PARASITOLOGY.

- It is the study of parasites, which infect and produce diseases in hosts.
- **Parasitism** is the interaction between parasites and hosts. Parasitism of two types namely endoparasitism and ectoparasitism. Endoparasitism is the type of parasitism in which parasites live within the host body. Ectoparasitism is the type of parasitism, in which parasite lives on the external surface of the body of host.
- **Parasite** is an animal or plant, which lives in or on the outer surface of the host. It derives food and shelter from the host, and may or may not cause damage to the host. A parasite which causes disease is known as pathogenic parasite or pathogen. Parasites are of two types namely endoparasites and ectoparasites.
- **Endoparasite** lives within the host body and are of four different types.
  1. **Obligate parasite** – The parasite which cannot exist without parasitic life in the host.
  2. **Facultative parasite** – Lives as parasite and also can lead free living life in the host.
  3. **Accidental parasite** – It attacks an unusual host.
  4. **Aberrant parasite** – Parasite migrates to the site of host in which it cannot live or develop further.
- **Ectoparasite** is the parasite which lives on the surface or superficial tissues of the host. Infection caused by this parasite is called **infestation**.
- **Host** is an organism, in which the parasite lives and it provides the nourishment and shelter to the parasite. It is large in size. Hosts are of six types.
  1. **Definitive host** – An organism, which harbours adult or highly developed form of parasite or in which parasite replicates sexually.
  2. **Intermediate host** – The host which harbours asexual forms of the parasites.
  3. **Reservoir host** – The animal which harbours the parasites and serves as an important source of infection to other susceptible hosts.
  4. **Paratenic host** – The host in which the parasite cannot develop further.
  5. **Natural host** – The host in which naturally infected with certain species of the parasites.
  6. **Accidental host** – The host, in which the parasite is not usually found.

ENTAMOEBA HISTOLYTICA.

Phylum - Protozoa
Super class - Sarcodina
Class – Rhizopoda
Genus – *Entamoeba*
Species - *histolytica*

OCCURRENCE – It has world-wide distribution, but clinical manifestations are frequent only in areas where sanitation is poor and standard of living is low. It is an endoparasite found in the **lumen, mucous** and **submucous** layers of the **large intestine** of human beings.

DISEASE CAUSED – It causes a disease known as **amoebiasis or amoebic dysentery,** primary **(intestinal lesions)** and secondary **(metastatic lesions), abscesses of liver, lungs etc**.

MODE OF TRANSMISSION – It is transmitted from man to man through contaminated food, drinking water or vegetables. Houseflies carry the **quadrinucleate cysts** on their legs and abdomen when they sit on faecal matter and transmit these cysts on the unprotected or exposed food, then enters into alimentary canal of man.

LIFE CYCLE – Entamoeba histolytica is a monogenetic parasite means life cycle involves only one host, i. e man. Entamoeba reproduces by **binary fission** and **Encystment**. Number of parasites is increased in the host by simple binary fission. The cystic form is passed in the faeces of the host. Encystment occurs in the lumen of bowel. It is a preparatory stage to infect a new host. Before Encystment the active amoebae divide to produce smaller forms which expel food particles.

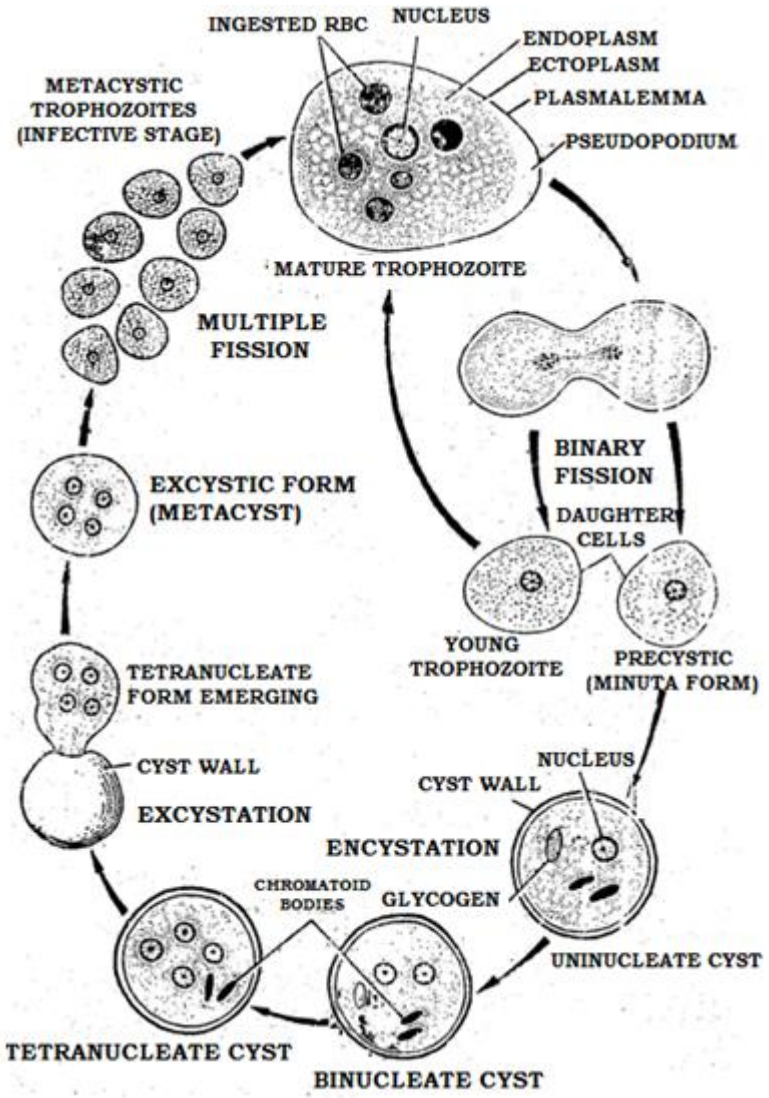
Infestation begins when food containing cysts are taken by man. Each cyst is spherical / ovoid contains four matured nuclei with stored food, is mature stage, protected by a resistant cuticle. These remain viable and are capable of inducing new infection. The cyst reaches the stomach along with food and then to small intestine, where the cyst wall is dissolved by a powerful proteolytic enzymes trypsin and four nuclei come out by a process called **excystation**.

Eight **amoebulae** are formed from each cyst, are very active and reach the large intestine, pierce the mucous membrane, and settle in the submucosal layers, spread laterally and produce a flask shaped ulcer, which has a narrow neck leading to the lumen of intestine and a dilated distal part in the submucosa.

TROPHOZOITE – The young amoebulae voraciously feed on the submucosal tissues and grow rapidly. This secretes a proteolytic enzyme called **histolysin** which can dissolve the intestinal layers of man. Parasite causes intestinal lesions in host by continuous invasion and consumption of the mucosal layers of intestine. Few trophozoites, dead mucosal and blood cells can be detected in the faeces of infected persons. In acute infections the trophozoite may reach the portal veins of the intestine, liver, lungs and brain, where they form secondary abscesses.

After completion of growth phase, amoebae multiply by simple binary fission to produce large number of daughter amoebae during multiplication phase. These cause extensive damage to the intestinal wall.

ENCYSTMENT- After active growth and multiplication amoebae withdraw their pseudopodia and become round in shape. The nucleus enlarges and divides into four nuclei and **chromatin** matter increases. Reserve food (glycogen) is secreted by the cytoplasm. Then the cell wall becomes thick by deposition of cuticle to form a hard resistant cyst wall is called encystment. Further development of this is possible only if it gains entry into a new host. The cyst is able to survive in the soil for about 10 days. By contaminated food by flies or by mechanical means the cyst may reach the human intestine and cycle is repeated.



LIFE HISTORY OF *ENTAMOEBA HISTOLYTICA*.

PREVENTIVE MEASURES.

- Personal health and hygiene.
- Food stuffs, drinking water and utensils must keep clean.
- By preventing contamination of food by houseflies, ants, mice, cockroaches etc.
- Treat the vegetables with acetic acid and vinegar at least for 15minutes before consumption as salad.

- Improvement of general sanitation by proper disposal of faeces.
- Prevention of water supply from faecal contamination.
- Washing hands with soap and water after handling dirty articles before taking meals and after using toilet.
- Cutting finger nails regularly.

SYMPTOMS- Abdominal pain, nausea, bowel irregularity with fatigue and head ache.

TREATMENT- Metronidazole, emertin, iodine and arsenic compounds

LEISHMANIA DONOVANI.

Phylum – Protozoa

Sub phylum – Sarcomastigophora

Super class – Mastigophora

Class – Zoomastigophora

Genus – *Leishmania*

Species - *donovani*

OCCURENCE – It is an obligate intracellular parasite of man and other mammalian hosts. It is always found as intracellular amastigote form in leucocytes or reticulo-endothelial cells of liver, spleen, bone marrow, lymphatic glands etc. In sandfly found in buccal cavity, pharynx, salivary glands, midgut.

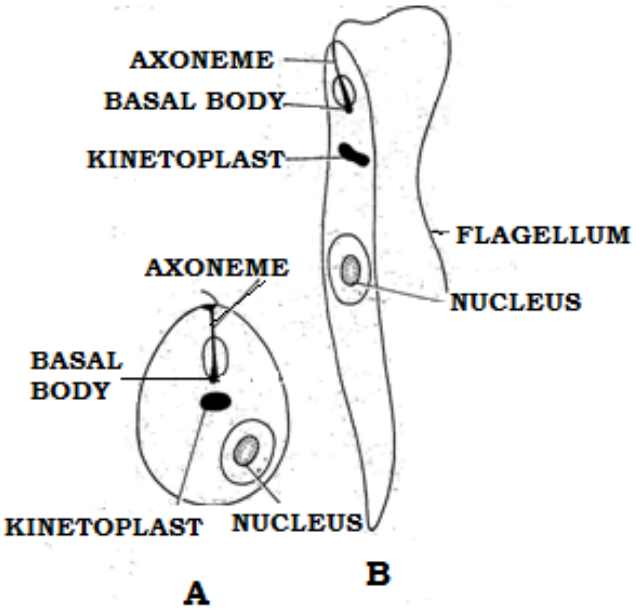
DISEASE CAUSED – It causes visceral leishmaniasis / Kala-azar / Dum dum fever / black fever / Asian fever / Assam fever / infantile splenomegaly in various parts of the World.

MODE OF TRANSMISSION – It occurs in two forms namely **amastigote (leishmanial)** and **promastigote (leptomonad)** forms. Amastigote form is transmitted to the man by the bite of anthrophilic **Phlebotomus argentipes** (sand fly) and less frequently by blood transfusion, congenital infection, accidental inoculation of cultured promastigotes in the laboratory workers and sexual intercourse.

MORPHOLOGY- The Parasite exists in two forms:

Amastigote (Leishmanial) form- In man and other mammals.

- It is a white or round cell about 2-4mm in size.
- It is found in macrophages, monocytes, neutrophils or endothelial cells.
- It has large oval, peripheral nucleus, Kinetoplast right angle to nucleus.
- A delectate thread like axoneme arises from blepharoplast and extends to the anterior tip of the cell.
- Near the Kinetoplast a small clear vacuole is present.
- Flagellum is absent.



A- AMASTIGOTE (LEISHMANIAL) FORM IN MAN

B – PROMASTIGOTE (LEPTOMONAD) FORM IN SANDFLY

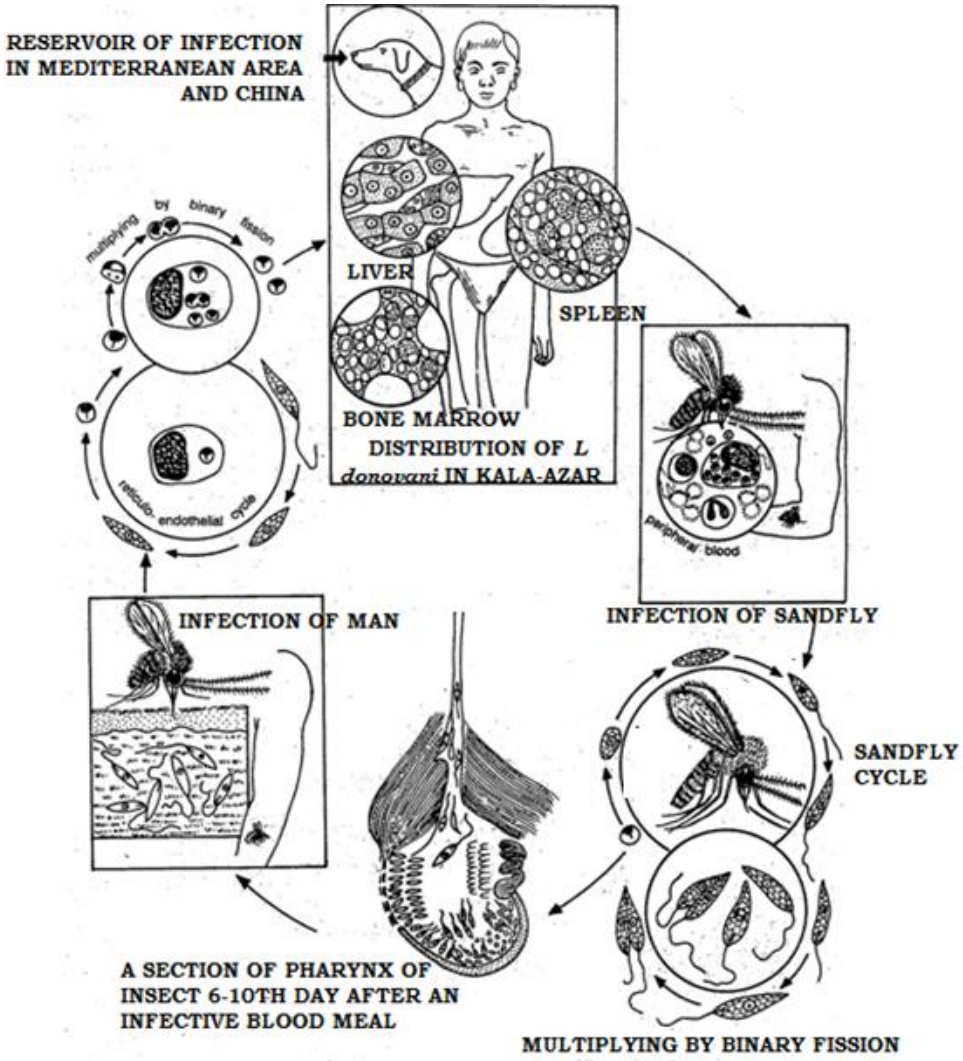
Promastigote form- Present in Insect vector (sand fly).

- It measures about 15-25µm and 1.5-3.5µm in breath.
- It is short, oval or pear- shaped forms, subsequently become long spindle-shaped cells.
- A single nucleus situated at center and kinetoplast lies transversely near the anterior end.
- A vacuole is present near the root of flagellum.
- Delicate, single, about 15-28µm long Flagellum arises from basal body.

LIFE CYCLE.

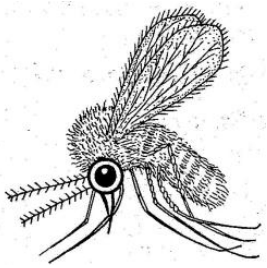
Leishmania is **digenetic** parasite. It completes its life cycles in two hosts. Primary / principal host is a man or other mammals like dog. The secondary / intermediate host or vector is female sand fly (***Phlebotomus***). Mammals like dog, jackals, and squirrels are reservoir hosts, in which the parasite does not undergo any change but waits for human host in other countries, but in India canine leishmaniasis does not exist so the man is the main and sole host.

LIFE CYCLE IN MAN – When infected sandfly bites man it liberates the parasites in the skin wound caused by the proboscis. But actual mode of transmission is not clear in India. It does not bite but spreads infection by crushed possibly by slapping. The **promastigote (leptomonad)** forms are introduced into human body. Some of those enter the blood directly but they become destroyed. While those enter the reticulo-endothelial cells of liver, spleen, bone marrow and lymph nodes change into **amastigote (leishmanial)** forms. These undergo slow binary fission so that the host cells become greatly enlarged. The host cell ruptures when there are about 50-200 or more parasites and liberate outside, then these are taken by new host cells and multiplication is repeated so that the reticulo-endothelial system becomes progressively infected. Some free amastigotes enter neutrophils and monocytes by phagocytosis and spreads the infection.

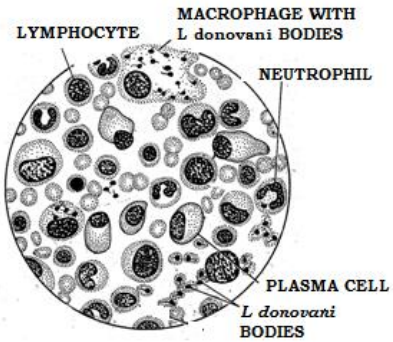


LIFE CYCLE OF *LEISHMANIA DONOVANI*.

LIFE CYCLE IN SANDFLY – When **sandfly** insect sucks the blood of infected person, free amastigotes and heavily parasitized neutrophils and monocytes enter the proboscis of female vector along with blood meal. In the mid gut of the sandfly, the amastigote forms transformed within 72 hours through series of flagellated intermediate promastigote forms to flagellated promastigotes. These multiply by longitudinal binary fission. In 6-9 days the number becomes enormous and spread into the pharynx and buccal cavity. Sandflies that ingest fruit or plant juice after the first blood meal show heavy pharyngeal infection and causes blockage of the pharynx. Such sandfly transmits infection to new host when it bites susceptible person and the life cycle is repeated.



SANDFLY (*PHLEBOTOMUS*).



SMEAR OF BONE MARROW FLUID FREE AND PHAGOCYTOSED AMASTIGOTES

PREVENTIVE MEASURES.

1. Eradication or reduction of sandfly population by spraying of insecticides mainly DDT, dieldrin, malathion etc.
2. Reduction of reservoir hosts by killing all the infected dogs in the cases of zoonotic kala-azar and treatment of human cases.
3. Prevention of exposure to sandfly by using thick clothes, bed nets, window mesh or insect repellents.

FASCIOLA HEPATICA (SHEEP LIVER FLUKE).

Phylum: Platyhelminthes
Class: Trematoda
Order: Digenea
Family: Fascioliodae
Genus: *Fasciola*
Species: *hepatica*

OCCURANCE: Adult fluke lives primarily in the bile tract of infected domestic and wild herbivorous animals like **sheep**, goat, horse, ass, ox, rabbit, elephants, man, monkey etc. It spends a part of its life history in an intermediate host **snail (Limnae truncatula or planorbis or bulinus).**

MODE OF TRANSMISSION: Infection is transmitted through contaminated **aquatic vegetations** and **water** which contain metacercariae. One sheep with moderate infection can contaminate the pasture with more than **2.5 - 3 millions** of eggs in a day. Man is accidental host. Mainly transmission occurs between sheep, cattle and snails. Infection is transmitted by ingestion of contaminated water plants mainly water cress and lettuce and other aquatic plants that are eaten raw, drinking contaminated water from irrigated canals, consumption of raw, infected sheep, goat or cow liver.

DISEASE CAUSED: The adult fluke causes disease known as **liver rot** in sheep and other animals. Migrating adult fluke causes extensive **haemorrhage**, **hematomas** and damages in the **liver** and inflammation of **bile duct**. The affected sheep usually dies.

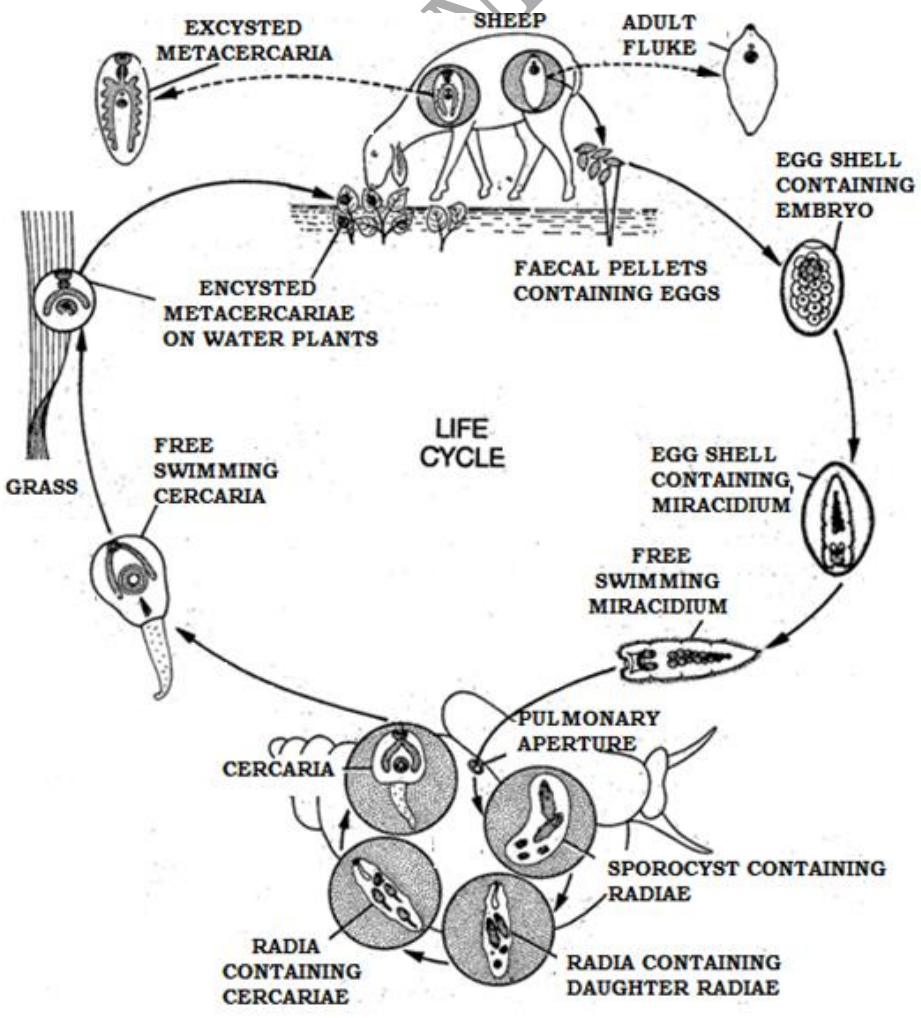
LIFE CYCLE.

§ Fasiola hepatica is **digenetic** parasite. The primary (definitive) host is sheep or cattle and secondary host is snail. Life cycle is complicated with number of larval stages. Sheep and other herbivorous animals and occasionally man acquire infection by consumption of aquatic plants containing **metacercariae**. These are round with **0.2mm** in diameter and with thick cysts. These infective metacercariae survive for weeks on grass and near water then enter the primary host then reach the intestine and excyst by digestive enzymes and young flukes come out. These young flukes migrate through the intestinal wall and peritoneal cavity and invade the liver capsule. So these larvae migrate through the hepatic parenchyma in to the hepatic portal system and common

bile ducts where they develop and sexually mature in to adults. The larvae sometimes also travel to ectopic body sites and develop in to adults and remain for years by feeding on hepatocytes and duct epithelium. Adult flukes begin to lay unembryonated eggs about four months after infection, which traverse the **sphincter of Oddi** and **intestine** from where they are excreted along with faeces in about **4-6 months** after infection.

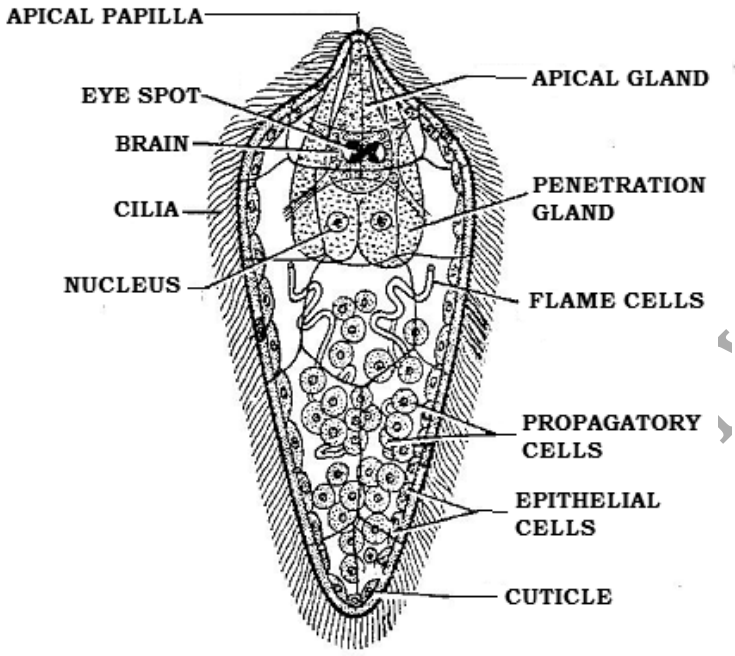
§ Further development of eggs takes place in water. Inside each egg the oval, ciliated, minute **miracidium** larva developed within 2-3 weeks. This larva escapes from the egg and invades appropriate secondary host snail usually within 8 hours otherwise it dies.

§ Inside the snail miracidium larva adheres by its apical papilla and enters the pulmonary sac then penetrates in to body tissues and finally reaches the digestive gland, and multiplies asexually through single generation in to second larval stage known as **sporocyst**. This move in the host tissues and its germ cells divide and passes through embryogenesis to give rise to third larval stage known as **radia**. Sporocyst forms 5-8 radiae, escape out by rupture of wall, feed on host's tissue and migrate to the liver of snail. The germ cells of radiae give rise to daughter radiae during summer but in winter it produces large number of 4th larvae **cercariae** within 4-7 weeks, few swimming cercariae escape from the snail in to water and attach to surfaces of aquatic vegetation in which they encyst over a few hours.

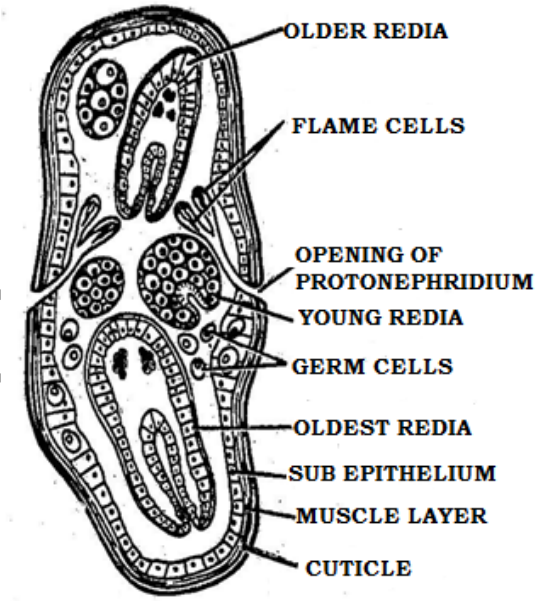


§ The infected plants with **metacercariae** infect the man and other definitive host when ingested and lifecycle is repeated.

MIRACIDIUM LARVA - It is microscopic, dorso-ventrally flattened, conical, free swimming, first larval stage of liver fluke. Animal body is uniformly covered by cilia. It has an outer layer of hexagonal cells arranged in 5 rows and a thin layer of muscles beneath the outer layer. Anterior end produced into conical apical papilla. Presence of apical gland, penetration glands, brain, two eye spots and flame cells, rudimentary gut and germ cells. This larva swims in search of an intermediate host, **Limnaea truncatula** for about 4-30 hours. If it does not come in contact with a suitable host, it dies. If it gets suitable host, it pierces into tissues of snail by apical papilla.



MIRACIDIUM LARVA.

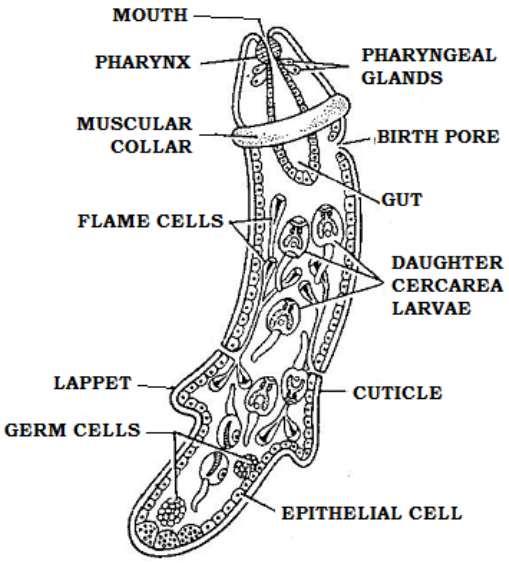


SPOROCYST LARVA.

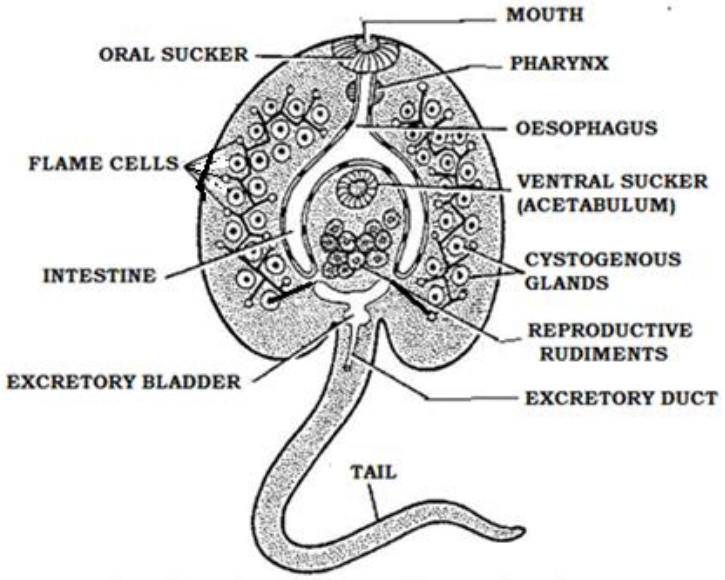
SPOROCYST LARVA- It is elongated sac-like of about 0.7 mm long. Its body wall is similar to body wall of miracidium except ciliated epithelium, which is lost in the process of penetration and immediately replaced by a thin cuticle. Glands, brain, eyespots and apical papilla of miracidium degenerate and disappear. Each protonephridium divides into two flame cells, on either side opens outside by a common excretory pore. Larva moves in the tissue of host and absorb nutrients and germ balls of each sporocyst develop into the 5-8 rediae larvae.

REDIA LARVA- It is elongated, cylindrical of about 1.3 – 1.6 mm long, sac-like, develops from the germ cells of the sporocyst. Body wall consists of cuticle, musculature of outer circular and inner longitudinal fibres and sub epithelium. Anterior mouth leads into muscular pharynx, which finally leads into sac-like intestine or gut lined by a single cellular layer. Many unicellular pharyngeal glands open into pharynx. Collar (muscular ring) lies behind the pharynx, and two stumpy lappets lie at the ventro-lateral of posterior region help in locomotion. Protonephridia divide further to form a much branched system,

flame cells of each side open outside through a common excretory duct. This larva enters various organs of snail but prefers to migrate to its digestive gland. Larva contains germ balls between the body wall and intestine which give rise to second generation of rediae which are similar to the parents during summer and when sufficient nourishment is available. During winter germ balls of rediae of second generation develop into the next stage cercariae larvae. Birth pore lies just posterior to collar, through which about 14-20 cercariae larvae comes out from redia.

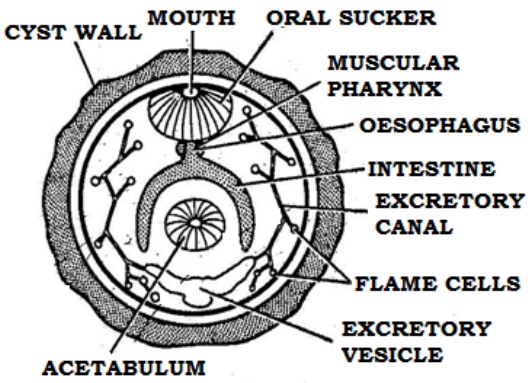


REDIA LARVA.



CERCARIA LARVA.

CERCARIA LARVA - It is developed from redia larva, comes out from the body of snail. It is flat, oval with tail for swimming. body wall is made up of cuticle, muscles and mesenchyme. It has two suckers, an anterior oral sucker present around the mouth and a ventral sucker in the middle of the body. Digestive system consists of mouth, muscular pharynx, oesophagus and inverted **"∩"** shaped intestine. Body space is filled with parenchyma and contains a few cystogenous glands on either side which form the cyst of the future larva. Excretion by flame cells. Presence of rudimentary reproductive organs. After swimming for a short period it attaches to the aquatic plants and finally undergoes encysted larva called metacercaria which is swallowed by the sheep.



METACERCARIA LARVA.

METACERCARIA LARVA – It is round with diameter of about 0.2 mm. Actually it is the juvenile fluke and also called as ***marita***. It is externally covered by thick hard cyst wall for protection against short periods of desiccation. It has large number of flame cells, **"∩"** shaped intestine and two suckers. Tail and cystogenous gland cells are absent. Excretory bladder opens out directly through a single pore. Genital rudiments are present.

PREVENTIVE MEASURES.

1. Through cleaning and washing of aquatic vegetables before consumption.
2. Introducing ducks in the ponds which feed on intermediate host snail.
3. By adding copper sulphate in the pond which kills the snails.
4. Treatment of infected sheep and cattle by drugs like **fasciolicides** to reduce excretion of eggs in the faeces.
5. Killing heavily infected sheep.
6. Health education.

TAENIA SOLIUM (PORK TAPEWORM).

Phylum – **Platyhelmenthes**
Class – Cestoda
Order – Taenoidea
Family – Taenidae
Genus – *Taenia*
Species - *solium*

OCCURENCE – It is cosmopolitan form, found in the World where pork flesh is consumed without proper cooking. The adult worm inhabits the small intestine of man and its larval stages occur in the different organs, especially in the muscles of secondary (intermediate) host i.e pig.

DISEASE CAUSED – It causes a disease known as **taeniasis**. Sometimes during its course of journey, the cysticercus may reach the eye, heart, spinal cord or brain causing disturbances in the respective systems. Patients may become anaemic. Brain infection leads to **epileptic convulsions**.

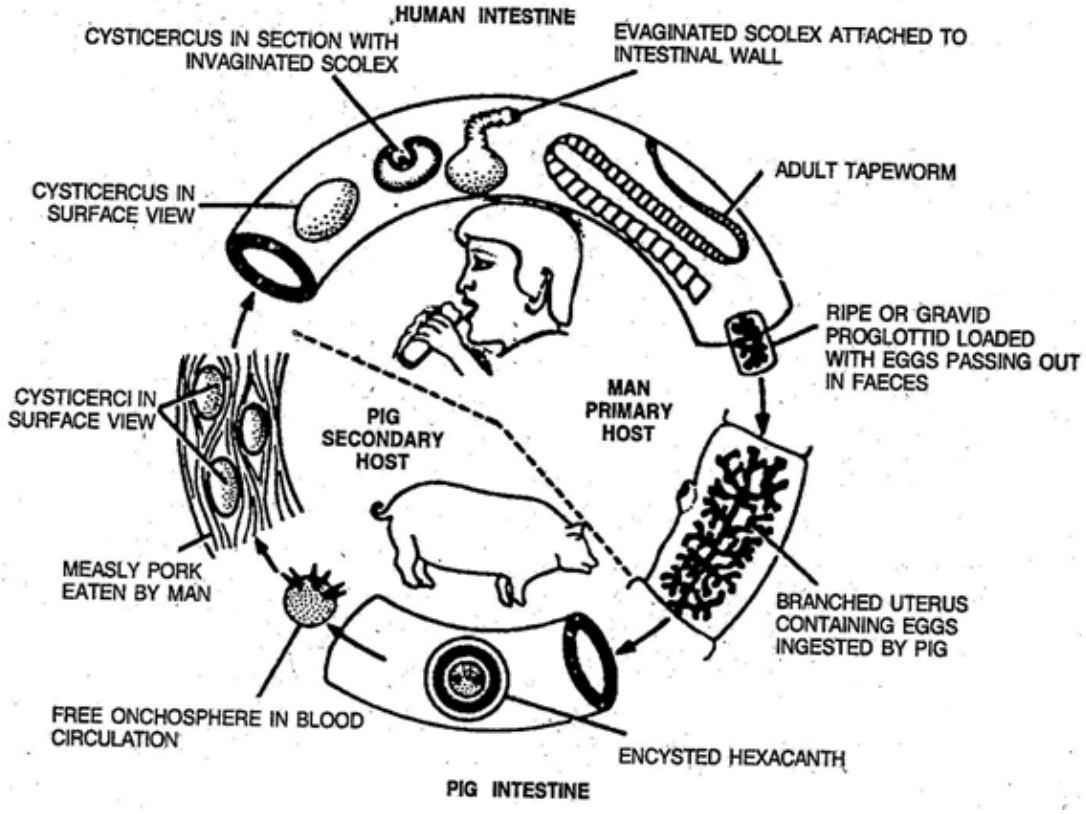
MODE OF TRANSMISSION – Man gets infection by ingestion of improperly cooked measly (infected) pork with **cysticerci**. These reach the small intestine and become active. Within 8-12 weeks become adults. Gravid proglottides with fertilized eggs pass out with the host's faeces. The secondary host acquires infection by ingesting human excreta with **onchopsheres**. Man himself may serve as the secondary host by ingesting onchopsheres with inadequately cooked or raw vegetables.

LIFE CYCLE.

- Taenia solium is **digenetic** form. The definitive host is **man** and intermediate host usually **pig** and sometimes dog, sheep, goat, cattle, horse, bear, monkey and man is occasional intermediate host.
- Life cycle is much simpler without a free larval stage. Man acquires infection by ingestion of raw or undercooked infected beef with live cysticerci. The chitinous wall of the larva is digested by gut enzymes of man and later with the help of bile in the small intestine. The scolex invaginates and attaches itself to the intestinal wall and begins to produce a chain of segments by strobilization. It develops into adult worm in **8-12 weeks**. When the proglottides become mature, copulation and mutual transfer of sperms take place between adjacent segments of the same animal by bending and folding of the ribbon shaped body. Normally inside the human body only a single tapeworm survives, hence **self fertilization** is the only method possible. Fertilization takes place in the terminal part of **vagina** and zygotes are formed. Zygotes reach the **ootype** and are covered by yolk cells and shell gland secretions and finally get invested inside the uterus. After fertilization other reproductive structures except the uterus disintegrate. The space in each gravid proglottid is completely filled with 7-13 branches of uterus in which there are fertilized and developing eggs. In the human intestine the gravid segments from the hind end of tapeworm detach and released outside along with the host's faeces. Inside the uterus fertilized eggs undergo some developmental processes to produce **hexacanth** embryos (onchopsheres). There are about **30,000- 40,000**

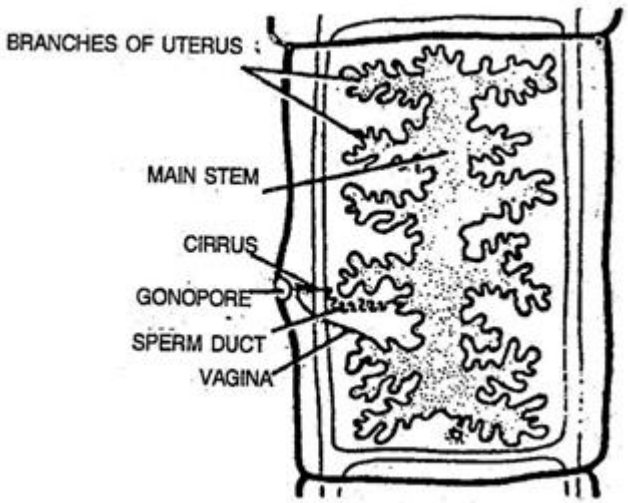
onchopsheres. Each onchosphere is a ball-like with six hooks. Gravid proglottid ruptures in the soil to release embryos.

τ These embryos are scattered around and infective to pig and man also when intermediate host ingests the embryos along with faecal matter, enter the secondary host's alimentary canal, then enter the portal circulation and travel to different organ systems like **portal veins, liver, right side of heart, lungs, left side of heart, systemic circulation** then reach preferably muscles of **tongue, neck, shoulder** and settle there. Hooks of the embryo are lost in the muscles and cells in the center are liquefied and the embryo becomes oval in a week called **bladder worm (cysticercus cellulosae)**. The larva has a small body with an invaginated proscolex with spines and suckers and secretes a chitinous covering and stays dormant in the pork muscles. About **2500 larvae** are present in **500 gm** of pork muscle. When man eats measly pork larvae enter into alimentary canal. Sexual maturity attained in **3-4 months** and the life cycle is repeated.

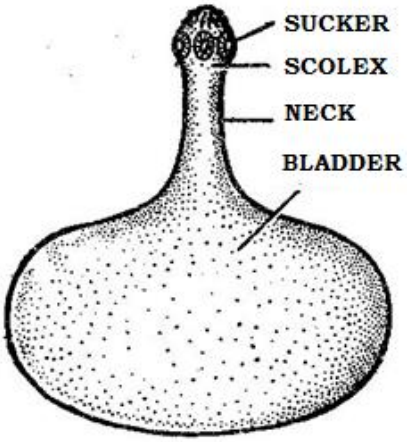


LIFE CYCLE OF TAENIA SOLIUM.

BLADDER WORM LARVA - It is also known as **"Cysticercus larva"** and develops in the muscles of intermediate host pig. The Onchopsheres first reach the stomach of pig with faeces of man, and then migrate to the muscles where the hooks are lost, cells in the center of the embryo disappear to produce a single layered large ovoid bladder, filled with fluid. As the bladder increases in size it invaginates at one side to form suckers and hooks is called proscolex of 6-18 mm long. Further development takes place in man, when man eats the contaminated part of pig muscles called measly pork, which contains cysticercus larva between muscle fibres and connective tissue.



GRAVID PROGLOTTID.



BLADDER WORM LARVA.

PREVENTIVE MEASURES.

- τ By providing proper sanitary facilities to prevent transmission of tape worm eggs to the intermediate host.
- τ By proper cooking of pork flesh to destroy cysticercus larva.
- τ Examination of flesh in slaughter houses at regular intervals for detecting tape worm infection.
- τ Personal hygiene to prevent autoinfection.

ASCARIS LUMBRICOIDES (ROUND WORM)

Phylum – Nematoda
Class – Phasmidia
Order – Ascaroidea
Family – Ascaridae
Genus – *Ascaris*
Species - *lumbricoids*

OCCURRENCE – It is worldwide in distribution. It is found in warm and moist places. In man the adult worm is found in the **small intestine**, particularly in the jejunum and middle part of the ileum, especially in children.

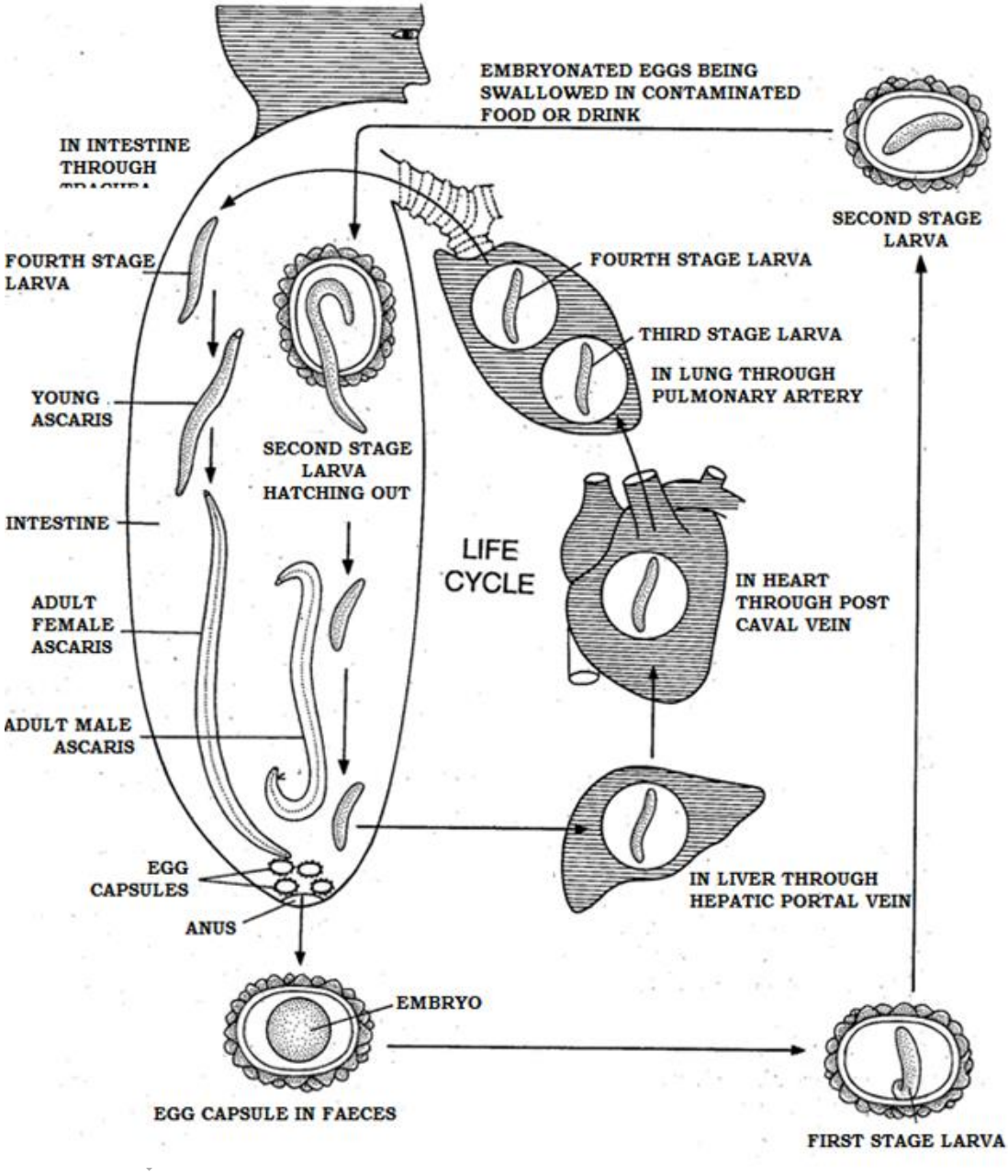
MODE OF TRANSMISSION – Man acquires the infection by ingestion of food, water or raw vegetables contaminated with **embryonated eggs** of the round worm. Eggs are excreted by man along with faeces and these remain viable in the moist soil for years, then under favourable conditions the eggs develop into active embryos, which infect the healthy man.

DISEASED CAUSED – It causes a disease known as **ascariasis**. It is more common in children than adults.

LIFE CYCLE.

- It is **monogenetic.** Life cycle is completed in single host, i.e man, because no intermediate host is required in the life cycle. Man acquires the infection by consuming food and water and raw vegetables contaminated with embryonated eggs of the round worm.
- The ingested eggs hatch in the small intestine **(duodenum)** to liberate the larvae. These larvae then penetrate the **mucous membrane** of the intestinal wall, enter **lymphatics** and **vacuoles**. These larvae are carried by the **hepatic portal system** to the **liver**, where they live for 3-4 days then carried to the **right heart**, then to the **lungs**.
- In the lung alveoli, the larvae increase in length and **moult twice** i.e first on **5th** day to become third stage larvae then second moult takes place on **10th** day to become **fourth stage** larvae. These larvae then breakout of the pulmonary capillaries and reach alveoli then ascend to **trachea, throat** and **oesophagus** then back to **small intestine**.
- In small intestine **fourth** stage larvae moult between **24-28** days of infection. The larvae of **2-3 mm** long grow to become adult and mature sexually in about **6-10 weeks** of infection. After fertilization each female begins to lay about **200,000 eggs** daily, which are passed in the faeces within **60-75** days of infection. The eggs have a thick, clear inner shell covered by a warty, albuminous coat. These eggs contain unsegmented ovum are not infective to man. These remain viable for years and complete drying is lethal.
- For further development they require a temperature lower than that of human body, a trace of **moisture** and **oxygen.** In moist soil with a temperature of **20-40^{0}C** and **humidity** over **40%,** first stage rhabditiform larvae develop inside the egg within **10-15** days. The first stage larvae undergo first moult while still inside the eggs to become second stage larvae on 7th day. These embryonated eggs with

second stage **rhabditiform** larvae are infective to man. These cause infection in another man and life cycle is repeated.



PREVENTIVE MEASURES.

- Soil pollution should be prevented, as it is chief source of infection and use of sanitary latrines.
- Vegetables grown in polluted soil should be thoroughly washed and boiled before consumption.
- By avoiding use of untreated faeces as fertilizers.
- By teaching children early in life to wash their hands before eating.
- Deworming of school children have been found effective in control of ascariasis in some Asian countries.
- Treating infected individuals.
- Personal hygiene.

WUCHERERIA BANCROFTI (FILARIAL WORM).

Phylum – Nematoda
Class – Phasmidia
Genus – *Wuchereria*
Species - *bancrofti*

OCCURRENCE – It is widely distributed in **Western** and **Eastern hemisphere**. Adult worms are found in the **lymphatic vessels**, especially in the **lymph nodes** of the humans and other vertebrates. **Microfilariae** are found in the peripheral blood but occasionally also found in **chylous urine** or in **hydrocoele fluid**.

MODE OF TRANSMISSION - Man acquires infection when a female Culex or Anopheles / Aedes mosquito bites, carrying the metamorphosed larva. The larvae are deposited in the skin then penetrate the dermal layers and reach the lymph ducts. Microfilariae are ingested by the mosquito from infected humans and infect another healthy human.

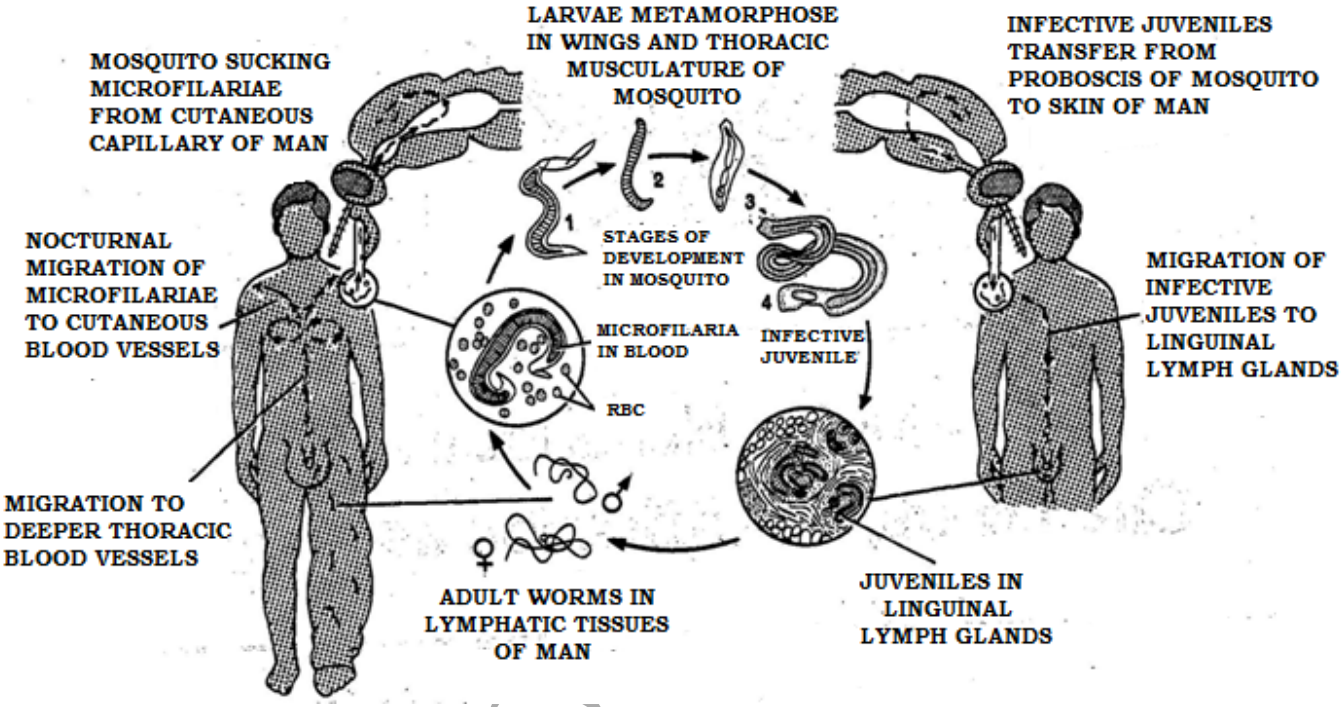
DISEASE CAUSED – Wuchereria bancrofti causes a disease known as **wuchereriasis / filariasis / elephantiasis**. Causes inflammation of lymph channels or glands. Male genital organs, arms, legs and breasts of the females are more prone to infections. Inflammation of lymph ducts called **lymphangitis**.

LIFE CYCLE.

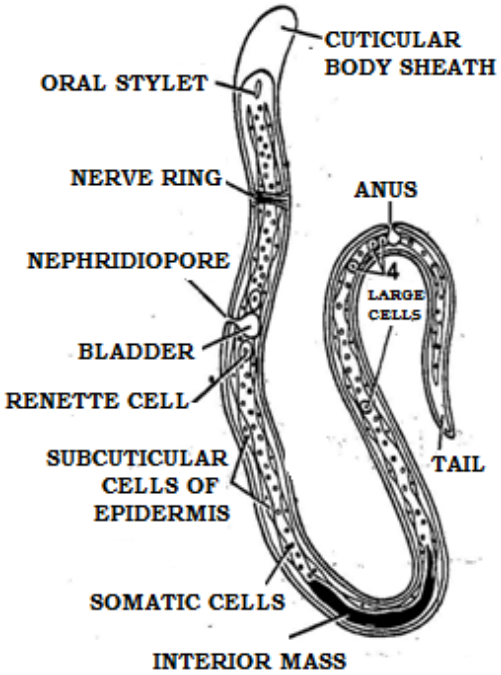
- It is digenetic parasite, as it is completing its life cycle in two hosts. Definitive host is man and intermediate host is mosquito- female **Culex / Anophele / Aedes** species.
- Man acquires infection by the bite of infected mosquitoes during which the **third stage larvae (L3)** are deposited on the skin. These larvae enter through the punctured wound made by the mosquitoes on the normal skin, on their own to reach the peripheral lymphatic vessels. Then these larvae quickly migrate to inguinal lymph nodes where they metamorphose and grow to sexually mature adult worms.
- The adult male and female worms live as coiled structures in regional lymphatic vessels and nodes. Mating takes place in the lymphatic ducts of man. Reproduction is by **ovo-viviparous** method. Adult worms cause **lymphangitis,** is caused due to the allergic reaction of the tissues due to some secretion of the adult parasites. This reaction may lead to the inflammation of the lymph glands. The irritation caused by the movement of the worm inside the lymphatic system. The lymph ducts are obstructed by the adult worm or by the inflammatory thickening of the walls of the lymphatic ducts.
- Females discharge microfilariae, which escape from smaller lymph capillaries to major lymphatic trunks and finally reach the peripheral blood in **8-12 months** of infection.
- Microfilariae circulate in the blood for 6 months to 2 years. Each microfilaria is about **300 μm** in length and **10 μm** in breadth, with transparent body. It is covered by a thin hyaline sheath which extends beyond the ends of the larval body. Inside this, larva slides forward and backwards. If not taken by the

mosquito microfilariae die. Further development takes place in an intermediate host.

- The microfilariae have **nocturnal periodicity**, i.e they flow in the peripheral blood during night. When mosquito bites a person, carries microfilariae which loose their sheath within **2-6 hours** of their arrival in the stomach. Then some of these larvae quickly migrate to the thoracic muscles within **4-17 hours**. In next 48 hours, these slender microfilariae develop and moult into short, thick and **sausage-shaped** worms with spiky tail called first-stage larvae (L1).



LIFE CYCLE OF WUCHERERIA BANCROFTI.



MICROFILARIA.

- **L1** larvae measure about **124-250 μm** in length and **10-17 μm** in breadth. In **3-7** days these larvae moult into larger sausage-shaped second stage larvae (L2).

- **L2** measure **225 – 300 μm** in length and **15-30 μm** in breadth. By **10th** and **11th** day they finally moult to the third stage larvae (L3).
- In each larva cuticle is shed off, tail atrophies and the internal organs begin to develop. Each grows about **15 mm** long and provided with three sub terminal **caudal papillae** and it is infective to man.
- **L3** larvae migrate to the salivary glands of mosquito on **14th** day of infection, then migrate to the proboscis of the mosquito and remain ready to enter the human blood stream when it bites a healthy person.
- Development of microfilariae is related to the atmospheric temperature. Development completes within **10-20 days**. In mosquitoes microfilariae do not multiply to increase in numbers, each develops into infective larva (L3).

PREVENTIVE MEASURES.

- Eradication of mosquitoes by spraying insecticides like **DDT, malathion** etc.
- Biological control by the use of carnivorous bacteria, fish and spore forming bacterium.
- Environmental control by efficient drainage and sewage system to eliminate mosquito breeding places.
- Reduction of man-vector contact by the use of mosquito nets and house screens.
- Keeping infected persons away from mosquitoes there by checking further spread of the disease.
- Treatment of filarial parasites with drugs like **hetrazon**.

PARASITIC ADAPTATIONS IN FLATWORMS.

- ♥ Animals are thin, dorso-ventrally flattened which is beneficial for endoparasitic mode of life as it enables the parasite to fit in narrow spaces in the host, it quickens the elimination of **carbon dioxide** by diffusion and it facilitates distribution of food digested in gut or absorbed through the **skin** as in **Taenia.**
- ♥ In parasitic flatworms **epidermis** is absent. External body covering or **tegument** is **thick**, permeable to water but **enzyme-resistant**, so that parasite is not digested by digestive **enzymes** and **antitoxins** of the host in **Liverfluke**. In Tapeworm tegument is freely permeable to water and nutrients, but protects against digestion by **host's alkaline digestive juices**. This ensures survival of the parasite in their environment.
- ♥ The parasites have an abundant supply of readymade food and they have not to face the competition with its fellows. In majority of the parasites **locomotory organs** are **absent** as not required by adult, but in some free swimming larvae like **miracidium cilia** and in **cercaria** locomotory **tail** is present. **Tapeworm** lack locomotory organs throughout life.
- ♥ **Internal osmotic pressure** is higher than that of the surrounding host's fluid or tissue and **pH tolerance** is high (4-11pH).
- ♥ **Adhesive** structures like **hooks**, **spines** and **suckers** serve for attachment with the host's body tissues. **Adhesive secretions** are common in parasitic forms.
- ♥ **Alimentary canal** may be **incomplete** or **absent**. In some parasites there is no undigested food for egestion, but some absorbs readily available digested food of the host through their body surface. **Suctorial pharynx** helps in sucking bile. Much **branched intestine** serves to distribute digested food to all parts of the body.
- ♥ The intestinal flatworms secrete **antienzymes** which neutralize the digestive enzymes of the host. Tapeworms stimulate host's intestine to produce a large quantity of **mucus**, that surrounds the parasite to further reduce the action of **host's enzymes** and **Lime cells** in the body wall neutralize the acids formed in the host's gut.
- ♥ Some endoparasitic flatworms simply avoid **host's immune system** by dwelling at the gut that is largely out of the reach of the immune system of the host. **Blood flukes conceal** themselves immunologically by absorbing the host's antigens on to their surface so that the host's immune system does not recognize them as "**foreign body**" or "**nonself**".
- ♥ **Circulatory, respiratory** and **sense organs** are **absent** as they are not needed. **Nervous system** is **poorly developed**. But free-swimming **miracidia** has sensory **eye spots**. Parasites must have marked **chemotaxis** that enables them to find their way to final habitat in the host's body.
- ♥ Respiration is **anaerobic** as free **oxygen** is not available in the body of host.
- ♥ Reproductive system is well developed. A large number of eggs are produced; face many challenges to survival of species.
- ♥ A fertilized egg, along with one or more yolk cells, is enveloped by a **resistant shell** (capsule), which leaves the host and lie in the open. The shell protects

the egg or the developing embryo from injury, desiccation, high and low temperature, etc. this adaptation ensures survival of the parasite outside the host.

- ♥ Infective larvae of many parasites are covered by cyst wall that facilitates their access to the primary host. For example the cercaria larvae of Fasciola encyst on the aquatic plant **Trapa**. **Hexacanths** of Taenia solium encyst in muscles of **pig**, forming **cysticerca**. These encysted larvae are taken by human being with undercooked or **raw pork**.
- ♥ Parasites face a problem of migration from one host to another, so capsules are produced. **Liverfluke** may lay about **50,000 capsules**, **tapeworm** can live about **30 years**, every year it sheds about **2500 gravid proglottids**, each containing **30,000 – 40,000 onchospheres**. Thus there is increased **fecundity rate**.
- ♥ Flatworms have **complex life cycle** due to the formation of several larval forms that inhabit one or more intermediate hosts. This adaptation brings about dispersal and reduces the period of exposure to the hazards of external environment.
- ♥ **Hermaphroditism** and **proglotization** ensures self-fertilization even in the absence of another companion for copulation. It is necessary for survival of the species.

PARASITIC ADAPTATIONS OF LEECH.

- Most leeches have a **semi-ectoparasitic life, Sanguivorous** sucks blood of vertebrates and they show parasitic adaptations.
- It lives in **fresh water pools, ponds**, slow running streams and mashes which are regularly visited by cattle, human beings and other mammals for bathing and drinking water. This **ensures regular supply of host**.
- It prefers to live in shallow waters, hide under stones, weeds, and logs for **protection**. **Dark Olive green** colour of the body helps hiding in undetected **weeds**.
- Its **active swimming** habit is ideal for **searching** the host and **escaping** from **predators**.
- It is **long, flattened, limbless** body is suited for aquatic life and offers **minimum resistance** to water, **slimy covering**, and **cuts down friction** in water and **prevents desiccation** of the body when the leech is exposed to air or when it comes on land.
- **Suckers** are **organs of locomotion** and also provide firm adhesion to the host's body at the time of feeding.
- **Three denticulated jaws** are highly specialized **weapons** for inflicting a painless **triradiate wound** on the host's skin for **sucking blood**. Certain secretions from the cutting apparatus of leech act as **local anesthetic**.
- Supply of **nutrient** is very irregular and a matter of chance, hence digestive tract is modified. Mouth leads into **muscular, suctorial pharynx**, connected with body wall by **radiating muscles**. Cavity of **pharynx** alternately expands and contracts to serve as a **suction pump**, so that blood oozing from the host's wound is sucked in. **Salivary glands** secrete an **anti-coagulant** called **hirudin** which prevents blood clotting, thus it ensures continuous supply of blood to the leech.
- At the time of single meal a leech obtains a **large quantity** of **blood** from the **hosts**. Leech can stores blood about **2-5 times** than its own **body weight**, in **thin walled**, **elastic**, **dilatable** and **spacious crop chambers** and their lateral **pouches** or **caecae**, is enough for at least **200 days** or several months or even a year. It can tolerate long period of fasting.
- **Digestion** is very **slow** lasts for several months. Last chamber of crop opens into stomach by a **sphinctered aperture** slows down the flow of blood. Leeches **lack digestive juices** and **enzymes**.
- Abundant **haemocoelomic capillaries** in the **skin** help for exchange of **gases** through the skin due to absence of **special respiratory organs**.
- A good degree of **sensitivity** increases the chance of survival. Sense organs are well-developed and provide the animal with greater opportunities of life.
- **Hermaphroditism** doubles the rate of reproduction as after copulation both individuals lay eggs.
- Development takes place within the **cocoon** which serves as a protective covering. **Development** is **fast**, completed within a fortnight.

ECONOMIC IMPORTANCE OF LEECH.

1. AS FOOD.

Certain **fishes**, **turtles**, **ducks** and other **birds** etc eat leeches. These animals are used by human beings as food. These form good **fish bait**.

2. AS PESTS.

- ♥ Leeches can cause economic loss either directly or indirectly as pests. Leeches are harmful, attack **invertebrates** like **crustaceans**, **insects** and **snails** and **vertebrates** like **fish**, **Amphibia**, **turtle**, **snakes** and **crocodiles**, **birds** and **mammals** including man. Few species are **host specific** but these are not vectors of diseases.
- ♥ **Fish leeches** in commercial fish ponds cause great loss to **fisheries**.
- ♥ **Cattle**, **buffaloes** and **horses** which pass considerable time in ponds suffer due to leeches, which can cause wounds, become infected with **bacteria** and this causes **crippling** effect and death of **buffaloes** and **cattles**.
- ♥ The bite of Indian land forests is very painful and **human beings** suffer serious loss of blood.

3. MEDICAL IMPORTANCE.

- ♥ Leeches are used for **medical purpose** from **older time**. These extract the blood in painless manner from the **host**. Due to this fact were extensively used in **phelobotomy** (blood-letting) from **boils**, **wounds** and **inflammations** etc under the impression that these remove bad blood from the patient and cure many diseases. **Tribals** still use leeches for this purpose.
- ♥ **Hirudin** is high molecular mass protein is secreted from medicinal leech retards the coagulation of blood. It is used as anticoagulant in **surgical operations** and has used for prevention of post operative **pulmonary inflammations** and for **surgeries** in which an incision must be kept open. **Saliva** contains powerful **antibiotics** and **anesthetics** which will prove useful in future medicinal practice.
- ♥ Leech extract which contains **mucolytic enzyme** is used in the treatment of **asthma**, **acute rhinopharyngitis** and **spasmodic coryza**.
- ♥ **Hiruda medicinalis** is used to release **pressure** and restore **circulation** in **tissue grafts** where blood accumulation is likely such as severed fingers and ears.
- ♥ Many people were engaged in **leech farming** and leech collection. It is estimated that one **American leech farm** sold over **1,000 leeches** daily.

VERMICULTURE (EARTHWORM FARMING).

- ξ Scientific method of large scale **multiplication** and **culturing** of earthworms for **organic composting** activities is called vermiculture.

OR

- ξ It is defined as science of **culturing selected species** of earthworms under **controlled** or **semi natural conditions**, in suitable organic materials with a view to utilizing **agricultural** and **animal wastes** and to improve **soil fertility**.

- It includes **rearing, multiplication, management** and **exploitation** of earthworms for organic composting activities. It is an **ecofriendly** method of **organic waste management**.
- **Aristotle** named earthworms as **"Intestines of the earth". Gilbert White (1789)** recognized their contribution to soil fertility by their feeding and burrowing activities. **Darwin (1881)** recognized vegetable mould formation through actions of worms, by breaking down organic matter and its incorporation in the soil. The benefits provided by earthworms are now globally recognized and they are named **"Nature's most useful converters".**

TYPES OF EARTHWORMS.

- There are three groups of earthworms based on their ecology.

1. EPIGEIC (LITTER-DWELLER) EARTHWORMS. (Gr. Epi – on, above, ge, earth, ground or soil).

- These are **surface feeders**. Occur mostly heaps of **litter** or **loose soil** with high **nitrogen** content. These do not burrow but move through **crevices** on the surface. These remain active throughout the year, if the conditions are favourable. They feed exclusively on decomposing **organic wastes**. Their **life cycles** are short and produce a large number of cocoons and offsprings. These have higher **adaptability** to waste and converts waste to **compost** in large scale. Ex: **Eudrillus Eugenie. Eisenia foetida, perionyx excavates**.

2. ENDOGEIC (SHALLOW – SOIL- DWELLERS) EARTHWORMS.

- These form only **horizontal burrows**, which are strengthened by **cutaneous secretions** and even worm **casts** to prevent collapse of the burrow. Most earthworms of **tropical** countries are endogeic. Worms exhibit diapauses or dormancy when conditions are unfavourable. Life cycles are short, produce less number of cocoons. Ex: **Lampito, Pontoscolex**, **Pheretima postuma**. These are subdivided into three categories based on their **food habits**.
  - i. **Polyhumic endogeic** worms ingest **more humus** and **less mineralized soil**.
  - ii. **Mesohumic endogeic** worms ingest almost equal amounts of **humus** and **soil**.
  - iii. **Oligohumic endogeic** worms can survive in soils with minimum humus.

3. ANECIC (DEEP-BURROWING) WORMS.

- These found in **tropical forests and plantations.** These are often **large-size** and make **vertical** and **complicated burrows** in soil and reinforce the walls of their burrows with their castings. **Drag litter** of the ground into their burrows and feed on it when it is softened by **microbial activity**. **Growth** is very **slow** and their life cycles are long. Ex: **Lumbricus**.

SELECTION OF SPECIES FOR VERMICULTURE.

- Earthworms must **thrive well** in the organic biowaste provided.
- **Life cycle** must be **short**, must produce **large number** of **cocoons**, and should not possess any dormant or inactive stage in life history.

- ξ Should have a wide range of **feeding** habits and a high **metabolic demand** and a good power to **convert biowastes**.
- ξ Must be **resistant** to common **diseases** and should **acclimatize** to varying **environmental conditions**.
- ξ **Growth rate** must be **high**, must **attain maturity** within a **short period** and must **reproduce** successfully in the culture-conditions.
    a. **Eudrillus eugeniae (African Night Crawler).**
    b. **Eisenia foetida (Red worm).**
    c. **Perionyx excavates (Oriental Compost Worm).**
    d. **Dichogaster bolani.**
    e. **Lampeto mauritii.**
    f. **Drawida willsi.**
    g. **Octochaeta surensis.**
    h. **Amynthas morrisi.**

NOTE : The most preferred are the first three especially the first.

Eisenia foetida.

CULTURE MEDIUM.

- ξ **Agricultural waste** like **paddy, wheat, millets** and chopped straw and cut pieces of pretreated **maize stem**. Upper tender portion of **sugarcane** including leaves. Waste plant material obtained after harvesting, **banana stems**.
- ξ **Weeds** like **parthenium, cassia, Eupatorium, grass**.
- ξ **Domestic organic waste** like core of fruits, grains, vegetable matter, egg shells, coffee powder waste, tea dust waste, used tea bags, saw dust, leaves, paper card board etc.
- ξ **Cattle waste** in the form of cow dung and urine. The dung is a very favourable material to promote growth of earthworms. Faecal pellets of **buffalo, cow, horse**, **goat, sheep** and other animals. Pig and poultry waste contains organic and inorganic compounds like **uric acid** and many **salts** and likelihood **pathogens** which require for pre-processing or pre-treatment.
- ξ Wastes from **fruit industries**.
- ξ **Silk pupae** after reeling cocoons.
- ξ The **wood industry** provides saw-dust and **paper-pulp industry** provides both solid and liquid wastes.

- The **sugar industry** provides wastes like press mud and **bugsas** which are ideal for earthworm growth. Distillery waste. **Biogas slurry**.
- Extensive research work indicates that even terrestrial weeds like **Chromolena odorata** and aquatic weeds like **Eichhornia crassipes** can be converted into suitable media.

Uses of earthworms for Biodegradation of organic wastes.

- Organic wastes especially the **industrial** and **urban** ones are difficult to dispose. Dumped in open spaces for their degradation, where the **pests** and **pathogens** can breed and repelling odours, source of **air pollution** and **water pollution**.
- Vermicomposting is the best method to manage the organic wastes from almost all sources, like waste from **paper mills & breweries**. There are very little chances of pollution and release of **fowl smells**.

VERMICOMPOSTING TECHNIQUES.

- The process of turning organic debris into **"Worm-castings"** a rich soil fertilizer by using earthworms is called vermicomposting.
- It is a technique of converting decomposable **biowaste** into valuable plant fertilizers or vermin-fertilizers through the activity of earthworms and **microorganisms**.
- India is a chief producer of organic wastes originating from the animals. Technology is **simple** and does not require **expensive equipments** and **sophisticated laboratories**.
- Technique naturally requires a good background of **biology**, **physiology**, **distribution** and **ecology** of the earthworms to be cultured.
- It can be **indoor (small-scale)** or **outdoor (large-scale or field composting).**
- On small scale, vermiculture can be carried out in **earthen flower pots, in pits**, is discarded **wooden boxes**, **plastic buckets** or **concrete rings of 3 ft length X 2 ft wide X 9 inch depth.**
- In small scale or pot culture vermicomposting the **kitchen** and **garden wastes**, **worm beddings**, **soil**, **water** and **worms** are used.
- The **bin** is filled with **compost bedding** with water absorbing moisture retaining bedding like **saw dust**, **coir** or **rice bran**, then covered by a decomposable organic matter like **vegetable waste**, **moist leaf litter** or even **wet paper**, mixed with **cow dung** and **garden soil**. Sprayed with **water** to moist it. A pH of **6.2 – 7.8**, because worms will die in **extreme acidic** and **alkaline conditions**. The organic matter undergoes **microbial decay** is called primary degradation, might take 15-20 days. Depending on the size of container, **20-100 earthworms** are introduced over the bedding, added **dried cow dung** over the worms, and sprayed water, under ideal conditions the worm population in the pot can double in about a month's time. Vermicompost is harvested or collected when it is seen to be **granular** and **brownish** in colour.


Small scale – pot culture plastic tray culture.

- ξ Large scale techniques include different methods like **Field vermicomposting pit method** and **Heap method**. In **pit method 10 m long X 1 m wide X 0.5 m** depth pits are dug in the ground. In **heap method**, the various organic waste materials are heaped in order on the ground itself in a **rectangular shape**. Bedding should be consists of following layers,

i. **Bottom layer** of **sand** or **green coconut shell** of **5-10 cm** thick to hold **moisture** or allows **drainage** of excess of water.

ii. **Second** layer of **straw or coconut fibres** of **25 cm** thick for **aeration**.

iii. **Third** layer of **cowdung** of **30** cm thick.

iv. **Fourth** layer consists of **agricultural wastes** like paddy, wheat, tender portion of sugar cane, banana stem, maize stem, weeds like parthenium, grass, fruit industry waste, waste silk pupae, waste vegetable from city markets, biogas slurry, domestic organic waste like coffee, tea powder waste.

v. **Fifth** layer of **dung and soil**.

- ξ The quantity of **water** to be added depends on nature of waste. The temperature of the bedding should be **25-35^{0}C**, **pH-6.8-7.5**, and **humidity 55-60%.** After 15-20 days of degradation or decomposition of organic matter, earthworms are released into bedding and covered with wet **gunny bags** periodically to keep them moist.
- ξ It is done **3-4 times** a day during **summer** and **1-2 times** during **winter**. The layer of agricultural waste will be converted into vermicompost in about 2-3 months.
- ξ During vermicomposting earthworms reproduce and increase in there number. When **90%** of waste has been re-cycled worms settle at the bottom of the bed.
- ξ After 7 days the worms are separated and vermicompost is sieved out. The collected vermicompost from the bed dried in a shade for **12-24 hours**, then can be used directly in the fields as top soil or organic manure to reduce the carbon deficiency and soil erosion or packed in gunny bags.
- ξ In recent days, many farmers and private organizations have undertaken large scale vermicomposting and Vermicompost is sold through fertilizers shops.
- ξ **Monoculture** is a technique of mass culture of any **one species** of the cultivable species. Ex: **Eudrillus or Eisenia or Perionyx**.
- ξ **Polyculture** is a technique of rearing two or more species of earthworms at a time in a suitable vermibin under controlled or semi-natural conditions. This

technique requires a greater insight into habits of the worms to be cultured in order to reduce competition among them and to limit the superiority of one species over the other. Ex: **Eudrillus and Eisenia, Eudrillus and Lampito or Eudrillus, Eisenia and Perionyx.**

Field composting.

Heap method.

ADVANTAGES OF VERMICULTURE.

- It helps in the proper utilization of **agricultural** and **animal wastes** which could otherwise cause pollution.
- It helps to maintain and enhance the quality of the environment.
- It consumes natural **fauna** and **flora** and adds to **soil fertility**.
- It is a **low cost technology** which can provide **employment**.

VERMICOMPOST OR EARTHWORM MANURE.

- It is the product of **consumption**, **biological degradation** (digest the waste in the gut and physical, chemical biological changes taken place) and **egestion** by earthworms. It is discharged as **excreta** in the form of **worm casts**.
- It is a rich source of plant nutrients, soft, spongy, dark brown or black, odourless, earthy, is called "**Black gold**".
- It contains macro or major nutrients like **1.10% Nitrogen, 0.86% Phosphate**, **0.98% Potash** and **micro** or minor nutrients like **Cu – 52 ppm, Fe-930 ppm, Zn-186.6 ppm, Mg, Ca, boron** etc, useful **soil bacteria**, some **fungi** and even **growth hormones**. All its nutrients are not used at the same time, but slowly over a period of time.
- It can be used as **top soil** or organic manure in fields to reduce **carbon deficiency** and **soil erosion**.
- It does **not burn** the roots and leaves of plants. The nutrients in worm castings are in more readily available form for plants than conventional manure. Worm castings are more potent as a bioorganic fertilizer than conventional compost.
- Vermicompost **improves the physical, chemical** and **biological qualities of soil** and enhances **soil structure** and **drainage**, because it contains considerable amount of **mucus** and is **spongy**.

- In some soil organisms like **Agaricus bisporous** and plant like **Raphanus sativus**, protein synthesis is enhanced by the availability of worm castings.
- Plants fertilized by Vermicompost clearly show **improved group** of various species of **crops**.
- If chemical fertilizers are used for long term can **kill** the soil completely, but vermicompost is **ecofriendly** and is the best solution for sustained organic farming.
- Presence of worm castings results in greater **electrical conductivity** of soil, so that mobilization of **mineral resources** for plants if more effective.

VERMIWASH OR WORM-TEA.

- It is the **yellowish, aqueous fluid** that is drained out of a vermibin.
- It contains excess secretions of worms, **plant nutrients, plant growth factors**, **vitamins and enzymes**.
- It is collected by different techniques has numerous qualities which is ideal substance in agricultural, horticultural and sylvicultural practices to **improve plant growth.**
- It acts as a **biopesticide**, initiating **early flowering**, inhibiting **fungal growth** and biodegradation.

ENEMIES OF EARTHWORMS.

- Earthworms are often included in a "**saprophytic food chain**" in ecology as consumers of dead organic matter. Earthworms are eaten by **frogs, birds**.
- The natural enemies of earthworms like **ants, centipedes, scorpions, termites, pigs, rats** and **bandicoots** damage the whole vermicomposting process.
- Some birds like the **Indian robin, mynah, wagtail** and **bulbuls** search earthworms in decaying leaf litter and feed on them.
- **Nocturnal owls** are also predators of earthworms.

ROLE OF EARTHWORMS IN SOIL FERTILITY.

- The burrowing habit of earthworms make the **soil porous**, loosening of the soil, to hold more **air** and **water**, which are required for roots and help in plant growth.
- These bring the **lower sub soil** to the upper surface, about **8-18 tons** of soil or acre of land, thus help in **biological ploughing**.
- Earthworms ingest the soil, enrich it by their digestive secretions and egest it as worm casts.
- Porocity of soil allows atmospheric air to reach deeper parts of the soil. The nitrogen of the air reaches the **root nodules** of leguminous plants. The **nitrogen-fixing bacteria** of the nodules can fix nitrogen into **nitrates** and make it available to roots. Thus earthworms indirectly help in **nitrification**.

Earthworms as a Protein source.

- The chemical composition of the earthworm (**Eisenia foetida**), worm casts and worm body fluids was investigated and compared with common foods and animal feeds.
- Common nutrient analysis showed that Eisenia foetida meal has high protein content in the range of **54.6 to 71.0% dry matter**.
- **Protein** content and **amino acid** composition were close to that of **fish meal** and **hen egg**, and higher than that of **cow milk powder** and **soybean meal**.
- Casts of E. foetida had a protein content of **7.9% dry matter**, which is similar to that of **corn meal**, and hence worm casts could be used for partial replacement of corn meal or **wheat bran** in animal diets.
- Worm body fluids contained **9.4% protein** and **78.79 free amino acid** per liter and were found to be rich in **vitamins** and **minerals**, particularly iron (**Fe**).
- Our nutrient analyses suggest that earthworm (Eisenia foetida) could be an excellent source of protein to supplement animal feed and human food.
- Earthworms as a source of protein for **chicken feed**. In an area of 25 m^2, one kg of fresh earthworm **biomass** was produced daily. This is sufficient to supplement at least **50 chickens** with high-quality protein.
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  - **NOTE:** A milky fluid containing fat droplets which drains from the lacteals of the small intestine into the lymphatic system during digestion is called chyle.
  - **Chyluria**, also called **chylous urine**, is a medical condition involving the presence of **chyle** in the **urine** stream, which results in milky white **urine.** The condition is usually classified as being either parasitic or non parasitic.
  - A **hydrocele** is an accumulation of **serous fluid** in a body cavity.

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PLASMODIUM VIVAX

Phylum – Potozoa
Class – Sporozoa

OCCURANCE –Plasmodium species are obligate, either intra or inter cellular parasites of both invertebrates and vertebrates. These are wide spread in tropical and temperate countries. Plasmodium vivax is most widely distributed in temperate regions of the world.

DISEASE CAUSED- It causes malaria.

MODE OF TRANSMISSION- malaria is an infectious disease caused by malarial parasite. This is transmitted by the bite of infective female Anopheles mosquito to man. Transfusion of blood from infected persons and use of contaminated needles, syringes, organ transplantation or congenitally from mother to foetus.

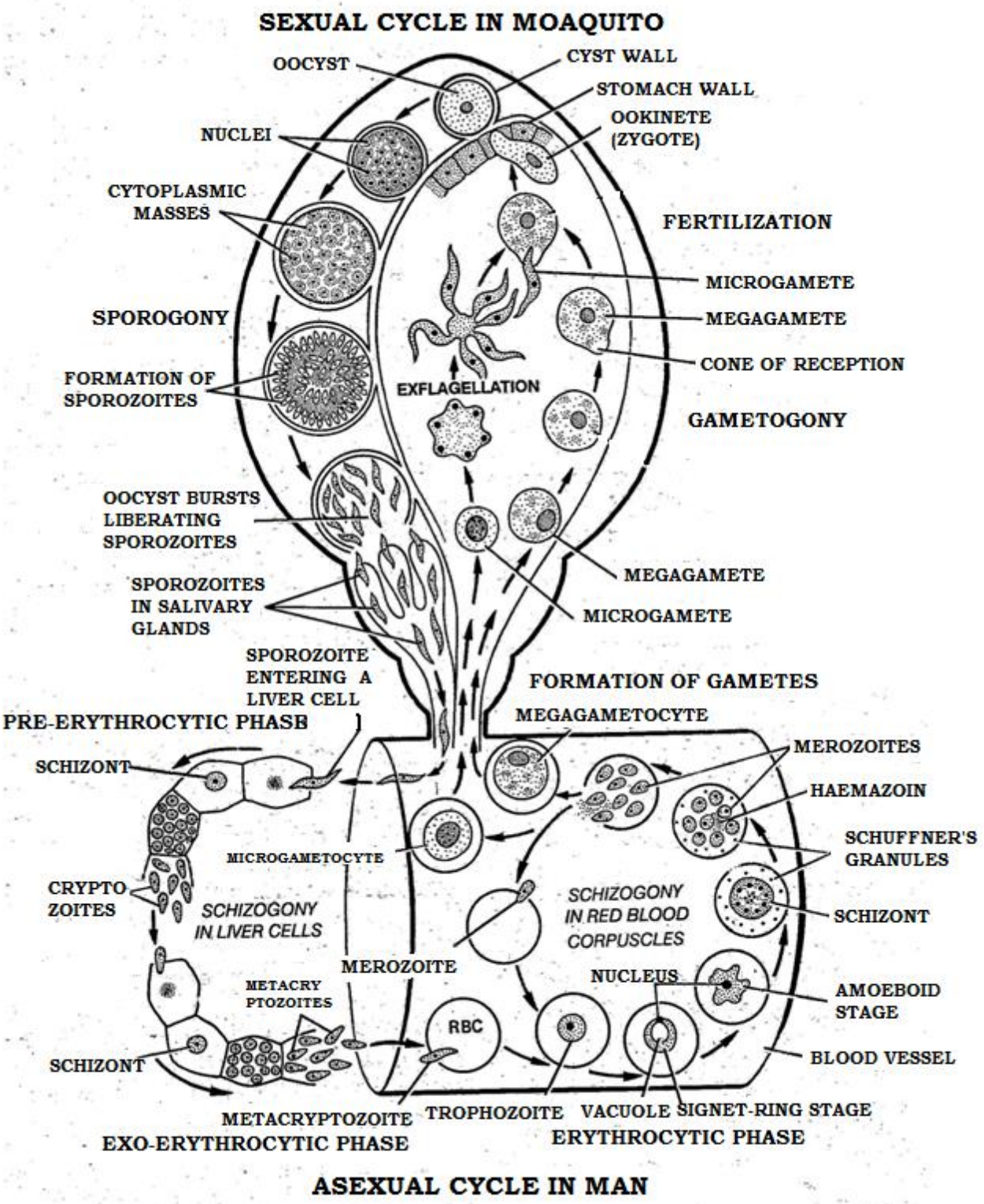
LIFE CYCLE- Plasmodium vivax is digenetic, its life cycle completes in 2 hosts namely man and mosquito. It is 48 hour cycle.

I- ASEXUAL CYCLE IN MAN.

1. **INFECTION-** A healthy person acquires infection by means of small, fusiform (spindle shaped), slightly curved, **uninucleate** of **11-12** μ length and **0.5-1** μ in width called **sporozoites** injected along with saliva of an infected mosquito when it bites. Initially mosquito ruptures the host's skin by its proboscis and introduces saliva to check clotting of blood as it contains anticoagulant and then sporozoites are introduced. The sporozoites remain in the blood for a short time but after an hour blood is no longer infective for another host.
2. **EXOERYTHROCYTIC SCHIZOGONY-** After about half an hour sporozoites enter the parenchymal cells of liver and develop into special and non pigmented **pre erythrocytic schizonts**. Each schizont divides by multiple fission and forms large number of uninucleate **cryptozoites**. These are liberated when the liver cell bursts. Cryptozoites grow to become large mature schizont of different sizes of different species. Cryptozoites undergo repeated schizogony to produce large number of **metacryptozoites.** Pre and exoerythrocytic phases of parasite remain immune to the resistance of host and parasites are not susceptible to the action of any anti malarial drug. Incubation period is about 8 days.
3. **ERYTHROCYTIC SCHIZOGONY-** Metacryptozoites after escaping from liver invade RBC's and become round parasites known as **trophozoites**. Each trophozoite grows in size and with peripheral nucleus due to development of central vacuole is known as **signet-ring stage**, since peripheral nucleus looks like of gem of ring. This signet-ring trophozoite ingests the cytoplasm of RBC and forms a food vacuole and it secretes digestive enzymes into that. Digestion takes place in many pinocytic vescicles which are formed towards periphery of the parasite. The enzymes help in proteolysis of haemoglobin into its protein

component and **hematin**. Protein is used as food by trophozoite and hematin forms the toxic malarial pigment **haemozoin**.

Signet-ring trophozoite develops into an active **amoeboid trophozoite**. It sends pseudopodial processes into cytoplasm of the blood corpuscle and small red eosinophilic granules (**Schuffner's granules**) appear in the cytoplasm. This amoeboid trophozoite after active feeding becomes round and grows in size to become schizont, undergo schizogony. Its nucleus divides to from 12-24 nuclei, which are arranged towards the periphery and these are surrounded by cytoplasmic masses. Each mass becomes oval shaped **merozoites**. The haemazoin granules are present at the center. RBCs rupture to release merozoites into the blood plasma. These invade fresh cells to repeat the erythrocytic cycle. One complete cycle takes in 48 hrs.



4. **POST ERYTHROCYTIC SCHIZOGONY** – Some merozoites reach the liver cells to undergo schizogonic development.
5. **FORMATION OF GAMETOCYTES** – After many schizogony merozoites enter into RBCs and increase in size to become round gametocytes. Male and female gametocytes are differentiated. The **male (microgametocyte)** is smaller with a large diffused nucleus. The **female (megagametocyte)** is larger with compact peripheral nucleus. These do not divide, but remain within host RBCs until they either die or are ingested by the vector.

II – SEXUAL CYCLE IN MOSQUITO.

- Gametocytes are sucked by female Anopheles mosquito from infected person and enter into the cavity of gut. Development of gametes from gametocytes is known as **gametogony**. Male gametocytes undergo a process **exflagellation** in the midgut of mosquito due to drop in temperature during transfer from man to insect. In each microgamete the nucleus divides by mitosis to produce 6-8 haploid daughter nuclei, arranged towards periphery. The cytoplasm project out as long, thin and flagella-like projections and daughter nucleus enters into each projection. These projections breakdown as **sperms** of **20-25** μ length and swims rapidly away.
- Female gametocyte undergoes some reorganization and becomes a female gamete which is ready for fertilization. Ovum produces a small cytoplasmic projection called **fertilization cone** and nucleus lie near this cone. When sperm comes in contact with ovum it penetrates into it to fuse with nucleus of ovum, results in formation of diploid zygote.
- The round fertilized non-motile zygote becomes elongated, vermiform and motile **ookinete** of about **15-22** μ length and **3** μ width. It penetrates through the epithelial cell of the mosquito's stomach. Then settles down just under thin membrane that separates midgut from haemocoel, then becomes spherical and undergoes encystment to become oocyst. Cyst wall is thin, membranous and elastic partly secreted by ookinete and partly derived from midgut.
- Oocysts grow in size to become transparent and round outside the midgut. Each oocyst multiplies asexually by sporogony; its nucleus divides first by **meiosis** and subsequently by **mitosis** to form large number of **haploid nuclei**. At the same time the cytoplasm develops large vacuoles to produce irregular cytoplasmic masses, which are connected by **protoplasmic strands**. The daughter nuclei arrange themselves along the free margins of cytoplasmic masses, then finger like process with daughter nucleus are formed called sporozoites. About **10,000 minute**, slender and sickle shaped sporozoites are formed. Uninucleated spindle shaped sporozoites are released from ruptured oocyst into haemocoel of mosquito, then move to different organs and penetrate the salivary glands. Thus sexual cycle is completed within 10-20 days depends on temperature. Salivary glands of a single infected mosquito may contain about 200,000 sporozoites, when it bites healthy person thousands of sporozoites are injected in blood and start the cycle again.

DIFFERENT SPECIES OF PLASMODIUM.

1. **P.falciparum** has worldwide distribution with incubation period about **12** days, causes **malignant tertian malaria**, falciparum malaria/sub tertian malaria. This is the common most species to infect the man and is greatest killer of the human race over the most parts of Africa and Tropic but uncommon in temperate zones the death rate is high.
2. **P.malariae**: It has worldwide distribution with incubation period about 18 to **24 days**, causes **quartan malaria**. It is less common, occurs in tropical and

sub tropical areas. It is not very pathogenic organism but chronic infection sometime gives rise to a lethal condition.

3. **P. Ovale**: It causes **mild tertian malaria**. It is confined in Africa Philippines and India. It is also not greatly pathogenic. Incubation period is about **14 days**.

PREVENTIVE MEASURES.

It depends on treatment of infected individuals and reduction in transmission of malaria.

1. **Control of mosquito population**
   - Spraying the breeding sites with oils and chemicals.
   - Elimination of breeding places like legumes and swamps
   - Flushing of breeding places.

2. **Prevention of mosquito bite**
   - By avoiding contact with infective mosquitoes, can be done by screening the windows and doors of houses with fine mesh netting
   - Personal protection by proper use of mosquito nets while sleeping.
   - Wearing protective clothing that minimize contact with mosquitoes.
   - Use of mosquito repellents like oil of citronella, dimethyl phosphate, mosquito repellent coils etc.