**. It is approximately 14mm long and 60 µm in diameter.

Posteriorly the proximal tubule continues as the **loop of Henle**. Each loop has a descending limb and an ascending limb. The first part of the descending limb is similar in structure to the proximal tubule. The loops of Henle that extend into the medulla become very thin near the end of the loop. The first part of the ascending limb is also very thin and it consists of simple squamous epithelium, but it soon becoms thick. The distal tubules, also called the distal convoluted tubules are not as long as the proximal tubules.

Ureters and Urinary bladder

The ureters extend inferiorly from the renal pelvis. They arise medially at the renal hilum to reach the urinary bladder. The bladder is meant for temporarily storing the urine. The urinary bladder is a hollow muscular bag. It lies in the pelvic cavity. The size of the bladder depends on the presence or absence of urine. The bladder capacity varies from 120-320ml. Filling upto 500 ml is tolerated. Micturition will occur at 280ml. The ureters enter the bladder inferiorly on its posterolateral surface. The urethra exits the bladder inferiorly and anteriorly. At the junction of the urethra with the urinary bladder

Vas deferens or ductus deferens : It emerges from the tail end of the epididymis and ascends along the posterior side of the testis. It becomes associated with the blood vessels and nerves that supply the testis. Collectively these structures constitute the **spermatic cord**. Thus the spermatic cord consists of (1) Vas deferens (2) testicular artery and venus plexus (3) lymph vessels (4) nerves (5) fibrous processes and muscles. This cord enters into the pelvic region. The end of the vas deferns enlarges to form the **ampulla**. At this region the vas deferens is surrounded by smooth muscles capable of peristaltic contraction. They help to propel the sperm cells through the ductus deferens.

Ejaculatory duct : Nearer to the ampulla of each vas deferens there is a sac like **seminal vesicle**. It joins the ductus deferens to form the ejaculatory duct. These ducts are about 2.5 cm long. They project into the prostate gland and end by opening into the urethra.

Urethra : The male urethra extends from the urinary bladder to the distal end of the penis. It is about 20 cm long. It is a passageway for both urine and reproductive fluids. The urethra is divided into three parts. They are

1. The prostatic Urethra - It is closest to the bladder and passes through the prostate gland.

2. The membranous urethra - It is the shortest part of the urethra and it extends from the prostatic urethra.

3. The spongy urethra or penile urethra - It is the longest part of the urethra. It extends from the membranous urethra, through the length of the penis. There are several minute mucus secreting urethral glands opening into the urethral passage.

Penis - It is the male copulatory organ. It consists of two parts namely **the radix** or **root** and **the corpus** or **body**. The radix attaches the penis to the lower abdomen. The corpus is normally pendulous. It is covered by a loose skin.

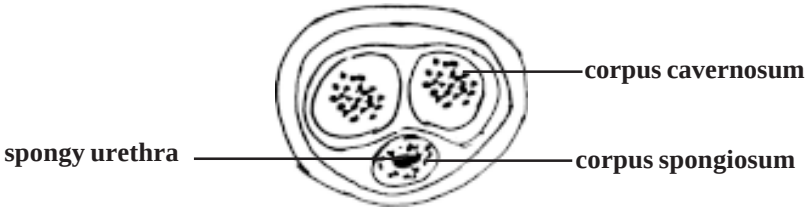

Fig. 3.12.3. C. S of Penis

Ovaries - These are paired structures. The two ovaries are placed on each side of the uterus in the pelvic region. They are greyish pink in colour. Each ovary is almond shaped. They are about 3cm long,1.5cm wide and 1cm thick.

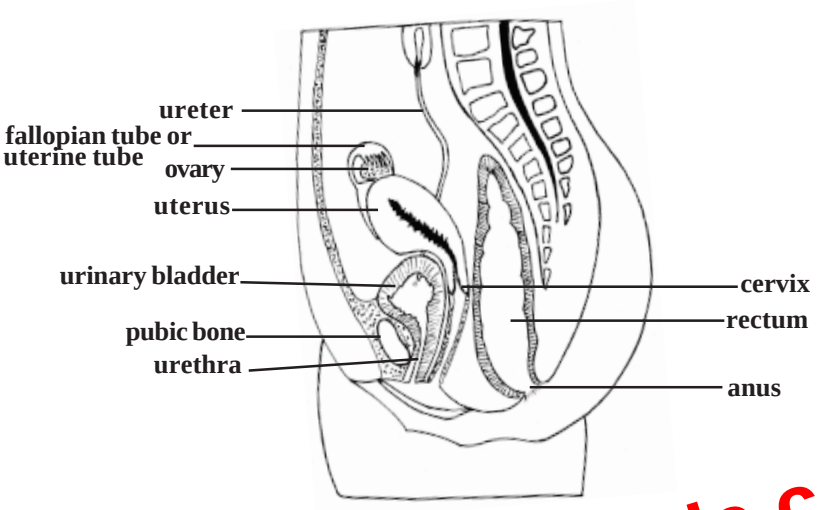

Fig. 3.12.4. Human female reproductive organs

The ovary is attached to the posterior surface of the inner body wall by a membranous fold called the mesovarium. The ovary is further supported by suspensory and ovarian ligaments.

Ovarian structure - In young female the surface of the ovary is covered by a layer of **ovarian surface epithelium**. It consists of a single layer of cuboidal cells. Beneath the epithelium the ovary is surrounded by a tough coat named **tunica albuginea**. It is made of collagenous tissue.

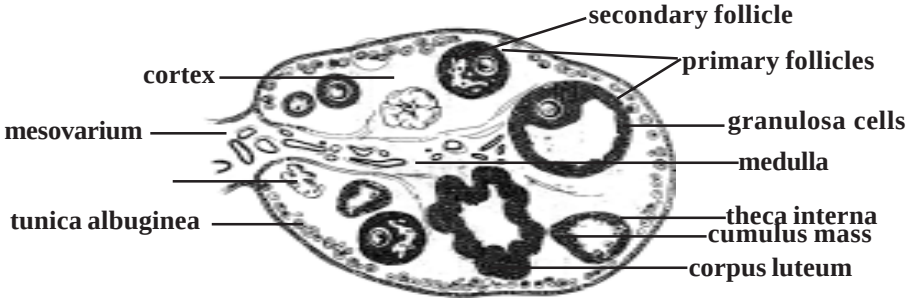

Fig. 3.12.5. Histology of the Ovary

The overy proper is divisible into two regions, namely the **cortex** and the **medulla**. The cortex region contains the ovarian follicles. The medulla is interior. It receives blood vessels and nerves at the hilum.

eyed male individuals of F_1 are intercrossed the F_2 generation possessed 50 % red eyed and 50 % white eyed females. Similarly the male population of F_2 included 50 % red eyed and 50 % white eyed flies.

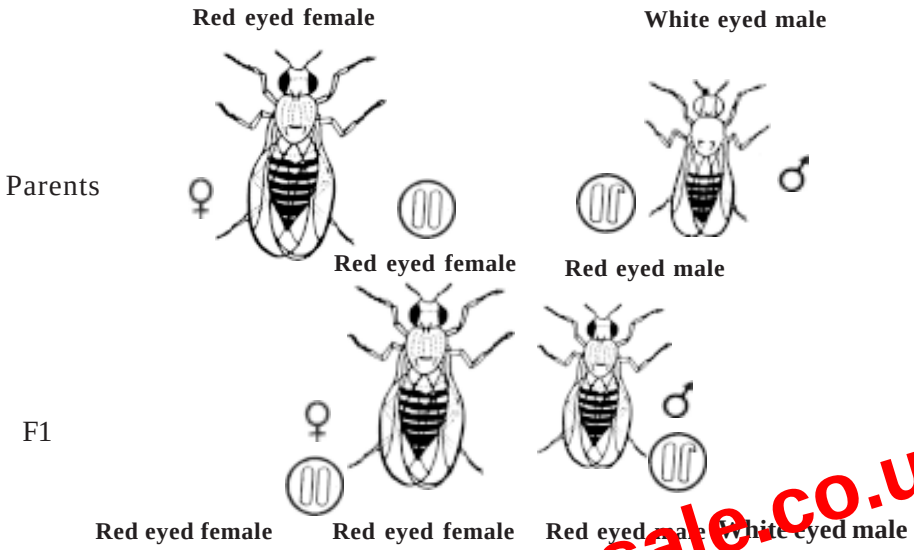

Fig.4.4.1. Drosophila - Red eyed female x White eyed male

Sex linked inheritance in Humans

Most of the sex linked characters in humans are **X - linked**. There are 150 confimed X- linked traits known. Most of them are recessives.

Colour blindness :

The human vision is basically due to cells called rods and cones found on the retina of the eye. The cone cells are sensitive to red, green and violet light. The formation of colour sensitive cones is controlled by a dominant X-linked gene.

An egg need not be spherical always. In invertebrate animals oval shaped eggs are seen. The pattern of cleavage and further gastrulation also deviate from that of the vertebrates. In **insects** the eggs are oval in shape and the yolk remains in the centre of the egg. However, the eggs of echinoderms are similar to that of the vertebrates.

5.2 Cleavage and types - Frog's egg.

The process of cleavage reamains one of the earliest mechanical activity in the conversion of a single celled egg into a multicellular embryo. It is initiated by the sperm during fertilization. However in parthenogenetic eggs cleavage can commence without the influence of fertilization.

The process of cleavage or **cellulation** happens through repeated mitotic divisions. These divisions result in cells called **blastomeres**. In later stages of development the blastomeres occupy different regions and differentiate into several types of body cells.

The first cleavage of frog's egg was observed by **Swammerdam** in 1738. The entire process of cleavage in frog's egg was studied by **Prevost** and **Dumas** in 1824. With the development of microscopes, cleavages and further stages were observed in the eggs of sea urchin, star fishes, amphioxus and hen's eggs.

From all these studies it has become clear that all divisions in cleavage are **mitotic**. The mitotic process is very rapid. In the eggs of sea urchin division of the blastomeres can be observed every 30 minutes. As the cleavage progresses the resultant daughter cells, namely the blastomeres get reduced in size. During cleavage there is no growth in the blastomeres. The total size and volume of the embryo remains the same. The cleavages result in a compact mass of blastomeres called **morula**. It gets transformed into **blastula**. While the wall of the blastula is called the **blastoderm**, the central cavity is called the **blastocoel**.

The planes of cleavage

An egg can be divided from different planes during cleavage. Depending on the position of the cleavage furrow the planes of cleavage are named.

1. **Meridional cleavage**: The plane of cleavage lies on the animal vegetal axis. It bisects both the poles of the egg. Thus the egg is divided into two equal halves.

3. In the next stage a **latitudinal** furrow is formed above the horizontal furrow nearer to the animal pole. Such a furrow is due to the influence of yolk concentration in the vegetal pole. The latitudinal furrow uniformly affects all the blastomeres. It results in the formation of eight blastomeres. Four of them remaining in the vegetal pole are large. They are named as **macromeres**. Another four blastomeres remain in the vegetal pole. They are named as **micromeres**. The micromeres are smaller in size than the macromeres.

4. The fourth set of cleavage planes are **meridional** and holoblastic. They are unequal. They divide yolkless micromeres more rapidly than yolk-rich macromeres. These cleavages result in the production of 16 blastomeres.

5. As a result of further cleavages, a ball of several small blastomeres result. A closer observation reveals that, while the blastomeres above the equator are small and remain as micromeres, the blastomeres of the vegetal pole remain progressively larger. The larger blastomeres are called the macromeres.

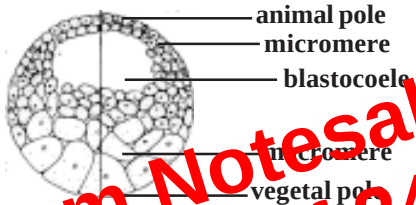

Fig 5.2 L.S of Frog blastula

At the 8 cell stages of cleavage the embryo acquires a characteristic, mild oblong shape. In this stage it is called the **morula.** The morula initially contains a shallow cavity called the **blastocoele**. Gradually the blastocoelic space increases into a large cavity occuping the middle of the blastula. However the blastocoele mostly remains in the animal pole region in the middle of the micromeres.

The blastomeres gradually adhere to each other, and arrange themselves into a true epithelium called the **blastoderm**. The blastoderm remains two cell thick in the animal pole. The embryo having a fluid-filled blastocoele and blastoderm is called the **blastula**.

It has been reported that around 12th cleavage the blastula possesses about 4096 cells. The blastula moves to the next stage, namely gastrulation at a stage in which it has about 20,000 cells.

The ultimate blastula is a ball of blastomeres which have to form different embryonic body layers and organs of the body. The fate of each and every blastomere has been observed and marked. A map showing various

Initially, the first pharyngeal endodermal cells undergo invagination over the dorsal blastoporal lip. These cells move to the interior. They are followed by other cells. The inwandering cells gradually occupy the region of the blastocoele. Thus the blastocoelic cavity gets reduced. A new cavity among the involuted cells results. It is called the **gastrocoel**. The gastrocoel later becomes the **archenteron**. The interior region of the archenteron gradually transforms into the pharyngeal region. This region remains as the foregut. The mesodermal and endodermal cells gradually occupy their positions.

The inward movement of the exterior cells through the blastoporal region is called **involution**. The involution results in the positioning of chordamesodermal cells and pharyngeal endodermal cells.

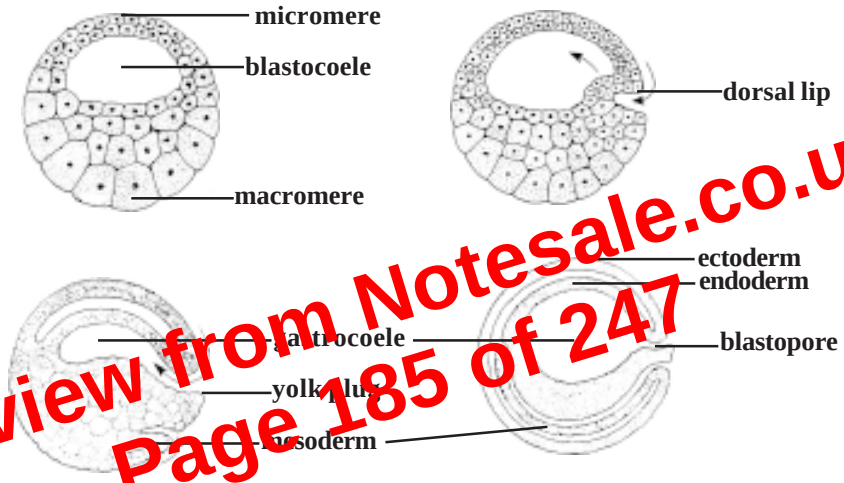

Fig.5.3.3. Gastrulation of Frog

The mesodermal cells occupy the region between inner endodermal and outer ectodermal cells. While the exterior chorda-mesodermal cell involute inside, their place is taken up by the ectoderm. The expansion of the ectoderm is due to **epiboly**. Epiboly causes overlapping or '***the roofing over***' of the gastrula by the ectoderm.

The blastopore is gradually covered by certain endoderm cells. The closing cells of the blastopore constitute the **yolk-plug**. Gradually the yolk-plug withdraws to the interior and the blastopore gets reduced into a narrow slit.

The process of gastrulation converts the blastula into a spherical, bilaterally symmetrical, triploblastic gastrula. Gradually the gastrula undergoes the process of **tubulation** or **neurulation** to become a **neurula**.

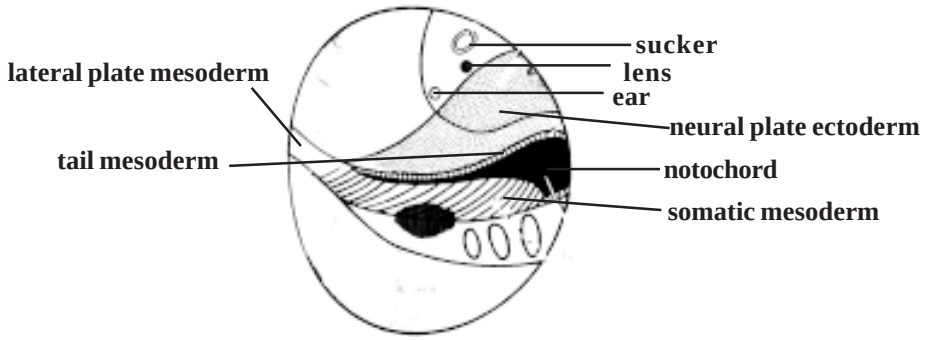

Fig.5.3.4. Fate map of frog blastula

Neurulation

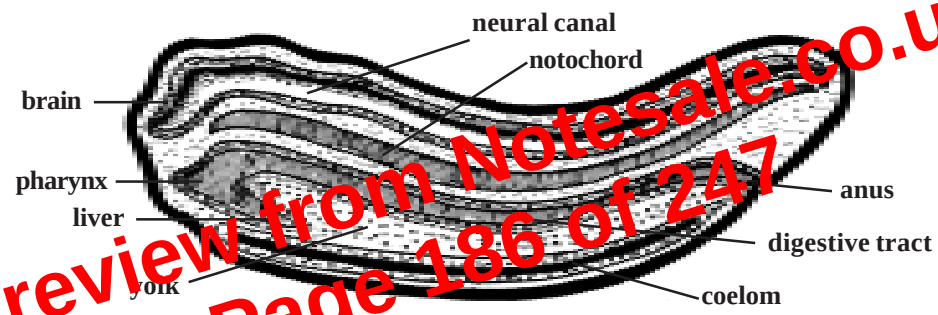

Fig.5.3.5. Neurula of frog

The process of neurulation is the formation of a neural tube. However during this process mesoderm and endoderm also undergo differentiation.

During neurulation the embryo lengthens along the anteroposterior axis. The dorsal side of the gastrula is lined by ectodermal cells. The presumptive area of the nervous system gets differentiated from the rest of ectoderm. It remains as **medullary plate** or **nerual plate**. The neural plate later thickens and it gets raised above the general level as ridges called **neural folds**. In the middle of the neural fold a neural groove appears. The **neural groove** deepens inside. The neural folds above the groove. The neural groove gets converted into a **neural tube**. This tube gets detached from the surface. The neural tube remains as the prospective nervous system. The embryo at this stage is called the **neurula**.

The CMFRI in India gives necessary training in pearl culture techniques. In this process shell beads are introduced into the soft tissues of the oyster along with a strip of the mantle so that the latter may secrete the pearly substance around the bead. The treated oysters are well taken care of in cages suspended from floating rafts in shallow waters of the sea. Thus, cultured pearls are produced in the same way as the natural pearls. The pearl is a concretion of calcium carbonate in an organic matrix. It is like the nacreous layer secreted by the mantle on the inner surface of the shell valve.

Shells having a brilliant silvery sheen are known in commerce as the "mother of pearl". They are collected for the manufacture of buttons and other fancy articles.

6. 1. 6 Fishes - Nutritive value

The marine fisheries of India are of importance in increasing the country's food resources and fetching a considerable amount of foreign exchange through the export of frozen and processed marine products. Besides, the major capture fisheries, a breakthrough has been effected in recent years to initiate the culture of selected species of finfishes and crustaceans. The establishment of Central Marine Fisheries Research Institute (CMFRI), Central Institute of Inland and Brackish water Aquaculture (CIBA), National Institute of Oceanography (NIO), Central Institute of Fresh water Aquaculture(CIFA), National Institute of Ocean Technology (NIOT) and Marine Products Export Development Authority (MPEDA) has led to the generation of considerable information on various aspects of Marine biology, Marine, Fresh water and Brackish water Fisheries and Oceanography. Consumption of fish for food has appreciably increased in recent years in all countries. The declaration of Exclusive Economic Zone (EEZ) has provided a great opportunity and challenge to coastal nations. In India there is good scope for development of marine resources to derive economic, social and nutritional benefits.

The nutritive and medicinal value of fish have been recognized from time immemorial. Fish flesh is an excellent source of protein in human diet. The principal biochemical contents of fish flesh are protein, fat and water. Protein constitutes about 20 percent.

The nutrional value of fish flesh is comparable and even higher than that of the flesh of birds and mammals. Fish flesh remains a good source for all essential aminoacids in needed concentrations.

In **worker honey bee** (undeveloped females) the poisonous sting is situated at the hind end of the body. It is a pointed structure provided with minute hooks or barbs at its free end. On stinging the tip of sting gets detached. Hence a bee can sting only once.

Unlike the bee the **wasp** is able to withdraw its sting from the wound. Hence it can sting again. In wasp the sting is a modified ovipositor and once it has penetrated the skin of the victim poison is injected as in a hypodermic syringe. The wasp's poison is a **histamine**.

The sting by honey bees and wasps lead to pain and inflammation.

Poisonous fishes

More than 700 species of fishes have poison glands. Venom in fishes is of two kinds. One kind of venom is produced by specialized glands which may occur in various parts of the body. In the second, the flesh itself may secrete some toxic substance and the fish becomes poisonous and inedible.

There are several poisonous **cartilaginous fishes**. The poison glands are usually associated with a spine or sting as in the case of **sting ray**. In the sting ray(**Trygon**), the poison glands lie along a late al groove on each side of the spine on its tail. The spine causes pain and numbness in the flesh of victim.

The large **Barracuda** of Cuba and other tropical islands have poisonous flesh, which when eaten cause pain in joints and extremities, nausea, vomiting and general trembling.

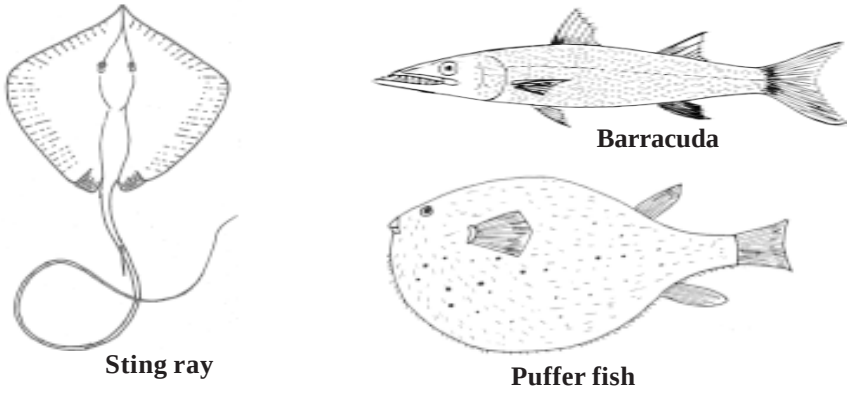

Fig. 6.2.4. Poisonous fishes

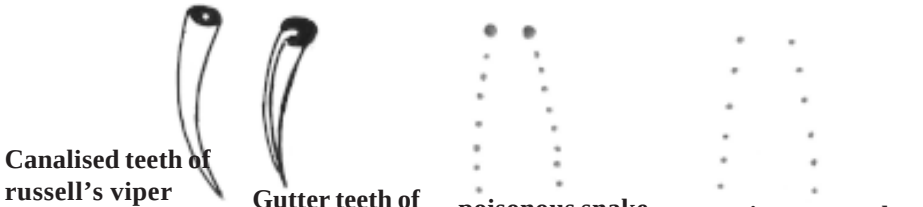

Fig. 6.2.7. Fangs of snakes and marks left by the bite of poisonous and non-poisonous snakes

Biting mechanism in Cobra

Cobra is not an aggressive snake. When disturbed, it attempts to escape. When the snake attacks, the mouth opens by lowering the lower jaw. This makes the fangs to be erect to penetrate the muscles of the victim. When the mouth is closed the poison glands are pressed. The venom thus reaches the fangs and is injected into the body of the victim. This whole process takes place in no time.

Snake Venom

There are two types of snake venoms. One type acts mainly on the nervous system (***neurotoxic***). It affects the optic nerves (***causing blindness***) or the phrenic nerve of the diaphragm (causing paralysis of respiration). The other type is ***haemotoxic***. It breaks down the red blood corpuscles and blood vessels and produces extensive extravasation of blood into the tissue spaces.

6. 2. 3 Fouling Organisms

Several aquatic organisms cause damages to submerged surfaces. Since this infestation has an economical importance, several studies are being made. Marine sedantary organisms may affect piles, floats, wooden dry docks and boats. These organisms are called **foulers**. Most of these organisms are distributed all over the world through the agency of ships.

They are of economic importance, since fouling of ships results in increased resistance to movement through water, reducing the efficiency, lowering of speed, increasing fuel consumption and leading to wear and tear of engine. The efficiency of underwater sound equipments fitted on to commercial and naval vessels is also seriously affeceted as result of the accumulation of fouling organisms.

I. **Paleozoic era** :- This era produced revolutionary changes in the biosphere. Further this era saw the origin and the radiation of several groups of animals and plants that remained as the forefathers for the modern groups. Thus this era is known as the **Cradle of ancient life**.

1. **Cambrian period** :- (600 to 440 million years ago)

The period preceeding cambrian is known as **Pre-cambrian period**. During precambiran time simple algae, protozoans, poriferans, annelids, were well established. Thus the cambrian started with the plants and animals that were suceessful during the precambrian period. During cambrian among plants thallophytes were well establised. They diversified into various groups. (Chlorophyceae, Rhodophyceae etc.,). Among animals the aquatic arthropods and echinoderms came to prominence. The fossils of such organism were obtained from several places.

2. **Ordovician period** :- (440 to 350 million years ago)

Fig.7.2. *Cyathaspis*- an earliest jawless fish

This period was marked by formation of coral rocks and molluscs and echinoderms. Among plants the semi terrestrial bryophytes were getting established. Interestingly this period saw the origin of first vertebrates. These were the now extinct **agnatha**. (Jawless, armoured fishes). The origin of early vertebrates was the major event that happened in the evolution of animals. Among arthopods, the trilobites were more prominent during this period.

3. **Silurian period** :- (350 to 315 million years ago)

The oldest land plant originated in this period. These plants possesed conducting tissues. They colonised the land. Among invertebrates except for insects all others flourised. The corals diversified. Several coral islands were formed. Jawed fishes originated. The fishes developed scales and paried fins, for the first time jaws originated in fishes. Origin of paired fins and jaws is considered as major events in chordate evolution.

amphibians. The origin of land living amphibians were further increased by the proliferation of several land living insects.

6. **Pennsylvanian** :- (255 to 235 million years ago)

The land living forms became more successful during this period. There were huge forests of ferns and cycas. Due to geotectonic changes several forests got burried under the soil. Today's coal and petroleum are obtained from such resources only. Hence the Pennsylvanian and the earlier Mississippian were collectively krown as **Carboniferous** (carbon bearing) **period**.

7. **Permian Period** :- (235 to 210 million years ago)

It was the last period in the Paleozoic era. This period was marked by extinctions of several older groups of animals and plants. Nearly 60% of the organism that survived at that time became extinct. Some of the amphibians dramatically laid land eggs (cleidoic eggs). Specifically the group of organisms that laid such eggs are identified as Seymouria. These are considered as inter-connecting links between amphibians and reptiles.

II. **Mesozoic Era** :-

This middle period in the history of life was marked by the prominence of land living forms. Among animals the reptiles became more dominant. They increased in size and in number. Hence this era is named as the **Golden age of reptiles**.

1. **Triassic Period** :- (210 to 160 million years ago)

For the first time fossils of turtles, crocodiles, and dinosaurs have been obtained from this period. Fossil evidences show that aquatic and flying reptiles thrived during this time. The mammals orginated from reptiles during this period.

2. **Jurassic Period** :- (160 to 130 million years ago)

There was a marked adaptive radiation among dinosaurs. They diversified into carnivorus and herbivorus forms. The first birds originated from the reptiles. The earlist bird thus originated is known as the **Archeopteryx**. The origin of birds was a major physiological change among animals. From a more common poikilothermic condition through feathers the birds became homeothermic.

The modern bony fishes were diversified into several groups.

Cretaceous Period :- (130 to 65 million years ago)

The larger marine molluscs became extinct. The fossils of such organisms are available in places like Ariyaloor, of Tamil Nadu, today.

The Dinosaurs of the Mesozoic era abruptly became extinct during this period. Several reasons are given for the extinction of the dinosaurs. Fossils of dinosaurs were not obtained from later periods.

III. **Cenozoic Era** :- (65 million years ago till date)

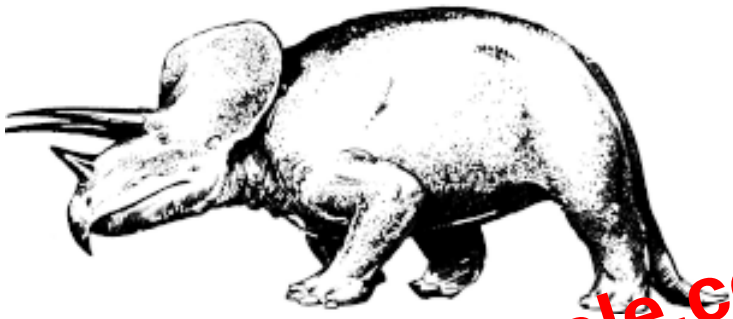

Fig.7.2.5 Triceratops - a horned dinosaur

Plenty of fossil of organisms belonging to this era had been obtained. All modern animals and plants were represented in these fossils. This era is subdivided into Tertiary and Quaternary periods. Further this era contains seven epochs. Through fossils we can trace the origin and evolution of independent groups of animals, camels and man.

1. **Paleocene epoch** :-

Modern placental mammals originated during this time.

2. **Eocene Epoch** :-

Ungulates originated. The ancestral form of modern horses lived during this epoch.

3. **Oligocene epoch** :-

Several animals with ancient characteristics became extinct. Modern mammalian families were established. The apes originated during this epoch.

4. **Miocene epoch** :-

Several varieties of grasses evolved in Europe and N. America. Thus large Priaries were formed. These changes encouraged the evolution of fast