S.Y.B.Sc Zoology
Semester- III
Paper- III Course- VII (A)
Unit: 2- Parasitology

Parasitology is the branch of biology which deals with the study of parasites with reference to their host, life cycle, pathogenicity and control measures. Parasites vary in size i.e. microscopic (all viruses) to macroscopic, 10 to 12m in length (*Taenia saginata*-a beef worm). Mostly, they include all viruses, some bacteria, fungi, protists, worms, arthropods and a few vertebrates. Parasites have evolved in response to the host defense against the infectious conditions.

2.1 - Definitions:

1. Parasitism

It is also called an antagonism. It is a type of negative interaction between members of two different species in which one is benefited and other is necessarily harmed. The one which gets benefited is referred to as a parasite while the other which gets harmed is called as a host. It is an interspecific association between parasite and host.

2. Host

It is any living organism which harbours the parasites. Host provides food and shelters to the parasites and supports their growth and reproduction.

3. Parasite

It is defined as any living organism (microbe, fungus, plant and animal) which derives food and shelter from other organism where it lives.

4. Vectors

They are the type of disease transmitting agents. They carry parasites from one host to another and helps them to continue their life cycle. There are two types of vectors.

1) Biological vectors:

These are the organisms which transmit parasites from one host to another. Bio-vectors provide favorable environment to the parasites to undergo developmental changes in the body or to multiply in it. Arthropods are efficient vectors which more often bite man and animals.
E.g., Insects like Mosquitoes, Rat flea and Bed-bugs carry germs to their respective host.

2) Mechanical vectors:

These are organisms which transfer certain stages of parasite through saliva or faeces indirectly without further development in the body.

E.g., i) Houseflies (*Musca* species) pick up parasitic stages while feeding and laying eggs on garbage, manure and faeces. Legs of flies have bristles with sticky pulvillus which enables them to contaminate food and water in the kitchens and restaurants. House-flies are known to spread parasites causing diarrhoea, typhoid, and cholera, amoebic and bacillary dysentery. ii) Cockroaches (*Periplaneta*) are also a type of mechanical vector which transmits pathogens causing cholera, leprosy, typhoid and dysentery.

2.1.1 - Types of Parasites:

Parasites are categorized in various ways on the basis of site of infection, number of hosts required, pathological conditions, duration of parasitic life in the host etc.

1) Ectoparasite or Exo-parasite or External parasite:
   The parasite that lives or attaches to the skin or external surface of the body of the host is called ectoparasite. Mostly ectoparasites have suckers or modified mouth parts to obtain nourishment and keep themselves attached to body parts of the host.
   e.g., Indian cattle leeches, mosquitoes, ticks and bedbugs.
2) Endoparasite or Internal parasite:
   The parasite which lives inside the body of host is called endoparasite. They occur in different tissues and body parts of their respective hosts.
   e.g., Ascaris and tapeworms are found in digestive tract of man, *Plasmodium*, *Leishmania* and trypanosoma are blood parasites found in man.
3) Temporary parasite:
   It is a parasite which lives on the body of host for a short period of time for food. After it satisfies hunger, it leaves the host.
   e.g., The Glochidium larva of fresh water mussels, mosquitoes, bed bug, Petromyzon and vampire Bats.
4) Permanent parasite:
   It leads a parasitic life during the entire period of its life.
   e.g., *Ascaris lumbricoides* - an intestinal parasite, *Wuchereria bancrofti* - a lymph parasite.
5) Intracellular parasite:
   These parasites reside and reproduce within the cells of host.
   e.g., *Plasmodium* in R.B.C's and hepatocytes, monocystis in the seminal vesicles of the earthworm and all types of viruses.
6) Extracellular parasite:
   These parasites inhabit the intercellular spaces of host.
   e.g., *Ascaris lumbricoides* and *Fasciola hepatica* (liver - fluke).

7) Monogenetic parasite:
   A parasite which needs only a single host to complete its life cycle is called monogenetic parasite.
   e.g., Giardia intestinalis (mostly children) and *Ancylostoma duodenale* (man)
8) Digenetic parasite:
   A parasite which requires at least two hosts to complete its life cycle is called digenetic parasite.
   e.g., *Dracunculus medinensis* (man and water flea) and *Taenia solium* (man and pig)
9) Obligatory parasite:
   It cannot exist without a parasitic life. Most of the permanent parasites are obligatory in nature.
   e.g., *Trypanosoma gambiense* and *Plasmodium vivar*
10) Hyperparsite or Epiparasite:
    It is a parasite whose host is parasitizing on another organism and the phenomenon is called hyperparsitism.
    e.g., 1) protozoan occurring in digestive tract of flea living on dog is an example of hyperparasite. 2) Malarial parasite, *Plasmodium* is nourished and grown to sexual maturity by female Anopheles mosquitoes which are parasitic to vertebrates.
11) Pathogenic parasite:
    It is a parasite which causes severe damage after infection to man resulting in pathological condition.
    e.g., *Wuchereria bancrofti*.
12) Non-pathogenic Parasite:
    It is not able to damage the host to the level of any pathological condition despite its prolonged period of exposure to its host.
    e.g., *Entamoeba coli*, *E. gingivalis.*

2.1.2 - Types of Hosts:

There are different types of hosts depending on their interaction with parasites. Different types of hosts are as follows:

1) Definitive host or Primary host or Principal host:
   The host which harbors the adult stages of parasite is called the definitive host. The parasites reaches sexual maturity in these hosts.
   e.g., Sheep is the definitive host of *Fasciola hepatica* (Liverfluke)

2) Intermediate host or Secondary host:
   The hosts that harbors the larval or asexual stages of parasite is called an intermediate host. Mostly, invertebrate hosts are ideal secondary host.
   e.g., mosquito (Anopheles) and pond snail (Lymnaea) are the secondary host of malarial parasites and liverfluke respectively.

3) Reservoir Host:
These are the hosts which store the parasitic stages in dormant condition in their body and infects fresh host. It serves as a potential source of infections which is resistant to the disease. It can rapidly spread the disease to other healthy hosts.
e.g., 1) Wild animals in tropical Africa act as a reservoir host of blood parasite, *Trypanosoma brucei*. 2) Domestic Dog (Canis familiaris) has been proved as a competent reservoir host of *Leshmania donovani* which causes 'oriental sore' in Mediterranean countries.

4) Carrier host or Paratenic host:
It is a type of host in which the parasite retains viability without any further development. It provides the ecological link between the primary and secondary hosts.
e.g., 1) *Acanthocephala* (spiny headed worms) cannot complete life cycle without the role of paratenic hosts. 2) Fishes play a role of paratenic host for the plerocercoid larvae of *Diphyllobothrium* (The fish tapeworm).

2.1.3 - Host-parasite relationship

The host parasite relationship is highly specific. The parasites invades only those organisms, which can provide them nutrition and suitable environment to lead successful parasitic life. The intracellular parasites, viruses mostly attack specific live host cells. Their host specificity is due to receptors and availability of cellular factors needed for viral reproduction in host cells.

Structural specificity:
The structural incompatibility of parasite may result into the death of the parasites. Structural modification help the parasite to invade the host successfully.
e.g., 1) Mosquito has powerful maxillae and mandibles for piercing and sucking the host blood. 2) Hook worms develop extensible buccal mass with six chitinous teeth inside to suck food.

Physiological specificity:
Many parasites undergo specific physiological changes to get established in various hosts.
e.g., 1) The tapeworms absorb the fully digested food through body wall as circulatory and digestive systems are absent. They also specifically secrete mucus to protect them from the action of digestive juices. They are known to secrete antienzymes to neutralize the digestive enzymes of the host. 2) Protozoan parasite, Entamoeba secretes proteolytic enzymes to hydrolyze and feed on the intestinal mucosa. 3) Leeches and mosquitoes secrete anticoagulant to prevent blood clotting.

Ecological specificity:
The origin of parasitism is largely based on ecological grounds. The parasite and host relationship depends on parallel evolution in host and parasites in given ecological conditions.
e.g. 1) Children often are affected by ectoparasite of pet like cats and dogs with which they are in close contact. 2) Liver flukes are parasites of sheep but as a natural consequence, they are capable of infecting different grazing animals and man also. 3) Growth of some parasites like Trypanosoma is highly temperature dependent. The immature stages flourish on growth media at 26°C to 28° C. When such cultures are exposed to varied temperature of 30°C to 31°C, most of them die.

2.2 - Parasitic adaptations in Ectoparasites and Endoparasites:
It is believed that animal parasites must have been originated from variation in feeding habit or accidental (sudden) exposure to new environment like digestive tract of higher animals or blood or tissues of vertebrates. Parasitic adaptations are the structural or physiological modifications of parasites with respect to their host environment. These adaptations impart survival value to the parasite by enabling them to lead successful parasitic life against the defense system of host.

Adaptations in Ectoparasites:

Mostly ectoparasites visit host temporarily so they are not modified much as compared to the endoparasites. They exhibit specific adaptation to their respective host. They mainly undergo changes to support their feeding habit and provide them defense against host. Ectoparasites are known to possess hooks, claws, suckers and spines or bristles. Following are the common adaptations in ectoparasites.

- Adaptations for Nutrition: Ectoparasites either feed on blood or subcutaneous tissues of the host.
  1. Mosquitoes and Bed bugs have piercing and sucking type of mouth-parts to puncture the skin of the host. They pour saliva containing anticoagulant at the site of injury. It causes more inflammation so that more blood will rush to suck.
  2. Leeches are sanguivorus in feeding habit which secretes anticoagulant hirudin.
  3. The itching mites feed upon subcutaneous tissues to form safe place to lay eggs.

- Organs of attachment:
  1. Annelid ectoparasite, Hirudinaria bears anterior and posterior suckers which enables them to get firmly attached to the host skin.
  2. Human head lice clings to hair with the help of modified legs ending into claws.
  3. Parasitic insects are well protected by their bristles and spines derived from cuticle. The itching mites also bear legs with long bristles.

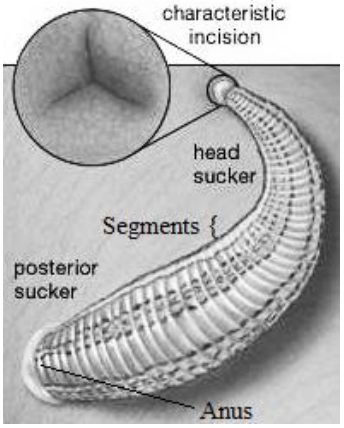
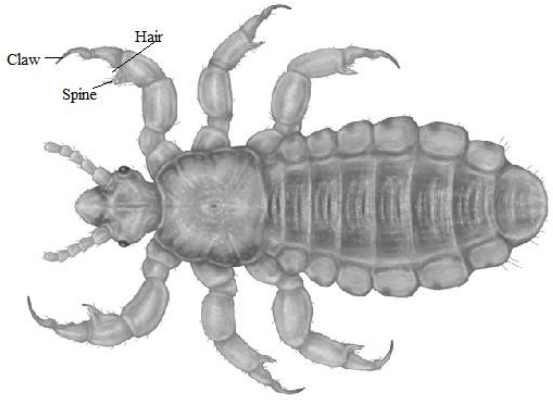


Fig. : a) Sucker of leech b) Long bristles in mite



c) Claws of head louse

- Rate of reproduction:
  Ectoparasites like ticks may reproduce by parthenogenesis. (Development of unfertilized egg into young one under the influence of environmental factors.). So, female alone can produce next generation without the involvement of males. Both bed bug and lice have more egg laying capacity. Bed bug lays 75 to 500 eggs while body louse lays 200 to 300 eggs in their short life span.

Adaptations in Endoparasites

The endoparasites require high degree of adaptability to sustain their parasitic mode of life. It is challenging for the parasites to invade and survive in their respective hosts since most of the host organisms have an efficient defense mechanism of their own.

I) Structural adaptations:

a) Degeneration of Organs:

i) Sense organs and nervous system undergoes no advancement as endoparasites live in constant environment. e.g Tapeworm.

ii) Digestive organs are simple and in exceptional cases like *Taenia* species, sporozoans like *Plasmodium*, monocystis, flagellate trypanosomes, they are completely absent. Semi-digested or digested food by the host gets diffused through body wall of parasite.

iii) There is a loss of locomotory appendages as parasites mostly use single host or two to complete life cycle also they need not move in search of food.

b) Development of special devices:

i) Cuticle: Body wall of endoparasites is ensheathed by thin or thick cuticle which protect parasite against the action of digestive juices. e.g flatworms and roundworms.

ii) Suckers and Hooks: These are the organs of attachment which enable them to remain attached to the organs or the body of host. e.g Hooks and suckers of tapeworm, Suckers in Liver flukes.

iii) Suctorial Pharynx: Liver flukes suck fluid by the sucking action of sectorial pharynx.

iv) Special structures for penetration into the host tissues: Miracidia larvae of Liver flukes has a narrow, pointed end which secretes tissue softening enzymes. These are released by penetration gland and apical glands. Miracidia can enter into very hard foot of the secondary host, Limnea (Pond snail).

v) Cystwall formation: The extra, resistant, protective outer wall is synthesized or secreted over the body wall of certain forms of parasites. e.g. i) Six hooked embryo, Hexacanth changes into Cysticercus larva of tapeworm which get encysted by secreting resistant wall around it. ii) Minuta form of Entamoeba is also synthesizing protective wall around it which form inactive and non-feeding stage till they change new host.

c) Reduced Shape: Platyhelminthes are dorso-ventrally flattened and acoelomate animals which enable them to reduce shape so as to accommodate in narrow spaces of host.

d) Shelled eggs: In helminthes, eggs change into capsule with yolk cells. These

capsules are surrounded by a resistant shells to protect them from injury and adverse conditions.

II) Physiological adaptations:
Life processes of parasites get adjusted to reduce the risk of parasitic life. They are also known to save energy by simplifying life in parasitic mode.
a) Anaerobic respiration: Animal parasites living in anoxic conditions like intestinal lumen or tissues respire anaerobically. It yields sufficient energy to survive. They are able to tolerate pH from 4 to 11. They are deriving energy from the fermentation of glycogen in turn forming lactic acid. e.g., *Ascaris* and *Taenia*.

b) High fecundity: The potential of an individual to reproduce number of fertilized eggs is called fecundity. Parasites produce more number of eggs in order to increase their chances of survival. E.g., *Ancylostoma* (Hook worm) lays 25 to 30 thousand eggs/day. *Ascaris* lays 15 to 20thousand eggs / day at maturity. Many are hermaphrodite undergoing self or cross fertilization facilitating the survival of species, e.g. Tapeworm.

c) Chemotaxis: Flatworms elicit more response towards chemical changes in their surrounding or host tissues by virtue of which they search and reach the specific body part of the host.

d) Protective secretions: Nematodes secrete anti-enzymes in order to prevent the hydrolytic effects caused by gastric and intestinal juices. Tapeworms enhances more mucus secretions to avoid effects of digestive enzymes produced by the host.

e) Tolerance against host environment: The parasite is in isosmotic conditions with the host so that there is no difficulty in exchange of water. A trematode, Schistosoma species produce chemical substances which suppress the host defense mechanisms. In order to evade the host defense system they cover their body with chemical substances having molecules that the host recognizes as “self.

2.3 - Life cycle, Pathogenicity, Control measures and treatment

1) *Entamoeba histolytica*:

- It is a unicellular, microscopic, intestinal parasite of man (mucosa and sub mucosa layer of large intestine).
- It is a member of Class: Sarcodina (Rhizopoda) and Phylum: Protozoa.
- It is able to hydrolyze tissues by secreting proteolytic enzyme, hence it is named as *Entamoeba histolytica*.
- These are cosmopolitian.
- It occurs in two form:- Trophozoite and minute form (ranging from 18- 40 μm diameter)
- It contains cytoplasm, nucleus, food vacuoles, pseudopodium.
- *Entamoeba* is monogenetic parasite which completes its development in a single host i.e man.
- The daughter Entamoeba feeds on bacteria, R.B.Cs. yeasts and other tissues.

Life cycle in carrier host:

- After complete maturity, trophozoites undergo asexual reproduction by binary fission and they multiply again and again.
- The parasites thus increase in number and penetrate the mucosa and sub-mucosa layer of intestine subsequently causing abs and bleeding ulcers.
- Trophic forms secrete proteolytic enzyme capable of hydrolyzing mucus membrane.
- As a result, it forms lesions and get spread to distant organs through blood circulation.
- The parasites released from the ulcerations, change into minuta form.
- They are discharged into the intestinal lumen of colon.
- They become small, round and undergo encystation. At this stage, it secretes a thin, transparent, flexible and protective cyst wall around it. Such stages bear single nucleus and are referred to as uninucleate cysts. It reserves food in the form of diffused glycogen granules.
- There are three to four retractile, bar like chromatid bodies with rounded ends. The uninucleate cysts form binucleate cysts by the division of nucleus. The two nuclei in binucleated cysts undergo divisionto form four nucleated stage called tetranucleate cysts. The chromatid bodies get disappeared.
- The tetranucleate cysts are15 to 20 um in diameter passes outside the carrier host along with faeces. Several thousand cysts are defaecated in case of chronic infection.

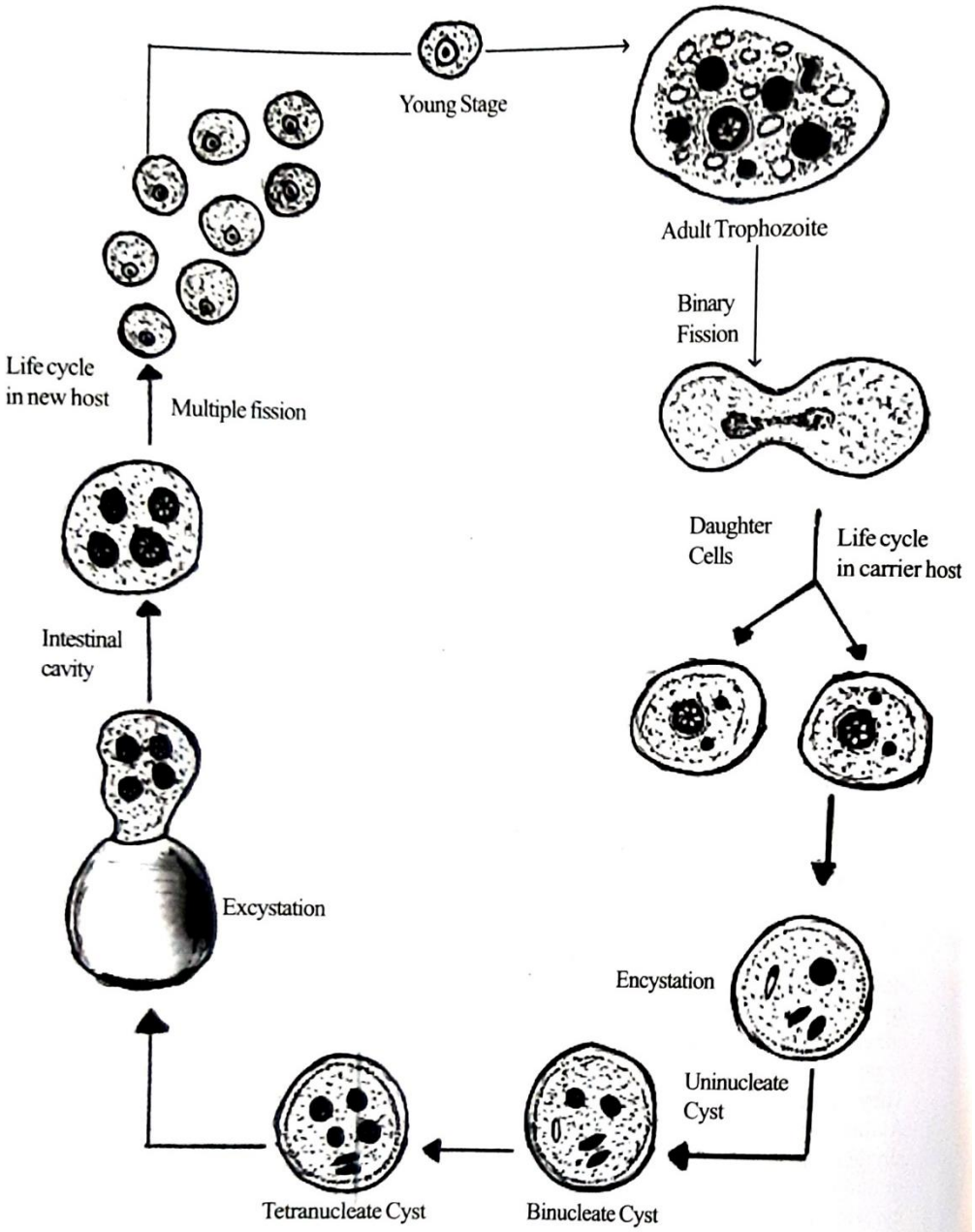


Fig. 2.3a Life cycle of *Entamoeba histolytica*

Life cycle in new host:

- The infective stage to man is 'the tetranucleate cyst.
- The incubation period of parasite is 4 to 5 days. These stages remain unchanged in the gastric juice due to resistant cyst wall.
- They ultimately pass into intestine. The cyst wall ruptures when it is exposed to trypsin, a proteolytic enzyme and excystment takes place.
- Now, the liberated stage is called metacyst or excystic form. It is transformed as a small, uninicleate, amoeboid and young trophozoite. It grows and repeat the life cycle.

Pathogenicity:

The pathological condition caused due to Entamoeba is called “amoebiasis' which causes amoebic dysentery and abscess formation in organs.

1. **Amoebic dysentery**: An adult parasites secrete protease which hydrolyses intestinal tissues. This may cause lesions in initial stage. Gradually, it results into ulcerations due to which blood and mucus passes along with the stool. This symptomatic condition is called amoebic dysentery.Intestinal functionsare disrupted so the patient experiences fever, nausea, anaemia and pain in abdomen.
2. **Abscess formation in organs**: Due to intestinal lesions, parasites are carried by blood stream into distant organs like lungs (Pulmonary amoebiasis), brain (Cerebral amoebiasis) and liver (Hepatic amoebiasis). They are badly affected by metastatic lesions. In chronic cases, it causes ulcers (abscess) formation in vital organs thereby resulting into death of the patient.

Control measures: (Prophylaxis - It is the treatment before disease is caused.)

1) Water should be boiled before drinking. Vegetables and fruits should be washed in salty water before consumption.
2) Personal hygiene has to be strictly observed.
3) Underground sewerage system should be constructed to avoid epidemic spread of amoebiasis in the rainy season.
4) Children should be trained to wash their hands and trim nails time to time as they play on grounds.
5) The cysts may be destroyed by using 1% formaldehyde, HgCl, HCl or 50% alcohol.

Treatment:

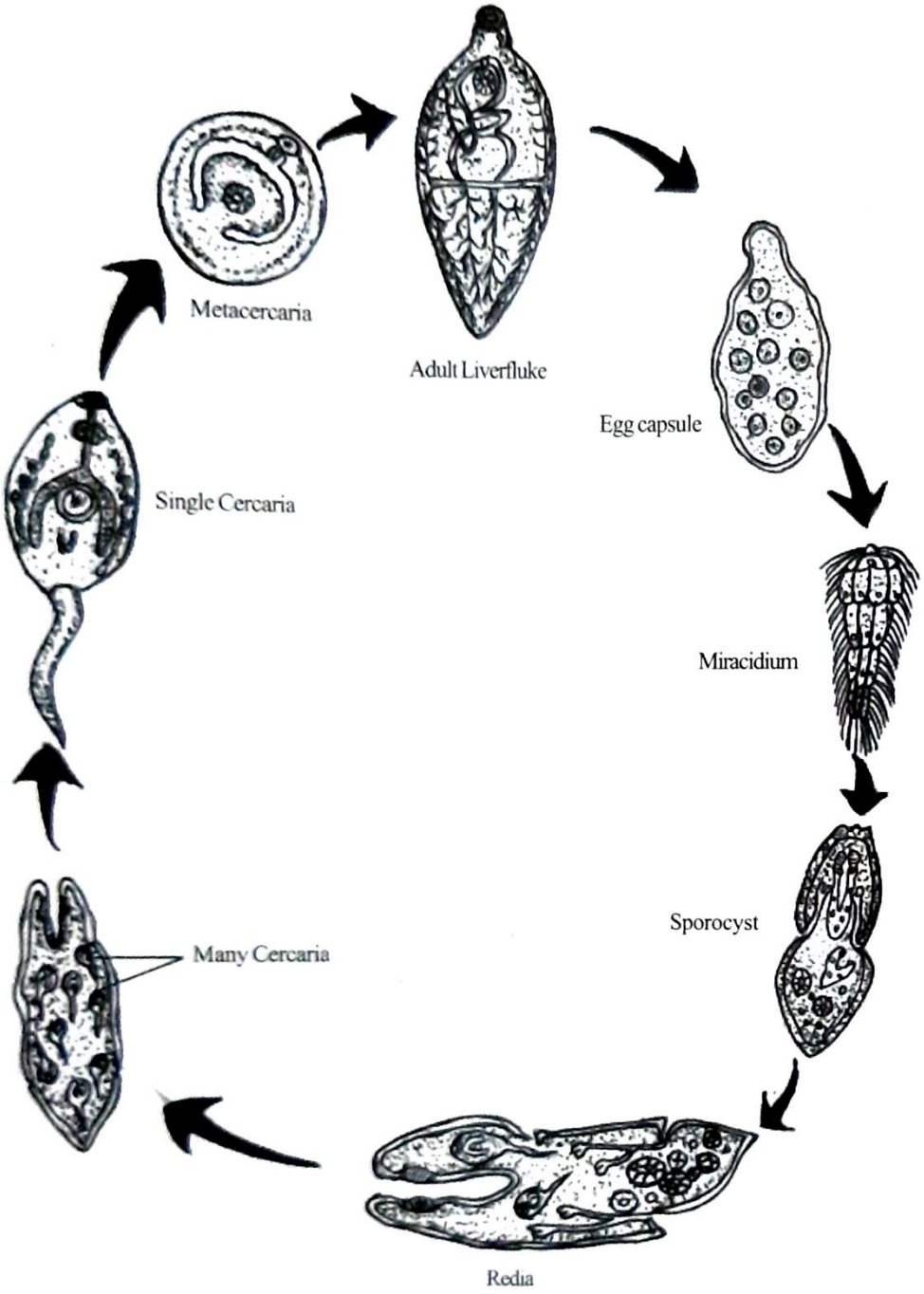
1) Emetin hydrochloride is found to be effective against acute amoebic dysentery and metastatic lesions.
2) Antibiotic like poromomycin is very useful in treating the trophozoites and minuta forms of Entamoeba.
3) Cloroquine phosphate cures the hepatic amoebiasis very effectively.

2) Fasciola hepatica

- It is commonly called as the 'liver fluke'.
- It is belongs to Class: Trematoda and of Phylum : Platyhelminthes.
- The body of liver flukes is leaf-like and flattened.
- They have simple digestive systems and primarily feed on blood.
- The anterior end is the oral sucker opening into the mouth.
- Inside, mouth lead to a small pharynx which is followed by an extended intestine that runs through the entire length of the body.
- The intestine is heavily branched and anus is absent. Instead, the intestine runs along an excretory canal that opens at the posterior end.
- They are hermaphrodite animals.
- Cross fertilization.
- It is a digenetic trematode

Life cycle:

- As it has a digenetic life cycle, it includes two hosts, primary host is sheep, goat, cattle or man and secondary host is Lymnaea i.e. a pond snail.
- Cross fertilization takes place in primary host.
- Adult flukes lays thousands of eggs at a time, which are passed out through the excretory pore.
- Eggs are ovoid, yellow brown, **operculated** and measured 140um by 80um in size.
- The eggs pass out via bile duct into the intestine. They are eliminated along with the faeces of vertebrate hosts.
- Miracidia swim freely in water or move to a moist surface
- The miracidium is a ciliated, non-feeding larva.
- Under favorable conditions, it escapes from the eggshell, usually through the operculum, into the environment.
- The miracidium is elongated and covered with flattened, ciliated epidermal plates.
- At the anterior tip of the miracidium is a flexible **apical papilla** with sensory organs and three secretary glands, the apical gland and two lateral glands, which secrete materials at the tip of the papilla during host penetration.
- During penetration, the papilla becomes partially invaginated and secretions from the glands are captured in the depression.
- The papilla thus acts as a suction cup, holding the miracidium to the site of penetration and allowing the secretions to exert both adhesive and lytic actions.
- In addition to the sensory structures in the papilla, there may be two to three anterior **eyespots**, as well as **lateral papillae**, on each side of the body.



- The mature miracidia penetrate through boring papilla and reaches pulmonary sac
- It changes into elongated sac like second larva, sporocyst
- It undergoes an embryonic development to give rise to next type of 5 to 8 larvae called rediae (Polyembryony).
- Germ cells in redia get differentiated into second generation of daughter rediae.
- In winter season, fourth larval stage is developed called cercaria. Each redia produces 15 to 20 cercariae, which are released into surrounding water.
- Cercariae are free swimming heart shaped larvae with a long muscular tail.
- The whole cycle is completed in 30 to 60 days.
- The cercariae attach to water grasses (aquatic vegetation), losing its tail undergoing encystment. These larvae are termed as ‘metacercaria’.

- It awaits its next host. The mammalian host then eats this vegetation and can become infected (It is swallowed by sheep or goat. Humans can often acquire these infections through drinking contaminated water and eating freshwater plants such as watercress).
- Inside the duodenum of the mammalian host, the metacercariae are released from within their cysts (dissolved by intestinal enzymes).
- From the duodenum, they burrow through the lining of the intestine and into the peritoneal cavity (body cavity).
- They then migrate through the intestines and liver, and into the bile ducts.
- Inside the bile ducts, they develop into an adult fluke. In humans, the time taken for F. hepatica to mature from metacercariae into an adult fluke is roughly 3 to 4 months.
- Adults can survive in sheep for 5 years and 5 to 9 years in man.
- The adult flukes can then produce up to 25,000 eggs per fluke per day
- These eggs are passed out via stools and into freshwater.
- Once in freshwater, the eggs hatch as miracidia, which then find a suitable intermediate snail host of the Lymnaeidae family and the life cycle begins again.

Pathogenicity:

- The disease caused by Fasciola species is termed as “fascioliasis”.
- It is primarily responsible for extensive damage to the liver through migration of young worms resulting into "liver rot”.
- It is characterized by vomiting, persistent diarrhoea, hepatomegaly with eosinophilia (40 to 85%).
- The bile duct, they may interfere with passage of bile causing obstructive jaundice.
- Epithelial lining of bile duct grows in uncontrolled manner, leading to adenomata.

Control measures:

1) Human infection can be checked by the <u>eradication of disease in animals.</u>
2) The population of pond snails; an intermediate host in infected area should be controlled by malacocide, copper sulphate.
3) Breeding in pond snails shall be checked by reducing vegetation near the pond.

Treatment:

1. Most effective drug against the fascioliasis is Bithionol.
2. Liver rot is treated by doses of certain drugs like Emetin hydrochloride, filicin compounds or tetrachloroethane.

3) *Taenia solium*

- It is commonly called as “pork worm'.
- It is a long, digenetic, intestinal parasite of man, belonging to Phylum: Platyhelminthes and Class: Cestoda.
- It occurs in all the countries especially those who prefer to eat pork. It is more commonly found in India, Germany, China and Yugoslavia.

Life cycle of *Taenia solium*

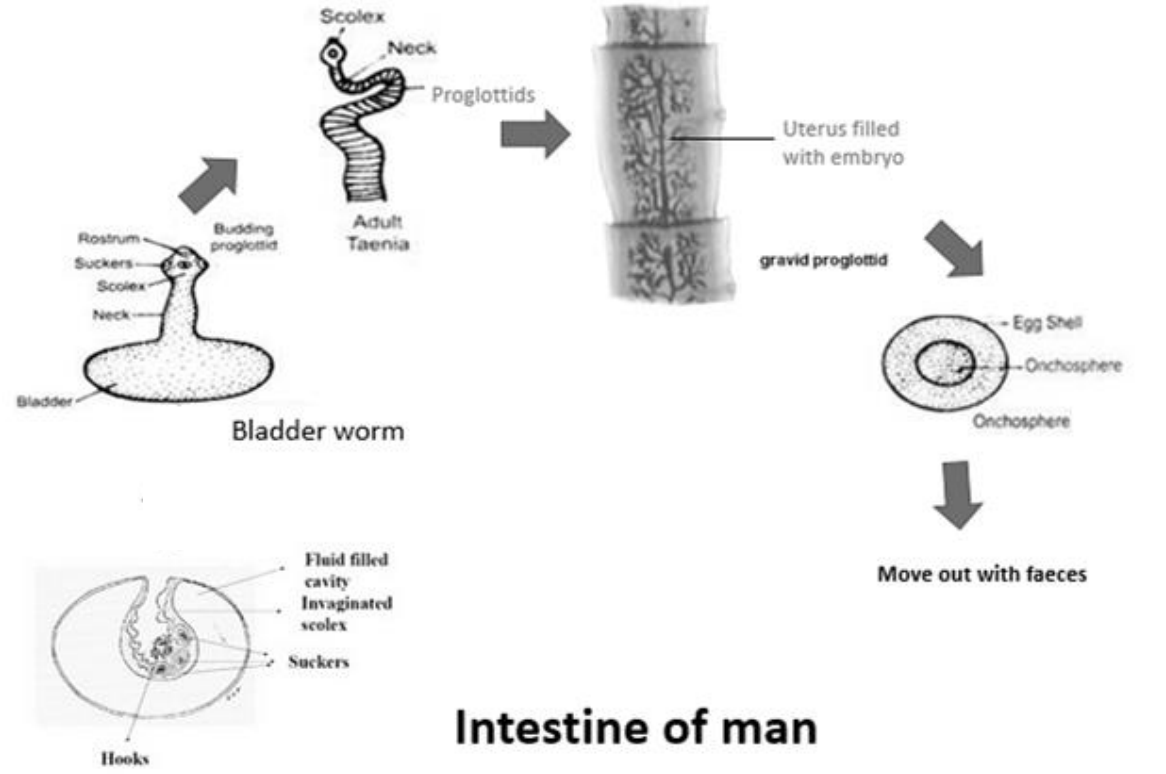
The life cycle in *Taenia* requires two hosts, man as a definitive (primary) host and pig an intermediate (secondary) host.

Life cycle in Man:

- The infective stage of tapeworm is “cysticercus larva'.
- It enters human body when uncooked or undercooked pork (meat of pig origin) containing infective bladder worm (cysticercus larva) stage is engulfed by man.
- Upon reaching gastric cavity, the outer cuticle and the part of the bladder is hydrolyzed by the gastric juice.
- In the intestine, the scolex start evaginating after it comes in contact with bile.
- The bladder worm now gets attached to the gut wall with the help of suckers and hooks. The cyst wall is completely dissolved and a young tape worm is developed.
- The neck elongates to form proglottids. The worm obtains its nourishment ready made from intestine of host.
- Gradually it forms a proper body called ‘strobili’. It attains sexual maturity within 10 to 12 weeks.
- It undergoes self or cross - fertilization.
- Egg capsules are stored in the uterus. An egg is well covered with shell. It is secreted by vitelline gland.
- In the beginning, the zygote undergoes unequal cleavage to form onchosphere. It is also covered by two embryonic membranes and shell.
- The matured and gravid proglottids containing thousands of onchosphere detaches from the body of tapeworm to change the host.
- An average life span of tape worm is 25 years.

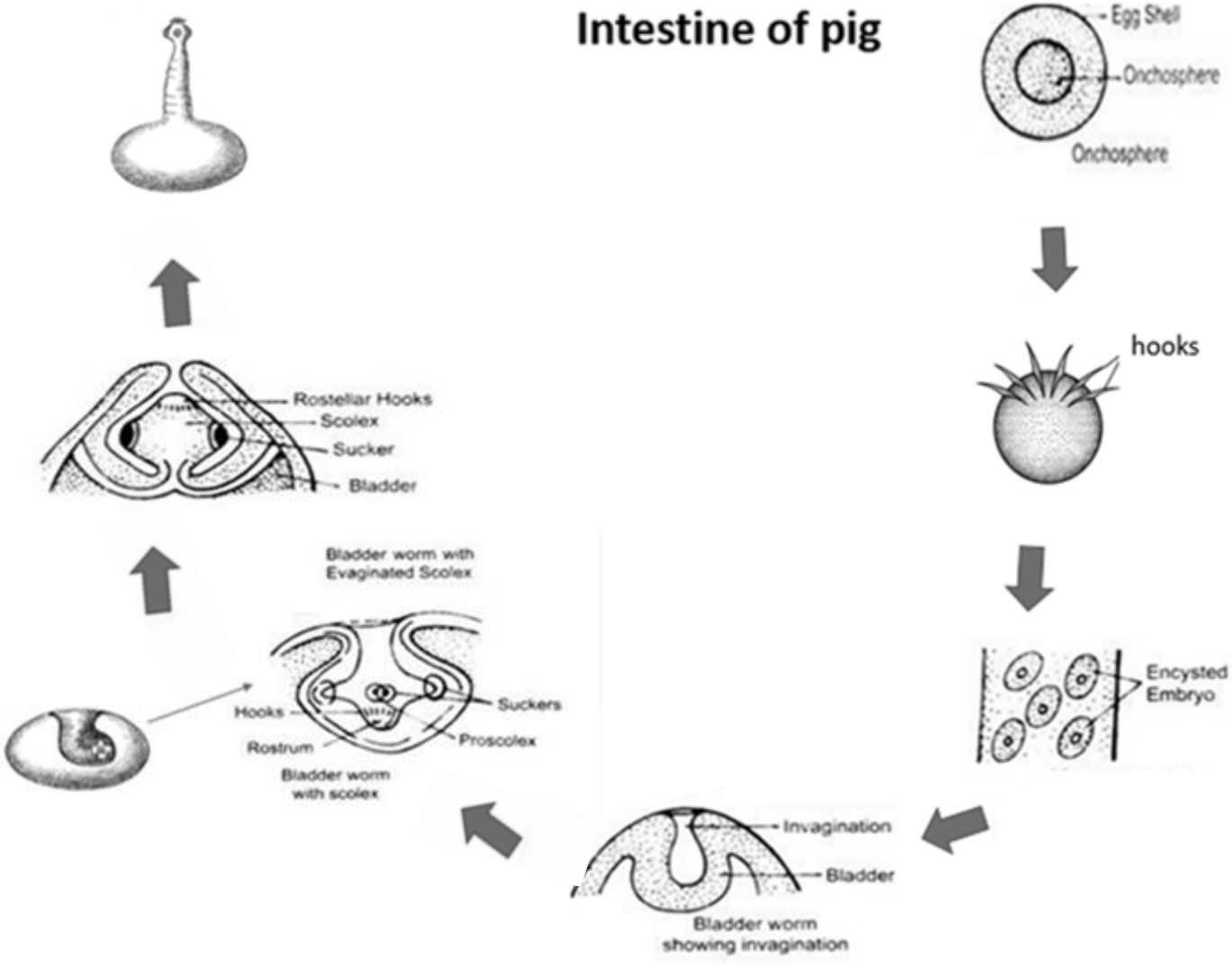
Life cycle in Pig:

- The hexacanth embryo is an infective stage of tapeworm.
- It enters the host when pigs feeds upon gravid proglottids.
- Gastric juice in the stomach dissolves embryonic membranes so as to release six hook embryo called ‘hexacanth embryo’.



Intestine of man

Intestine of pig



- Subsequently, it penetrates an intestinal wall and invades the portal vessels or lymphatic vessels of intestine.
- It successfully reaches systemic circulation and get filtered out from the blood into striated muscles of tongue, neck, shoulder and limbs. The cardiac muscles may be also involved.
- The hexacanth embryo looses its hooks and cells in the centre get liquefied in striated muscles in about 8 days of infection to pigs.
- It becomes enlarged and develops a fluid filled cavity with resistant cyst wall. It forms early bladder worm stage.
- The cyst wall invaginates from the region bearing hooks. At the base of hooks, rostellum and suckers, an immature head called 'proscolex' is developed.
- Now, this stage is called infective bladder worm stage or cysticercus larva. The period of development is about two months.

Pathogenicity:

- The pathological conditions caused by tapeworm is called "Taeniasis'. The ill effects caused to man due to tapeworm infection are called Taeniasis and Cysticercosis.
  - Taeniasis -It is caused due to the presence of adult worms in the intestine. It injures mucosa layer by clinging with the help of hooks and suckers. It obliterates the intestinal functions causing chronic indigestion, diarrhea, and weight loss with excessive appetite, anaemia and abdominal discomfort.
  - Cysticercosis -The bladder worm stage develops in various body parts associated with striated muscles. It invades eyes, heart and brain forming nodulesin such vital organs. The cysticercosis in brain may lead to epileptic convulsions, severe headache and vomiting.

Control measures:

1) The pork should be properly cooked before consumption.
2) The closed lavatories should be built to prevent epidemic spread of 'amoebiasis'.
3) The slaughter houses should be checked time to time.
4) A strict awareness about parasitic diseases and personal cleanliness is to be created through health columns of regional newspapers.

Treatment: There are two types of drugs used to treat taeniasis.

i) Vermifuge: It removes worm from intestine without killing it.
e.g. Mepacrine hydrochloride.
ii) Vermicide: It is a drug which kills the worms.
Both the drugs should be prescribed by family physician as per body weight and hypersensitivity. e.g. Albendazole, Hetrazan etc.

4) ***Wuchereria bancrofti***

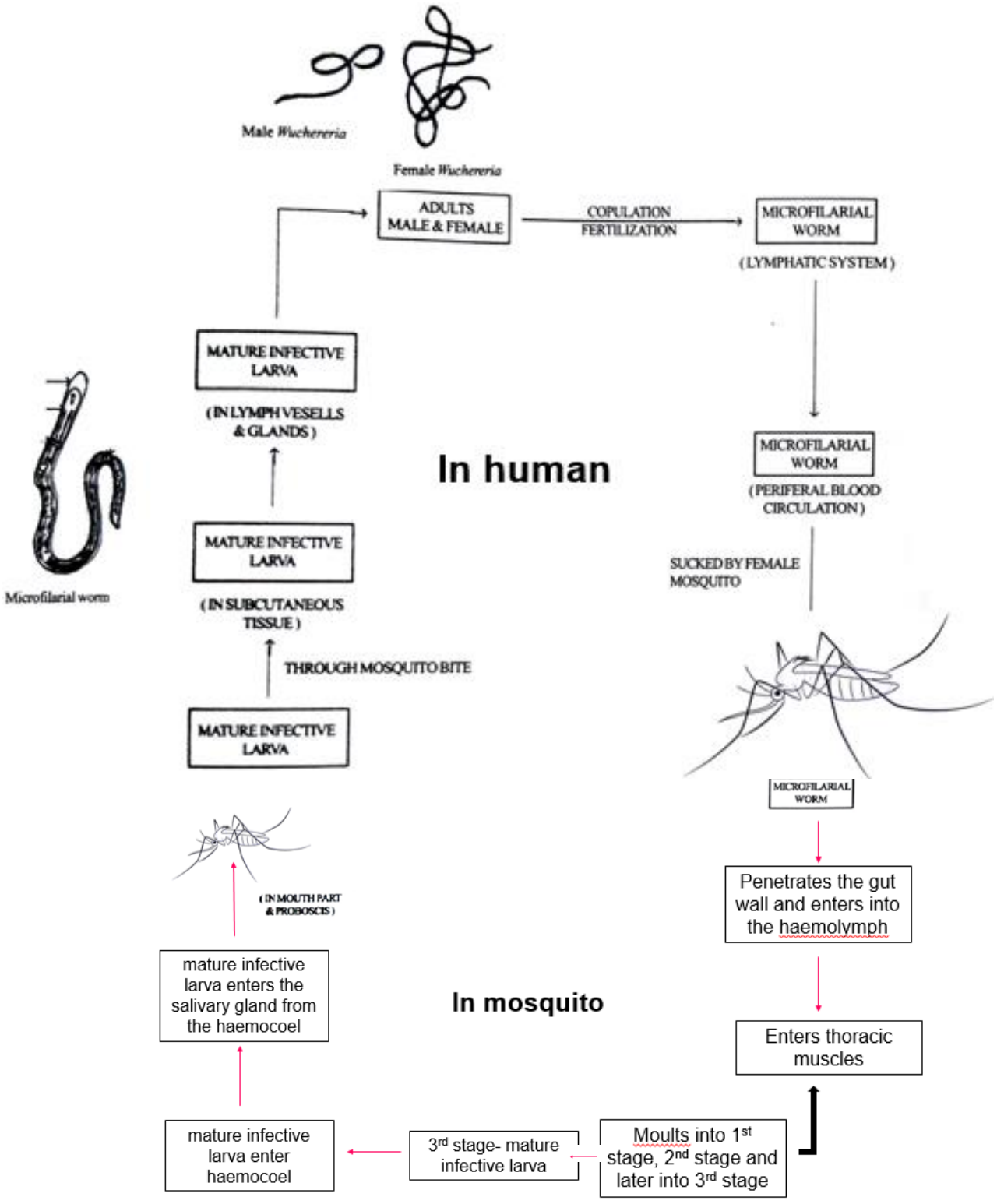
- It is also known as a 'filarial worm'.
- It is microscopic, and digenetic type of round worm, belonging to phylum: Ascheminthes and class: Nematoda.
- It is a lymph parasite living in lymph node and lymphatic vessels of man.
- It is indigenous in warm regions of the world and is found throughout Africa, southern and southeastern Asia, the Pacific islands, and the tropical and subtropical regions of South America and the Caribbean.
- The adult worm is long, cylindrical and slender (thread like) with smooth cuticle and bluntly rounded ends.
- It is white in colour and almost transparent.
- The body is quite delicate.
- It has a short cephalic or head region connected to the main body by a short neck, which appears as a constriction.
- Dark spots are dispersed nuclei throughout the body cavity, with no nuclei at the tail tip.
- W. bancrofti exhibits sexual dimorphism.
- Males and females can be differentiated by size and structure of their tail tips.
- The male worm is smaller, 40 mm (1.6 in) long and 100 μm (0.0039 in) wide, and features a ventrally curved tail. The tip of the tail has 15 pairs of minute caudal papillae, the sensory organs. The anal region is an elaborate structure consisting of 12 pairs of papillae, of which eight are in front and four are behind the anus.
- In contrast, the female is 60 millimetres (2.4 in) to 100 millimetres (3.9 in) long and 300 micrometres (0.012 in) wide, nearly three times larger in diameter than the male. Its tail gradually tapers and rounded at the tip. No additional sensory structures are seen. Its vulva lies towards the anterior region, about 0.25 mm from the head.
- The microfilaria is a miniature adult, and retains the egg membrane as a sheath, and is often considered an advanced embryo.
- Microfilariae are very active transparent, colourless bodies with blunt heads and pointed ends.
- It measures 280 μm long and 25 μm wide.
- It appears quite structureless in vivo, but histological staining makes its primitive gut, nerve ring, and muscles apparent.
- It is surrounded by a hyaline sheath.

Life cycle

- It is a digenetic parasite.
- It completes its life cycle in two hosts namely: Humans which serve as the definitive host and mosquitos as the intermediate host.

Life cycle in Human:

- The infective stage of parasite is 'microfilaria.
- It is inoculated in man through the bite of infected mosquitoes.
- The first-stage larvae, known as microfilariae, are present in the circulation.
- The microfilariae have a membrane "sheath". This sheath, along with the area in which the worms reside, makes identification of the species of microfilariae in humans easier to determine.
- The microfilariae are found mainly in the peripheral blood and can be found at peak amounts from 10 pm to 4 am.
- They migrate between the deep and the peripheral, circulation exhibiting unique diurnal periodicity.
- During the day, they are present in the deep veins, and during the night, they migrate to the peripheral circulation.
- One such reason for this periodicity of the microfilariae being in the peripheral blood during these hours may ensure the vector, the nighttime mosquito, will have a higher chance of transmitting them elsewhere.
- Physiological changes also are associated with sleeping, such as lowered body temperature, oxygen tension, and adrenal activity, and an increased carbon dioxide tension, among other physical alterations, any of which could be the signals for the rhythmic behavior of microfilarial parasites.
- If the hosts sleep by day and are awake at night, their periodicity is reversed.
- The larvae move through the lymphatic system to regional lymph nodes, predominantly in the legs and genital area.
- The larvae develop into adult worms over the course of a year (about 5 to 18 months), and reach sexual maturity in the afferent lymphatic vessels.
- The adult parasites reside in the lymphatics of human host. They are found mostly in the afferent lymphatic channels of the lymph glands in the lower part of the body.
- Adult males and females are most often coiled together and are difficult to separate.
- Females are ovoviviparous (does not lay eggs after fertilization, fertilized eggs develop inside the female body)and can produce thousands of juveniles larvae known as microfilariae.
- Microfilariae are discharged from the gravid females and appear in the peripheral blood in 8–12 months.
- They do not undergo further development till it is sucked by mosquitoes.
- It will otherwise die eventually after 70 days.
- The microfilariae are transferred into a vector, which are most commonly mosquito species of the genera Culex, Anopheles, Mansonia, and Aedes.


Male Wuchereria
Female Wuchereria
ADULTS MALE & FEMALE
COPULATION FERTILIZATION
MICROFILARIAL WORM
(LYMPHATIC SYSTEM)
MATURE INFECTIVE LARVA
(IN LYMPH VESELLS & GLANDS)
Microfilarial worm
In human
MICROFILARIAL WORM
(PERIFERAL BLOOD CIRCULATION)
MATURE INFECTIVE LARVA
(IN SUBCUTANEOUS TISSUE)
SUCKED BY FEMALE MOSQUITO
THROUGH MOSQUITO BITE
MATURE INFECTIVE LARVA
MICROFILARIAL WORM
(IN MOUTH PART & PROBOSCIS)
Penetrates the gut wall and enters into the haemolymph
mature infective larva enters the salivary gland from the haemocoel
In mosquito
Enters thoracic muscles
mature infective larva enter haemocoel
3rd stage- mature infective larva
Moults into 1st stage, 2nd stage and later into 3rd stage

Life cycle in Mosquito:

- Microfilariae ingested by mosquito cast of their sheath quickly (metamorphosis into a sausage-shaped organism) and penetrate the intestinal wall within 1 to 2 hours and migrate to the thoracic muscles.
- In the next two days of rest, it shortens its length by half and increase thickness. Now, this is called the first-stage larva.
- It undergoes one or two moulting in next 3 to 7 days to give rise the second-stage larva. The third-stage is developed after 10 to 11 days.
- In next 20 days, it completes its growth to form the next stage called the mature infective larva (motile larvae).
- It then migrates to proboscis (labium) of mosquito.
- The infective larva is liberated from the mosquito and deposited by flexure of the proboscis during blood feeding and then actively migrate through the puncture wound in the skin of the host.
- W. bancrofti migrate through microcuts in the dermis or the tract created by the proboscis into the blood stream of the new human host.
- The organism notably does not multiply within its intermediate host, the mosquito.
- In warm and humid conditions, they wait for the change of host and repeat the life cycle.
- The life span of *Wuchereria* is long (5 to 10 years).

Pathogenicity:

- The disease caused by filarial worm is termed 'filariasis' or 'elephantiasis' or 'Wuchereriasis'. Following three main pathogenic conditions are observed:
- Lymphangitis:
  It is an inflammation of lymph vessels and lymph nodes due to mechanical blockages, irritation and toxic secretion of filarial worms. It is also due to dilation of thickening of the walls of afferent lymph vessels and spaces in the lymph node.

- Filarial fever is recorded the body temperature between 103° to 104°F, followed by profuse sweating.

- Elephantiasis:
  Blockage and inflammatory damage to lymphatic vessels by dead and living worms cause the affected areas (like limbs, scrotum, clitoris, mammary glands etc.) to become grossly enlarged leading to the condition called filarial elephantiasis.

Control measures:

- Mosquito population can be well controlled by an effective insecticide like organo-phosphate or organo-chlorides.
- Mosquito bite should be avoided by using bed-net or by fixing mosquito net at window panes.
- Natural mosquito repellents like Neem seed oil, citronella oil can be used.
- Mosquitoes can be naturally controlled by rearing larvivorous fishes (*Gumbusia* or *Labistes*) in aquarium or stagnant water.

Treatment:

- DEC i.e., Diethylcarbamazine citrate is very effective drug against microfilaria. It helps to check the spread of disease.
- Adult population is well checked by the drug of choice, Hetrazan.

2.4 Morphology, life cycle, pathogenicity, control measures and treatment.

1. **Head louse** (*Pediculus humanus capitis*)

- It is a blood sucking ectoparasite and a wingless insect.
- It belongs to order anoplura and family pediculidae.
- It lives along the thick growth of human hair on the head, hence called as head louse.
- It is cosmopolitan in distribution.
- Head lice have been associated with man, since ancient times.

Morphology

- It is dorso-ventrally flattened, greyish-white in colour with dark markings along the sides.
- They are sexually dimorphic as males are smaller than females. Males are 2.5 to 3.0 mm in length with posterior end turned upwards and females are 2.8 to 4.0 mm in length.
- The body is divided into head, thorax and abdomen.
- Head is small with a pair of compound eyes and a pair of five jointed antennae.
- The mouth parts are piercing and sucking type as they feed on blood of the host.
- It bears 3 pairs of thoracic legs ending into claws.
- Abdomen has 9 segments.

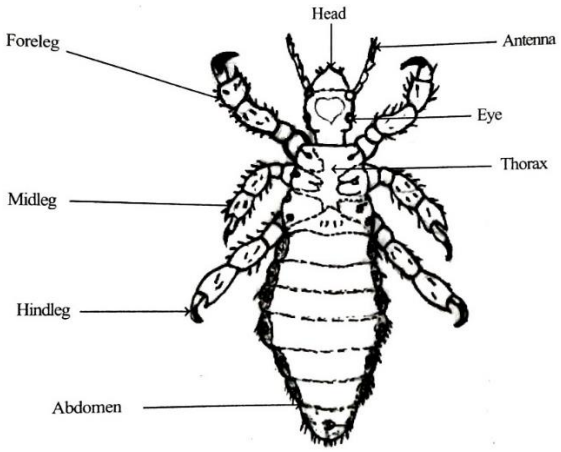
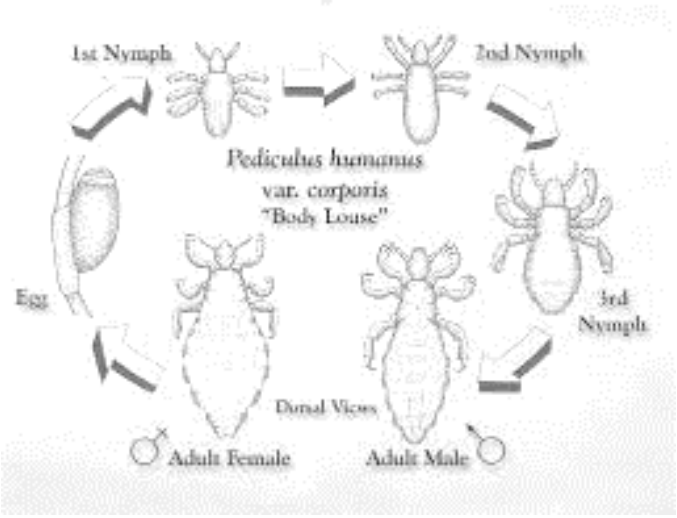


Fig., Morphology of Head louse

Life cycle:

- The life cycle is of short duration and comprises of three stages: egg, nymph, and adult.
- Lice can breed throughout the year once they reach adulthood.
- Female lays 8 to 10 eggs per day after fertilization.
- Head lice eggs are commonly called as 'nits'. They are white, oval and 1 mm in length with lid at broad end.
- Nits cemented at the base of the hair shaft nearest the scalp
- Eggs remain firmly attached to dense hair.
- It usually takes about 1 week to hatch. Viable eggs are usually located within 6 mm of the scalp.
- An egg hatches into miniature adult, a nymph.
- It feeds on host blood 2 to 6 times a day.
- They undergo three moultings within 15 to 18 days and become sexually matured.
- Adult lice can live up to 30 days on a person's head. To live, adult lice need to feed on blood several times daily. Without blood meals, the louse will die within 1 to 2 days off the host.
- The average life span is about one month.



Pathogenicity: Lice sucks blood of their host.

- It causes irritation and red spots at the site of injury.
- It is considered as a bio-vector for relapsing fever and typhus fever.
- It is also believed to be mechanical vector for germs of bubonic plague i.e., *Pasterella pestis*.

Control measures:

1. One should take regular bath and avoid close body contact with infected people.
2. A proper shampoo should be used to control head lice population.
3. Infested clothings should be fumigated with HCN or methyl bromide for effective delousing.
4. Use of common hair comb and clothes of infested people should be avoided.

Treatment:

- An insecticide powder of 2% malathion or 1% lindane is found to be effective against lice growth.
- Dust composed of carbamyl is also used as a louse powder for the control of Headlice.

2. **Mite** (Sarcoptes scabies)
   - It is basically a tissue feeding, microscopic arachnid which is ectoparasitic to man and farm animals.
   - It is a member of Order : Acarina and Family : Sarcoptidae.
   - It is commonly called 'the itching mite'.
   - They are worldwide in occurrence. They are found to occur in tropical countries.

Morphology:

- The body of mite is minute, whitish, nearly round and dorso-ventrally flattened with transverse striations.
- The whole body has long pointed and sensory spines.
- Body is with no distinction between prosoma and ophisthosoma.
- The mouth parts form head like structure called the gnathosoma that bears a paired chelicerae and a paired pedipalpi.
- The mouth parts are biting, piercing and sucking type.
- The eyes and trachea are not developed.
- There are 4 pairs of legs. Anterior 2 pairs of legs are stout and supported with terminal stalked suckers. Posterior 2 pairs of legs are shorter with long bristles.

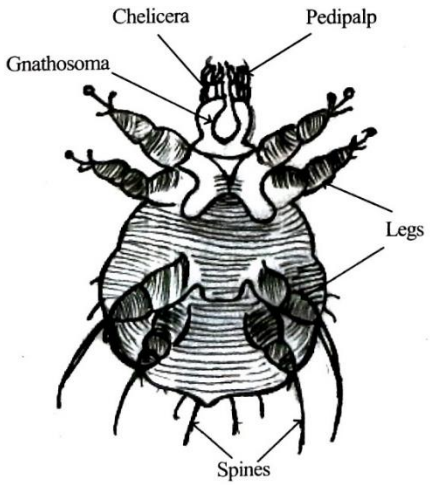
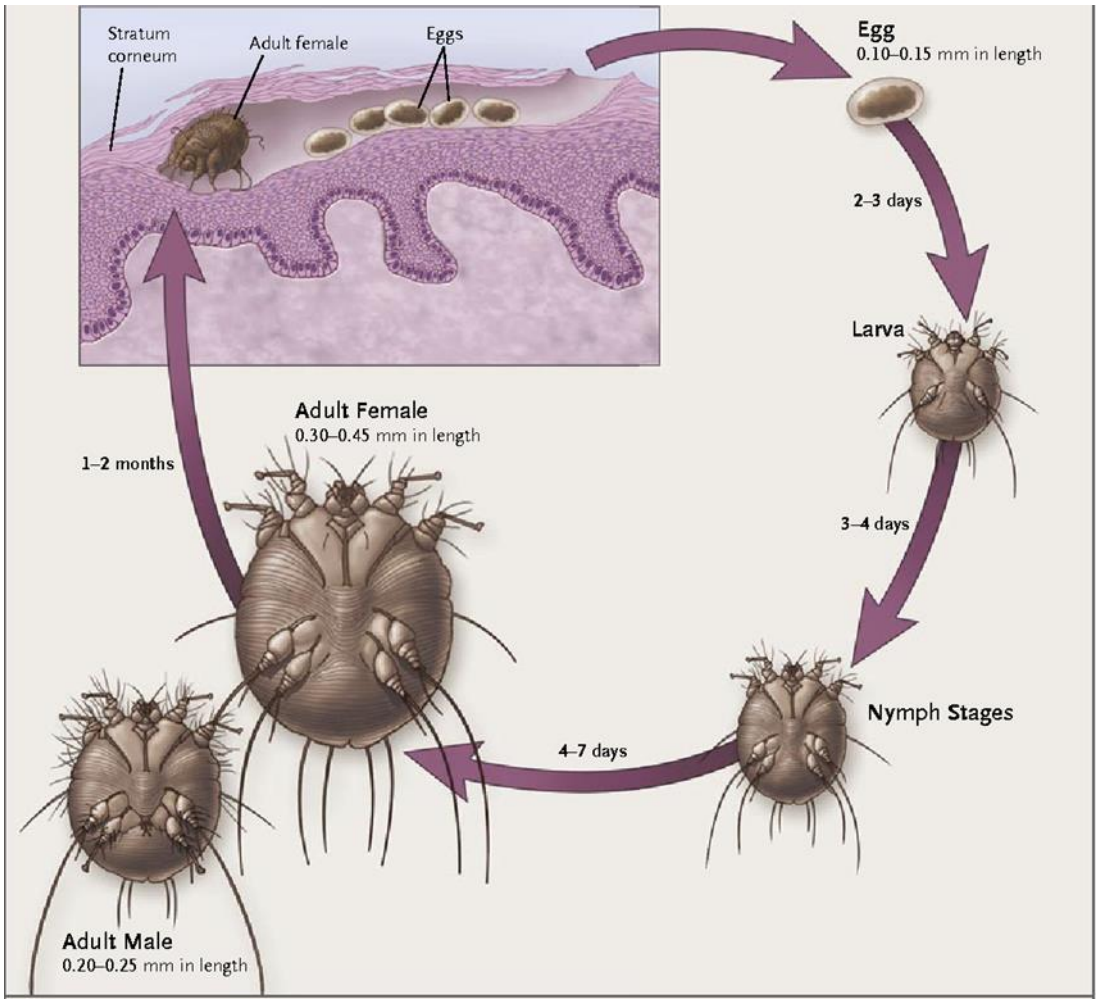


Fig. Morphology of Mite

Life cycle:

- The sexes are separate.
- After mating, female digs the soft skin of host and forms tunnels of 2.5cms in length.
- The females enters borrow and lays about 2-3 eggs per day.
- The eggs hatch in few days into six legged larvae.
- They gradually changed into nymph.
- It is feeding stage which damages the skin.
- It tries to change the host as and when opportunity arises.



Pathogenicity:

- The itching mites bore down soft skin between fingers and toes, on external genitalia and behind knee to form burrows in which eggs are laid by females.
- It causes extreme itching sensation.
- The hard pimples provided with yellow fluid are formed on affected skin.
- After scratching, it forms large and ugly sores and dry scabs.
- This pathological condition is termed as 'scabies' or 'itch'. The continuous itching may lead to eczema.

Control measures:

- The children should avoid the contact with infected children while playing.
- Early diagnosis of infestation is suggested.
- It is also advisable to keep infested person isolated from the household articles till scabies is cleared.
- Personal cleanliness and sterilization of garments and beddings prevent the spread of mites.

Treatment:

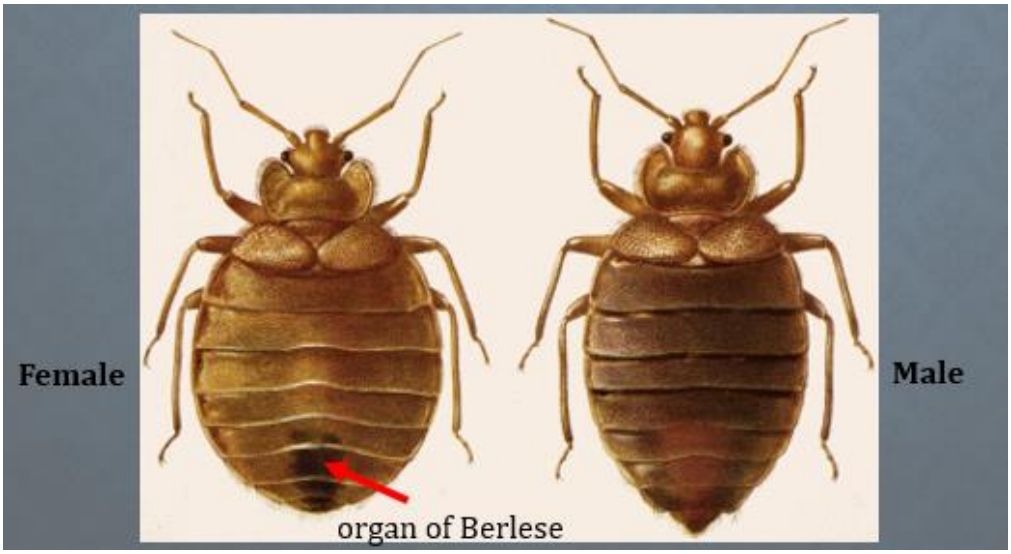
- 25% Benzyl benzoate is proved effective against the itching mite.
- Topical application of 5 to 10% sulphur ointment daily for 3 to 4 days is a cheap remedy.
- 0.5 to 1.0% Lindane in coconut oil is used as a sarcopticide.

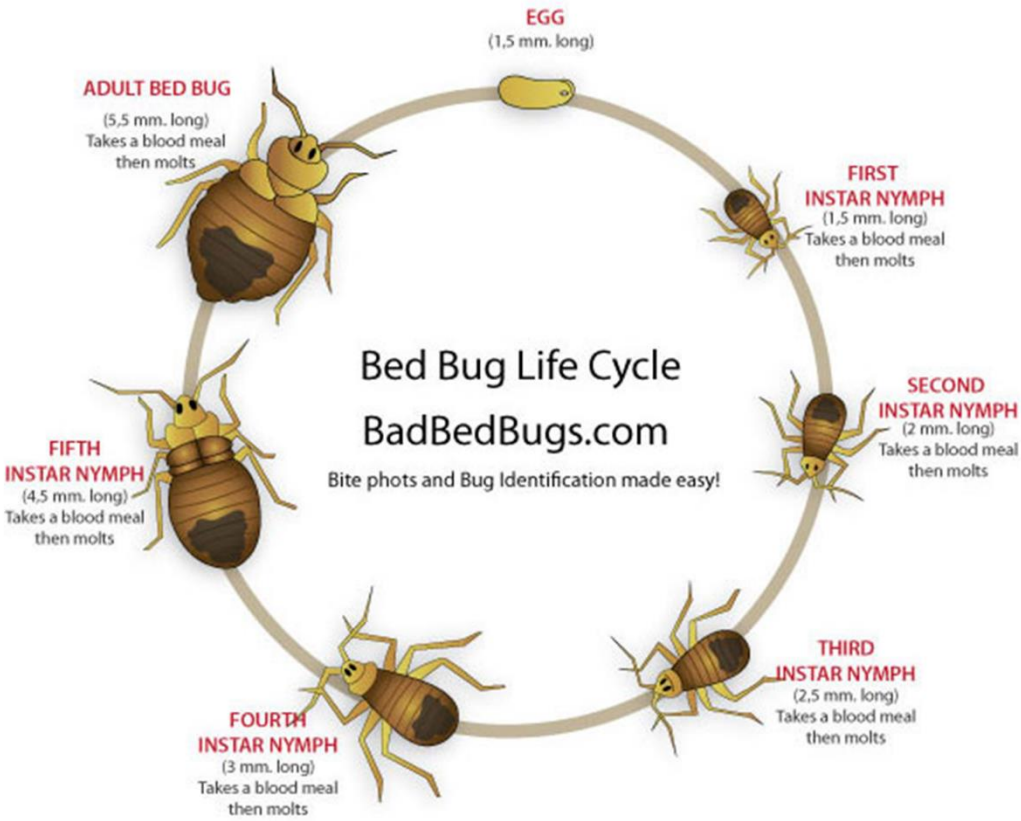
3. **Bed bug** (*Cimex lectularis*)
    - It is a common, blood feeding, small size, ectoparasitic insect.
    - It is categorized as a member of insect Order : Hemiptera of Family: Cimicidae.
    - It is nocturnal in habit.
    - They occur worldwide mainly in hotels or in old buildings particularly in crevices of furniture or cots.
    - They are found in America, Europe, Northern India, Northern China and Siberia.

Morphology:

- Bedbugs are oval, brown or red coloured, dorsoventrally flattened and wingless insects.
- They are 5.0 mm in length and 3.0 mm in breadth.
- Body is typically divided into head, thorax and abdomen.
- Head bears a pair of compound eyes and two short four jointed antennae.
- Mouth parts are enclosed in the form of proboscis called rostrum.
- The thorax is divided into prothorax, mesothorax and metathorax.
- The forewings are vestigial and hind wings are absent.

- Each thoracic segments bear one paired stout clawed legs so as to run quickly.
- Abdomen possesses 7 segments.
- Male posterior end is narrow and pointed than in the female bug.
- Female bug has a broad abdomen to develop copulatory pouch, known as the 'organ of Berlese'.





Life cycle of bedbug:

- Life span of adult is one and half year.
- Adults copulate after taking complete blood meal.
- Fertilization is internal. Female lays about 200 eggs, 2-3 eggs per day in the safe places.

- An egg is pearly white, cylindrical and slightly curved with lid at one end.
- An egg hatches to give rise nymhal stage after an incubation of five weeks or more depending on temperature.
- First nymphal stage is pale or semitransparent and size of pin's head.
- It feeds on blood and undergo 5 moults to reach adulthood.
- If host (like man) is not found, it is known to feed on blood of older bugs.
- The life cycle is completed in about 5 to 10 months if climatic conditions are optimum.

Pathogenicity:

- Bedbugs puncture the skin and feed on blood of man and rodents.
- Their bite induces swelling and imitation.
- Once fed completely, they can remain without food for six month or more.
- It is suspected to be vector for diseases like kala-azar, bubonic plague, typhoid and T.B of man.

Control measures:

- The human residence should be well ventilated to avoid humidity.
- Beddings, cots and wooden furniture cleanliness can keep away the bugs from houses.
- The insecticides like DDT, BHC, Chlordane or emulsion of kerosene benzene can easily exterminate the bugs.
- Rooms and furniture can be fumigated with HCN (costly and dangerous to man) with utmost care.

Treatment:

- As an immediate care, one can apply a little hydrogen peroxide or ammonia at the site of puncture.
- Calamine solution or skin ointments can find soothing effect to painful skin.

2.5 Parasitological Significance Zoonosis

1. Literally the term “Zoonosis" is confined to a disease of animals.
2. WHO defines zoonosis as 'those diseases and infections which are naturally transmitted between vertebrate animals and man'
3. It is the process of development of human diseases from naturally acquired infections of vertebrate animals.
4. Nearly, 1415 pathogens are known to cause infections to man, of which about 61%of all pathogens cause zoonotic diseases.
5. e.g. Leishmaniosis, Trypanosomiasis, Rabies, Anthrax etc. are typical examples of zoonotic diseases.

6. There are three categories of zoonotic diseases
    a. **Anthropozoonoses** : These are the infections transmitted to man from vertebrate animals. e.g. Plague and Rabies.
    b. **Zooanthroponoses** : These are the infections transmitted from man to vertebrate animals. e.g. Human T.B. in cattle and Amoebiasis in dogs.
    c. **Amphixenoses** : These infections are maintained in both man and lower vertebrate animals that may be transmitted in either direction. e.g. *Trypanosoma cruzi* (Chagas Disease) and *Schistosoma japonicum* (Schistosomiasis).

Bird Flu

1. It is also referred to as “Avian influenza”.
2. It is an acute respiratory tract infection caused by influenza viruses.
3. It is one of the serious pandemic disease affecting millions of people in the world every year.
4. Causative agent :
    a. There are three strains of influenza viruses, A, B and C.
    b. Bird flu is caused by influenza virus A, H_5N_1 type.
    c. Both A and B viruses have two distinct surface antigens, H-the haemoagglutinin and N-neuraminidase.
    d. The H antigen initiates the infection by attaching the virus to host cell while N antigen is responsible for the release of viruses from infected host cells.
5. Mode of transmission:
    a. A common influenza is spread from one person to another by droplet infection.
    b. However, human infection to highly infective strain of bird flu is uncommon.
    c. The site of entry of virus is respiratory tract.
    d. The virus, H5N1 is found to be originated in wild aquatic birds, but it can be communicated easily to domestic fowls or poultry birds.
    e. It is transmitted directly to human through bird excreta and secretions from mouth, eyes, and nasal cavity.
    f. Incubation period: 18 to 72 hours.
6. Signs and symptoms :
    a. The virus causes inflammation to respiratory tract.
    b. Epithelial lining of trachea and bronchi undergo necrotic changes.
    c. Fever, cough and sore throat develops.

d. Conjunctivitis (Eye infection), body pain and severe viral pneumonia.
e. Multi-organ failure in later stage of disease.

7. Control Measures:
   a. During epidemic spread, it is advisable to avoid direct contact with infected poultry birds.
   b. Culling of infected bird is one of the best measure to prevent infection.
   c. Residential zone should have good ventilation.
   d. To stimulate localized immunity, a live attenuated vaccines offer good resistance.
   e. Antiviral drugs like amantadine and rimantidine stops virus multiplication.

Anthrax:

- **It is** a bacterial disease caused by Bacillus anthracis.
- The term anthrax is derived from Greek word, -anthrakis in reference to black skin lesions patient develops
- In 2001, U. S. receive mail containing the spores of bacteria causing anthrax.
- It is basically a disease of herbivores like goat, sheep, cattle and horses.
- Cats, dogs and pigs are resistant to anthrax.

Causative agent :

- B. anthracisis a rod shaped pathogenic bacterium found in the soil.
- Normal bacteria can change into spores which remain dormant in condition for many years.
- They can germinate and reproduce after exposure to optimum conditions.

Mode of transmission :

- Infected animal to domestic animals through inhalation of spores.
- Ingestion of Infected carcass, diseased wild or domestic herbivores, infected animal by - products (Hides, bones resistant spores released from flesh).
- Direct contact with the skin of human with pathogen from soil.

Site of Infection and Incubation period :

- Skin (Cutaneous)-2 to 5 days, Lungs (respiratory) - 1 to 3 days and Digestive tract- 7 days.

Signs and symptoms :

- If skin is infected, pimple like lesion enlarging almost an inch in 1 to 2 days.
- It causes painless ulcers.
- Skin lesions will eventually turn black.
- If it infects respiratory tract, sore throat, chest pain or even heart attack, and severe difficulty in breathing is experienced. It may prove fatal.
- In case of ingestional infection, symptoms like nausea, blood vomiting, tiredness, no appetite, abdominal pain, fever and bloody diarrhoea are noted.

Control:

- Biothrax vaccine can prevent disease anthrax due to active immunization.
- Antibiotics can cure disease if proper line of treatment is followed.
- If persons is suspected to be exposed to spores, the regular 2 months treatment is must,
- Antibiotics like Ampicillin, Doxycycline and Penicillin can be very useful to control infections.

Toxoplasmosis :

- It is worldwide infectious disease found in cats, farm animals and man. It is a common parasitic disease of man caused by Toxoplasma gondii.

Causative agent :

- It is a sporozoan, digenetic, parasite belonging to Phylum: Protozoa.
- It exists in two forms pseudocyst and tissue cyst.
- Pseudocyst is 4 to 6 um in length and 2um in breadth.
- It occurs in reticulo-endothelial system.
- A tissue cyst is found in tissue fluid or embedded in nervous system or musculature where it is enveloped by membrane.
- It grows 100 um in size.

Signs and symptoms :

- Asymptomatic in healthy person or only few swollen lymph glands in the patient's neck.
- Person with less resistance develops infection that attack brain and nervous system which results into fever, seizures, headache, psychosis, problem with vision, speech and movement.
- Congenital disease can lead to still-birth or abortion.
- Incubation period : Few months or many years that depends on resistance of host.

Mode of transmission : It can occur two ways :

- Congenital : It takes place from mother to fetus through placental route
- Acquired : The organism may enter in children and also in adults by the following way
    - Through ingestion of improperly cooked meat, cow's milk and eggs containing pseudocyst. An oocysts can be also swallowed by other animals from excreta of cat.
    - By inhalation-animals sputum and bronchial secretion contains organism.
    - Direct contact with injuries of infected animals can penetrate Toxoplasma.

Control :

Prevention :

- Do not adopt or handle stray cat.
- Cat's litter box should be cleaned.
- Fruits and vegetables should be washed well before the consumption.
- Meat shall be thoroughly cooked to prevent the possibility of ingestion of viable Toxoplasma.

Treatment:

- Healthy person does not require to treat Toxoplsmosis as it could be well tolerated.
- Pyrimethamine and Sulphadizine together form the best remedy against toxoplasmosis.

Rabies:

- It is a type of viral infection caused by Lyssavirus.
- Rabies in human being is called hydrophobia.
- It is 100% fatal disease if not prevented. In India, rabies occurs in all parts of the country except Lakshadweep, Andman and Nicobar Island. Annually, 30,000 deaths are reported by govt. authorities.

Causative agent :

- It is a bullet shaped neurotropic RNA containing virus called Lyssavirus type.
- Rabies viruses have two distinct antigens, a glycoprotein antigen for the virus membrane and nucleoprotein antigen.

Signs and symptoms :

- A patient complains of pain or tingling at the site of bite.
- Headache, malaise, sore throat and slight fever lasting for 3-4 days.
- Gradually, symptoms get aggravated there with difficulty in swallowing liquid, sound of water induces spasm of muscles of deglution.
- Incubation period : In dogs, 20 to 60 days, in human being, incubation period depends on site of bite, number of wounds, amount of virus injected and species of the biting animal. It may vary from 4 days to many years.

Mode of transmission :

- Animal bites-When rabid dog containing viruses in its saliva bites man, it transmits the disease to man.
- Licks-Dogs have habit of licking, when they lick on abraded skin, it contracts the disease.
- Person to person- It is although a rare phenomenon, a child biting its parent is recorded in the past.
- Aerosols- a lab co-workers have been reported to contract rabies while handling infected animal brains.

Control:

- There is no specific treatment for rabies.
- The various vaccines develop immunity against rabies.
- Following 3 vaccines can relieve the patient from probable rabies.
- Rabies vaccine is either a fluid or dried preparation of rabies fixed virus grown in the neural tissues of animal or in embryonated duck eggs. 1. Nervous tissue vaccine 2.Duck embryo vaccine and 3. Cell-culture vaccine