UNIT 4 PARASITES AND VECTORS

Structure

4.0 OBJECTIVES

After completing this unit, you should be able to:

- define and learn different types of parasites, hosts and vectors;
- list the important protozoon and helminth parasites pathogenic to humans;
- describe the structures and life cycles of the parasites;
- diagnose the diseases caused by these parasites; and
- enumerate the important arthropod vectors and the diseases transmitted by them.

4.1 INTRODUCTION

By now, through the study of Units 1, 2 and 3, you all know what we mean by parasites and vectors. The parasites are merely inhabitants of our planet which have adapted themselves to a type of existence in which they derive nourishment from other living beings (hosts). Sometimes these parasites cause discomfort or injury to the host; at other times they may cause disease in host and often may also be responsible for the death of the host. When the host dies, the internal parasites also die along with the host. All parasites are highly specialised for the type of existence they lead. In this unit, you will become familiar with some of the important well known protozoon and helminth parasites pathogenic to humans. You will also learn the various diseases caused by these parasites and how these diseases are diagnosed and transmitted by the vectors. Methods to control these parasites and vectors are also stated at appropriate places in the text.

4.2 DEFINITION OF TERMS

Parasite: An organism which derives its nourishment at the cost of another organism (host) in or on which it lives is called a parasite.

Host: The organism which harbours the parasite is called a host.

Parasitism: The relation which exists between the parasite and the host is known as

parasitism. Parasitism may also be defined as an association between two living organisms in which one benefits and the other is harmed.

Parasitology: It is a branch of science which deals with the study of parasites (protozoa and helminthes).

Protozoology: It is a branch of science which deals with the study of protozoa.

Helminthology: It is a branch of science which deals with the study of helminthes.

Entomology: It is a branch of science which deals with the study of insects.

4.3 TYPES OF PARASITES

Parmanent Parasites: These are the parasites which remain inside the host for the whole life until either the age or some immunizing process of treatment removes them. All the pathogenic protozoa and helminthes are permanent parasites.

Temporary Parasites: These are the parasites which visit the host for a short period. Only one stage of the parasite development is passed in the host.

Ectoparasite: It is an organism which lives outside the body of the host.

Endoparasite: It is an organism which lives inside the body of the host.

Non-pathogenic Parasite: It is a parasite which does not harm the host.

Pathogenic Parasite: It is a parasite which lives at the expense of the tissues and fluids of the host and inflicts injuries on the host tissues.

Obligatory Parasite: It is a parasite which entirely depends on the host for its existence.

Facultative Parasite: It is a parasite which leads parasitic life but is also capable of independent existence.

Check Your Progress 1

1) Differentiate between parasite and parasitism.

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2) Differentiate between obligatory and facultative parasite.

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Activity 1

From the report of the patients, list the ecto- and endoparasites.

4.4 TYPES OF HOST

Primary Host: It is an organism which harbours the adult stage of the parasite.

Intermediate Host: It is an organism which harbours the larval stages of the parasite. In some cases more than one intermediate host is required for the larval development. They are called first and second intermediate hosts.

Alternate Hosts: When two hosts harbour the same parasite, either is called an alternate host.

Accidental or Casual Host: It is an organism wherein parasite is not normally found.

Reservoir Hosts or Carriers: Animals which do not show any symptom of infection but act as a source of infection are called reservoir hosts or carriers.

4.5 PROTOZOON PARASITES PATHOGENIC TO HUMANS

Protozoa parasites are unicellular. They are divided into four classes: Rhizopoda (Sarcodina), Mastigophora, Sporozoa and Ciliata. All the four classes contain pathogenic parasites of humans (see Table 4.1).

Table 4.1: Protozon Parasites Pathogenic to Humans

Class	Genus	Species	Habitat	Pathogenic Lesions
1) Rhizopoda (Sarcodina)	*Entamoeba*	*histolytica*	Large Intestine	Dysentery; Hepatitis, Liver Abscess etc
2) Mastigophora				
a) Intestinal Flagellates	*Giardia*	*intestinalis*	Small Intestine	Diarrhoea
	Trichomonas	*hominis*	Large Intestine	Diarrhoea
b) Genital Flagellate	*Trichomonas*	*vaginalis*	Vagina	Vaginitis
c) Haemoflagellates	*Trypanosoma*	*gambiense*	Blood; Lymph node and Central Nervous System	Mid and West African Sleeping Sickness
	Leishmania	*donovani*	Endothelial system	Kala-azar
3) Sporozoa	*Plasmodium*	*vivax*	Red Blood Carpuscles and Liver Cells	Beneign tertian malaria
	Plasmodium	*falciparum*	R.B.C. and liver Cells	Malignant tertian malaria
	Plasmodium	*malariae*	R.B.C. and liver Cells	Quartan malaria
	Plasmodium	*ovale*	R.B.C. and liver cells	Benign tertian malaria
4) Ciliata	*Balantidium*	*coli*	Large Intestine	Dysentery

Entamoeba histolytica

E. histolytica is an internal protozoon parasite found in the mucous and subsmucous layers of the upper part of the large intestine, feeds on tissue cells, red blood corpuscles, bacteria and produces several ulcers and abscesses. Faeces becomes loose and slimy containing mucous and blood leading to amoebic dysentery. In chronic cases *Entamoeba histolytica* may be carried alongwith the blood stream to the liver, spleen, lung, brain and other organs.

Morphology

The body of *Entamoeba* is more or less round and distinguished into outer clear ectoplasm and an inner granular endoplasm with a large round nucleus. It occurs in three stages: Tropozoite, precystic and cystic. It feeds only in the trophozoite stage while the precystic and cystic stages are non-feeding stages.

***Trophozoite Stage*:** It is a spherical mature parasite or active adult with one or two blunt finger like pseudopodia. Formation of pseudopodium in any direction leads to locomotion in that direction. It nourishes itself at the expense of the host feeding on red blood cells and the cytolysed tissues. The granular endoplasm contains a spherical nucleus and food vacuoles containing red blood cells, bacteria etc. The red blood cell in food vacuole is an important characteristic feature of the parasite. Outside the human body, the trophozoite lives only for few hours and dies.

***Precystic Stage*:** It is smaller in size, round in shape and has only one blunt pseudopodium. The granular endoplasm is free of red blood cells and other ingested food particles.

Cystic Stage: It is almost similar to precystic stage with the difference that it has a thick cyst wall and there is no pseudopodium. The cytoplasm of the cyst contains oblong chromatid bars and sometimes in the early stages a distinct glycogen mass is also seen. The glycogen mass and the chromotid bars gradually disappear. The single nucleus multiplies in two successive divisions into two and ultimately four daughter nuclei are formed. Thus, a cyst may be uninucleate, binucleate and tetranucleate.

Reproduction and Life Cycle

The trophozoites chiefly multiply in the mucous and submucous layers of the intestine by binary fission. After several rounds of binary fission when they are unable to continue their life cycle solely in the trophozoite stage, they come to the lumen of the intestine and undergo encystations transforming into precystic and further into uninucleate, binucleate and infective tetranucleate cysts. These infective tetranucleate cysts do not undergo any further development in the human body at this stage. They pass out with the faeces of host and are infective to human being. On being again swallowed by humans with contaminated food or drink, they reach the stomach and as such pass on into the intestine. Here the cyst wall dissolves by the action of intestinal enzyme and through a rent in the cyst the cytoplasm protrudes and each cyst liberates a single tetranucleate metacystic form. These four nuclei further divide by binary fission and give rise to eight nuclei. Each of these eight nuclei surrounds itself by a bit of protoplasm and forms an amoebula which grows and is known as trophozoite. These trophozoites again penetrate into the wall of the intestine and repeat the life cycle. [Fig. 4.1 (a) and (b)]

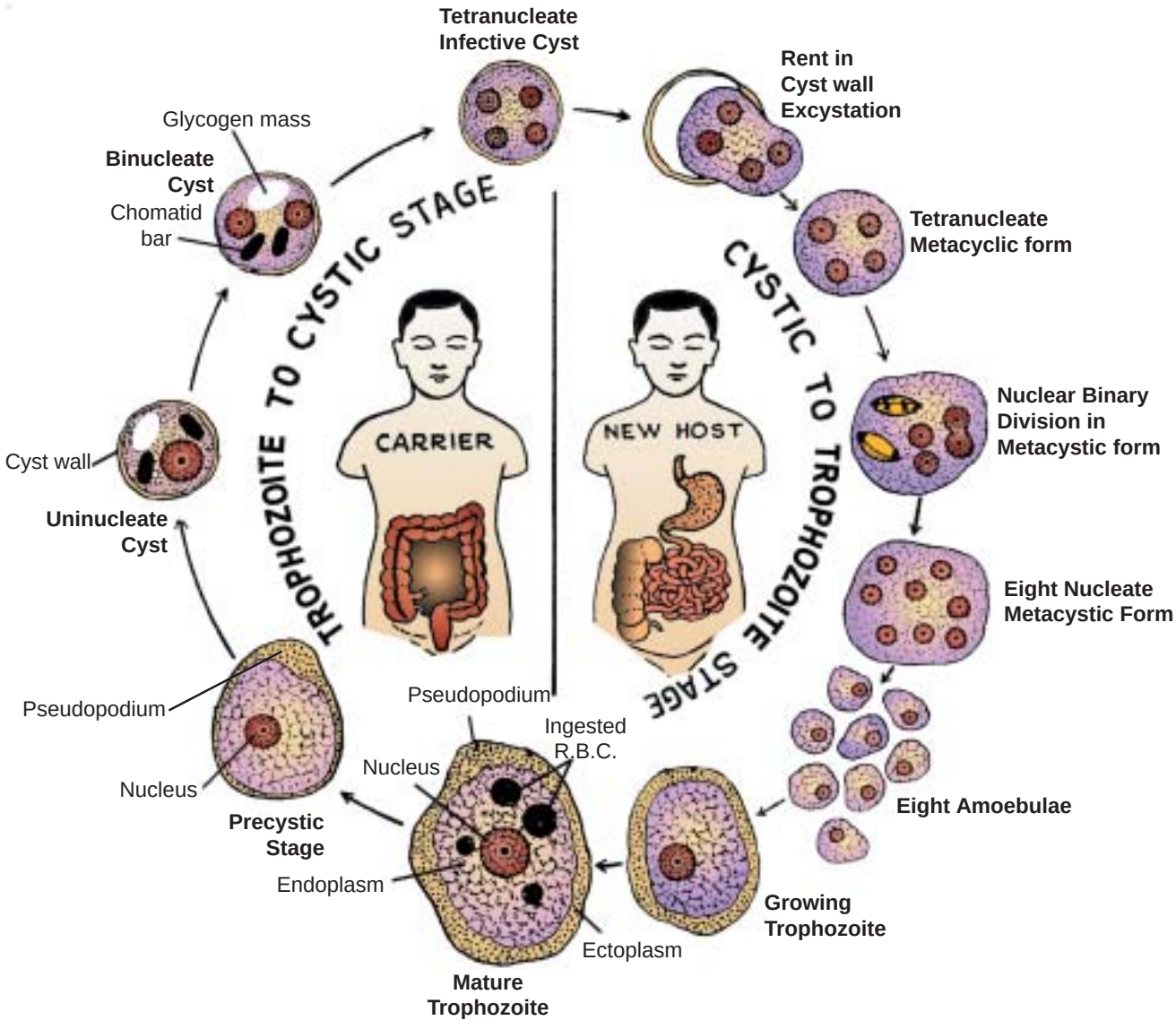


Fig. 4.1(a): *Entamoeba hystolytica* (Life cycle)

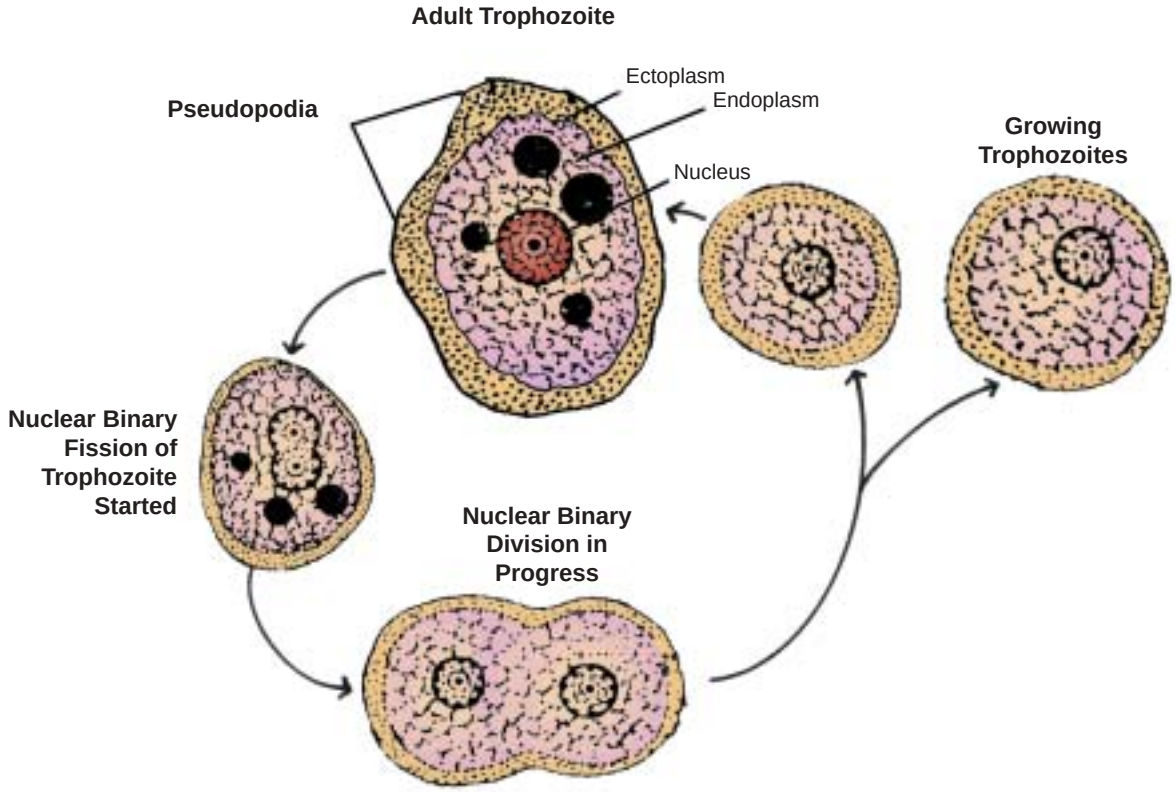


Fig. 4.1(b): Trophozoite multiplying by Binary Fission

Human Pathogenicity

E. histolytica causes infection at different areas of the invasion. The clinical term used for all the conditions is amoebiasis. The infection is generally limited to intestine causing intestinal amoebiasis or amoebic dysentery. In chronic intestinal amoebiasis, the symptoms of dysentery are accompanied by multiple ulcers in the caecum, colon, rectum, and each ulcer is covered with green or black slough. These ulcers may extend to the muscular and peritoneal coats and lead to peritonitis or haemorrhage. Sometimes there may be formation of tumour like masses amoebic granuloma or amoeboma in the large intestine. In chronic condition there is alternate diarrhoea and constipation. Hepatic complications may develop at any time during intestinal infection. There may be enlargement of liver and liver abscess. The trophozoites through circulation may also reach the lung, brain and skin. (Fig. 4.2 and 4.3)

Latent Amoebasis (Amoebic Carriers)

Sometimes the individuals do not show any symptom of amoebiasis but discharge a large number of cysts in the stool. This may be due to immunity developed by the individual resulting in an adjustment like symbiosis between host and parasite. These carriers sometimes develop serious complications since the trophozoites may be carried by the portal vein to liver and other organs. Hence, treatment in the case of carriers should not be neglected.

Mode of Infection

Transmission of *E. histolytica* from person to person is effected through the ingestion of mature tetranucleate cysts in a variety of ways as under:

i) Human excreta is used as a manure for growing vegetables and fruits in the field.

ii) Water fleas may drop cysts in drinking water.

iii) Houseflies and cockroaches may feed on human faeces, pick up cysts on their legs and wings and drop them on human food. Even dog feeds on human faeces and is a source of infection.

iv) Handling of food by infective individuals is a very common method.

Laboratory Diagnosis

Entamoeba histolytica is diagnosed by microscopic examination of stool for trophozoites and cysts.

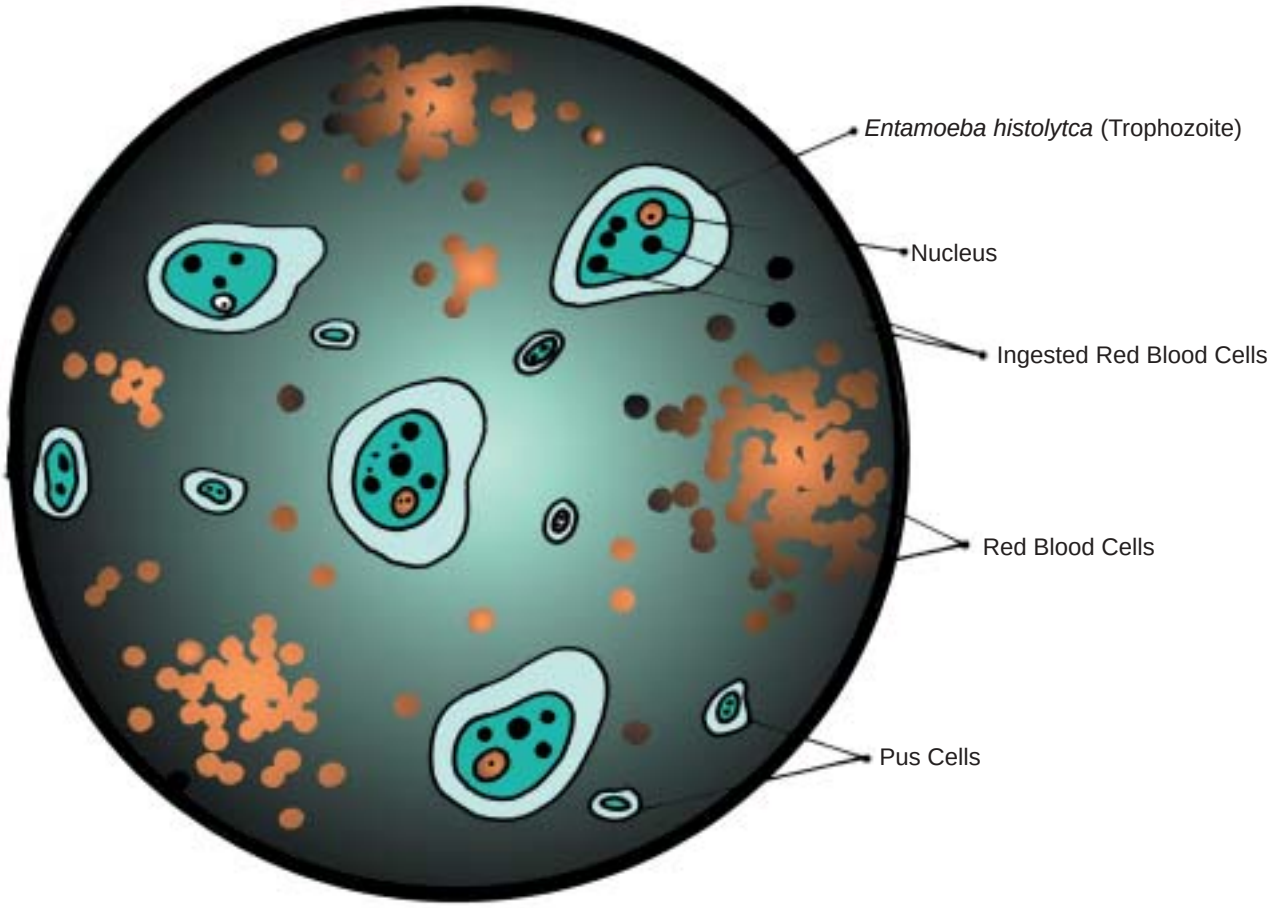


Fig. 4.2: Microscopic appearance of stool in acute amoebic dysentery

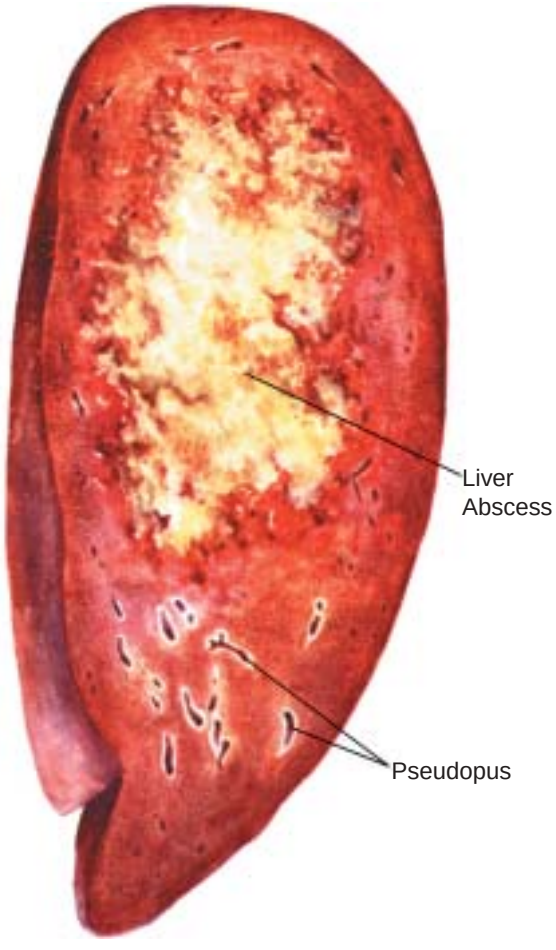


Fig. 4.3: Macroscopic appearance of amoebic solitary liver abscess

Activity 2

Examine the stool of the patients suffering from amoebic dysentery and look for trophozoites and cysts.

***Giardia Intestinalis* (*Lamblia intestinalis* or *Giardia lamblia*)**

Giardia intestinalis is an internal protozoon parasite that occurs in two stages, namely trophozoite and cyst. Both these stages are found in the upper part of the small intestine of human being. The trophozoites swiftly move in the intestine and feed on mucous. They are rarely present in the faeces. When they pass out in the stool, they die quickly. The cysts are found in large number in the faeces and may remain alive in faeces for 10 days or more. They are often swallowed by man with contaminated food or water.

Morphology

***Trophozoite Stage*:** Trophozoite when lying flat looks like a badminton racket without handle, with its broad anterior and tapering posterior end. At the anterior end is located a sucking disc to attach itself to the wall of the intestine. Under the sucking disc are two oval nuclei in the protoplasm. Behind the sucking disc, almost in the middle are two comma shaped parabasal bodies. There are also present two rod like axostyles and four pairs of flagella. The two axostyles run between the two nuclei and terminate anteriorly in the blepharoplasts. The four pairs of flagella are anterior, middle, posterior and caudal. [Fig. 4.4(a)]

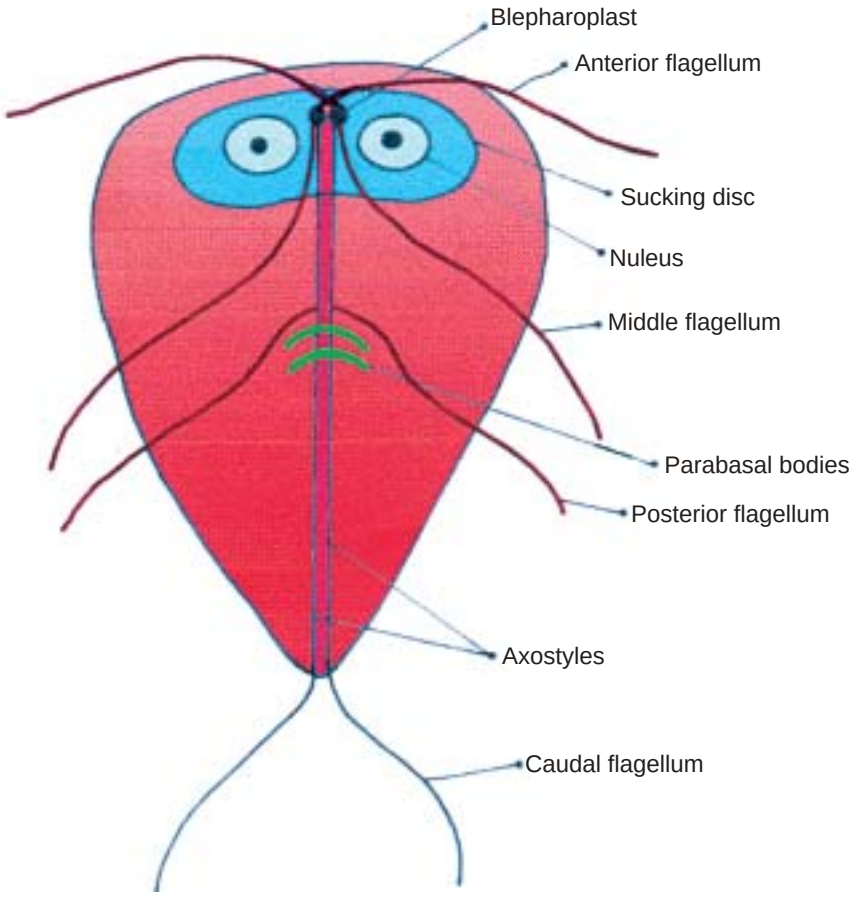


Fig. 4.4(a): *Giardia intestinalis* (Trophozoite)

***Cystic Stage*:** The oval cyst is covered by a smooth cyst wall which is a little separated from the cytoplasm giving an appearance of a double wall. The two axostyles are situated in the centre. The cyst contains four nuclei which remain clusterd anteriorly and a pair of curved parabasal bodies are present posterior to the nuclei. The retracted flagella and the margins of the sucking disc are also visible inside the protoplasm. [Fig. 4.4(b)]

Life Cycle

The trophozoite multiplies in the duodenum of man by longitudinal binary fission. If the conditions in the duodenum are not favourable, the trophozoite enters in the large intestine,

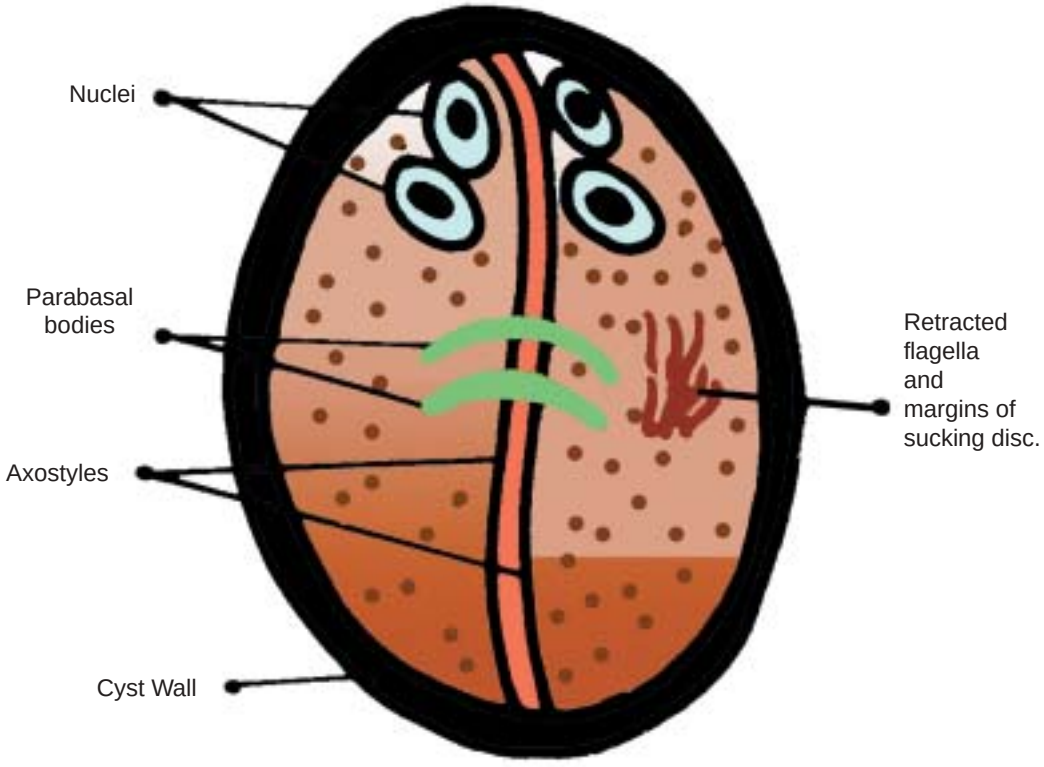


Fig. 4.4(b): *Giardia intestinalis* (cystic)

forms a thick cyst wall around itself and divides into two within the cyst. The cysts pass out with the faeces and are swallowed by man with contaminated food or water and within 30 minutes each cyst liberates two trophozoites in the intestine which multiply in large number and repeat the cycle.

Pathogenicity

Giardia parasite lives in the duodenum and attaches itself to its epithelium by means of its sucking disc and feeds on its fluid contents. It is believed that its presence in a large number may cause some disturbance in its intestinal function and sometimes may produce chronic giardiasis that is giardial dysentery or diarrhoea. In some persons it may cause flattulence and in others mild epigastric pain. In heavy infestation, the intestinal mucosa shows signs of extensive ulceration.

Laboratory Diagnosis

Giardia is diagnosed by microscopic examination of a freshly passed stool for trophozoites and cysts.

Activity 3

Examine the stool of patient suffering from giardiasis and look for the cysts.

Trichomonas

The genus *Trichomonas* includes pear shaped organisms. At least three species are well known in humans, namely *T. hominis* in the intestine; *T. vaginalis* in the vagina of female and in the urinary tract of male and female; and *T. tenax* in the oral cavity around the tartar of the teeth. (Fig. 4.5)

Morphology and Life Cycle

Trophozoite is pear shaped organism although at times it can alter its shape. A single ovoid round nucleus is situated at the anterior end which is often obscured by the numerous chromatin granules. Very near to the nucleus is a cleft like depression the mouth. A little in front of the nucleus is blepheroplast from which arise the following structures:

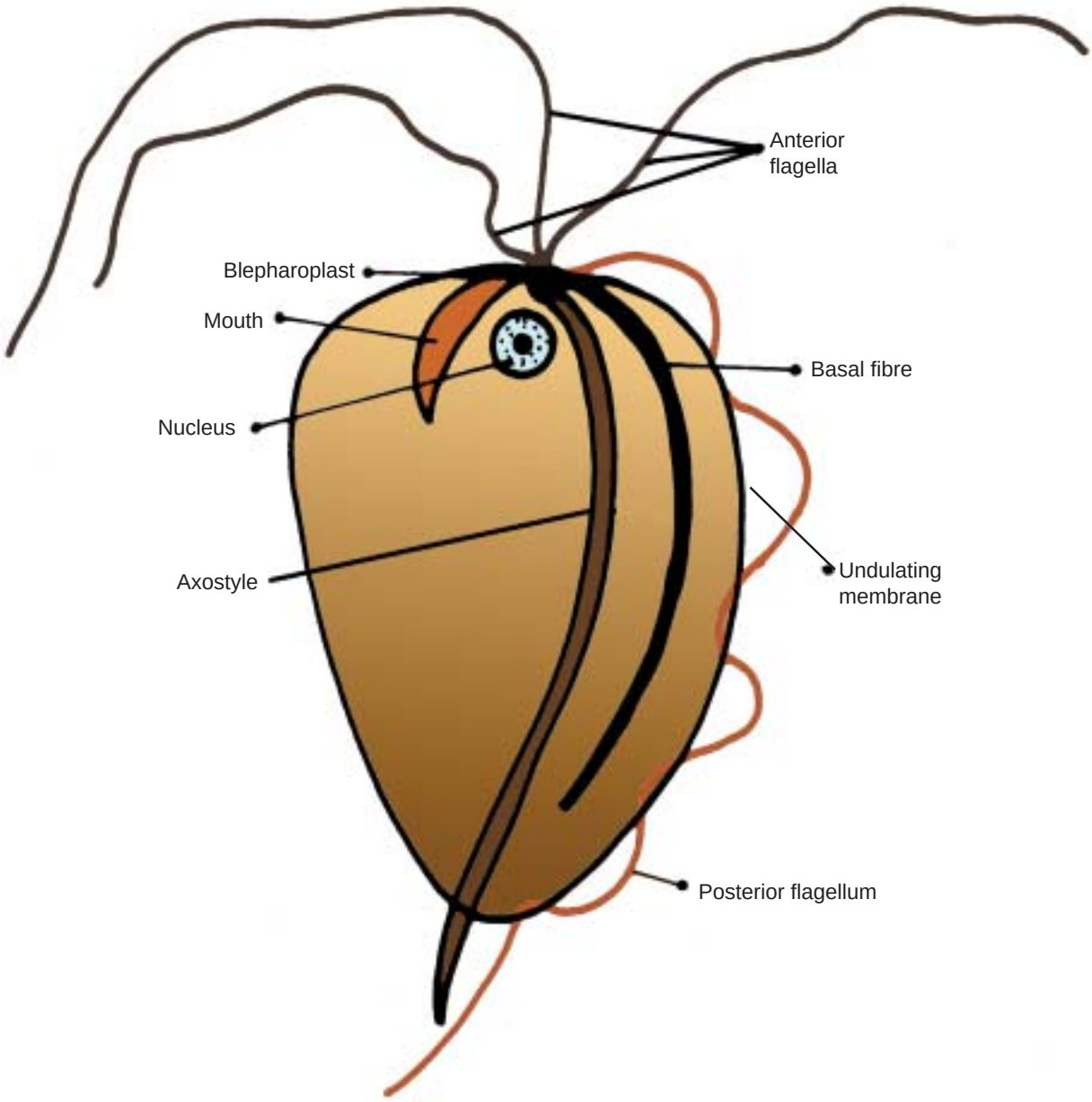


Fig. 4.5 : *Trichomonas hominis* (Trophozoite)

1) Anterior flagella directed anteriorly;
2) One thick posterior flagellum passes backwards along the side of the body forming undulating membrane and it comes out free at the posterior end;
3) A rod like basal fibre or costa which supports the undulating membrane;
4) The axostyle which runs down the body ending in a pointed tail like extremity.

It may be remarked here that if *T. hominis* has three anterior flagella it is termed as *Tritrichomonas*, if four *Tetratrichomonas*; and if five *Pentatrichomonas.*

Trichomonas trophozoite multiplies by longitudinal binary fission. Transmission results from swallowing these flagellated trophozoites.

Pathogenicity

T. hominis: These organisms when present in large numbers may aggravate an already existing inflammatory condition and may be seen in diarrhoeal conditions.

T.vaginalis: It causes vaginatis in females which is characterised by leucorrhoea, burning and pruritis of vulva. The local bacterial flora also plays an important role in the pathogenesis of vaginitis. *T. vaginalis* in most of the males remain asymptomatic carriers, but in few cases it can cause urethritis.

Laboratory Diagnosis

Trichomonas vaginalis is diagnosed by microscopic examination of vaginal secretion of females and prostate secretion of male.

Trypanosoma

Three species of *Trypanosoma* are parasitic in humans viz. *T. gambiense*, *T. rhodesiense* and *T. cruzi*. First two live as parasites in human blood, lymph or cerebrospinal fluid and cause sleeping sickness in Africa while the third *T. cruzi* is parasitic in the tissues of many mammals and causes chagas disease in South America. A part of their life-cycle is passed in blood sucking insect tse tse fly.

Morphology

T. gambiense has a fusiform body pointed at both ends and covered by a membranous pellicle which maintains the form of body. A single flagellum arises from the posterior end and curves in a spiral form round the body forming undulating membrane thrown into 3 or 4 folds depending upon the length of the parasite. The flagellum is free at the anterior end. The nucleus is present in the centre of the body and the cytoplasm contains volutin granules. At the base of the flagellum is located the basal granule or blepharoplast close to which is another granule the parabasal body.

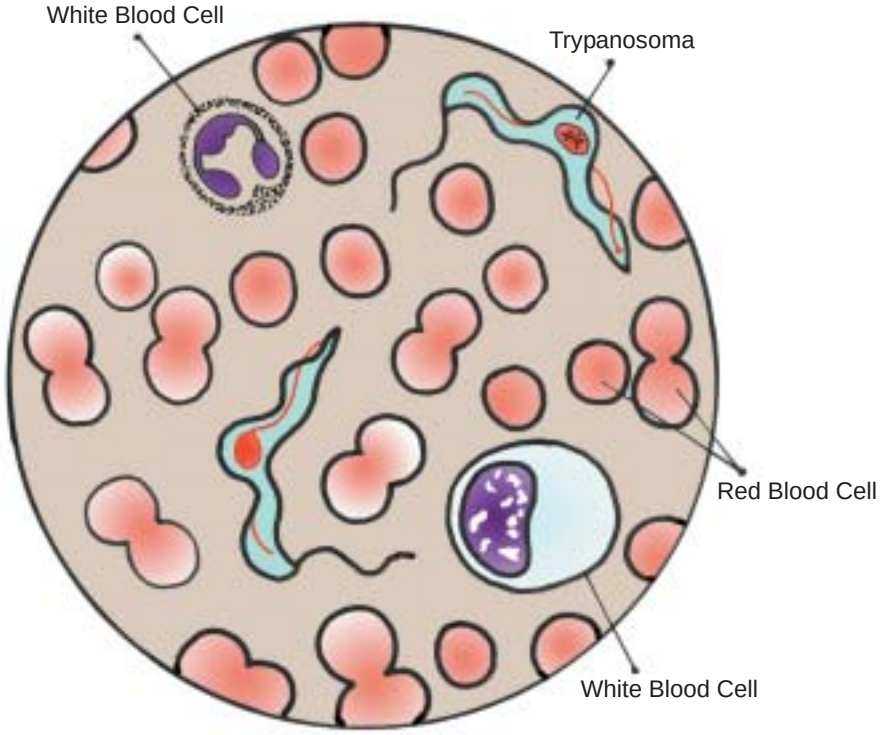


Fig 4.6(a): *Trypanosoma gambiense* in peripheral blood film

Life Cycle

The life cycle of *T. gambiense* includes two hosts—primary host is humans or any wild mammal in Africa and the intermediate host is blood sucking insect tse-tse fly of the genus *Glossina*. When tse-tse fly sucks the blood of any infected individual or wild mammal, it carries Trypanosomes to its mid gut where they divide by longitudinal binary fission and proceed towards the anterior part and get attached to the cells of the salivary gland and again multiply. Here they change their morphology and give rise to metacyclic forms which are similar to Trypanosomes except they are short and stumpy. At this stage, the fly is said to be infective. When the infected tse-tse fly bites a human host, it releases these metacyclic trypanosomes in the blood stream and repeats the life cycle.

Pathogenicity

Trypanosomes in the blood stream liberate toxins and cause Gambian fever. Finally they enter the cerebrospinal fluid surrounding the brain and spinal cord and cause sleeping sickness. In this disease the person is restless at night, has a tendency to fall asleep during

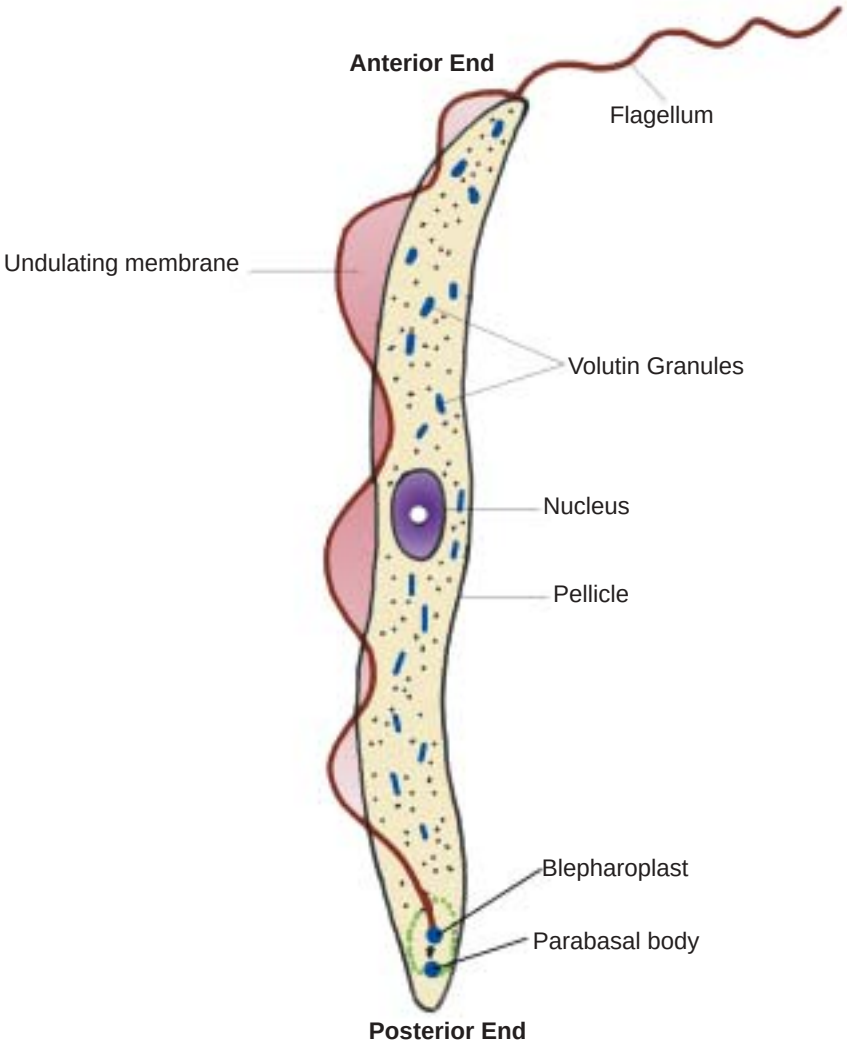


Fig 4.6(b): ***Trypanosoma gambiense***

the day while standing, sitting or eating. Finally the person looses consciousness leading to comma and death.

Some other symptoms are itching and irritation near the wound, fever, headache, enlarged lymph glands, anaemia, physical and metal lethargy.

Mode of Infection

Infection from one individual to another is brought about by tse-tse fly in two ways:

***Direct Transmission*:** Tse-tse fly bites an infected human being and some trypanosomes stick to mouth. When it bites another human being, it releases these trypanosomes in the blood. These parasites do not undergo any change in their morphology.

***Cyclic Transmission*:** Tse-tse fly sucks the blood of infected individual, carries trypansomes to its mid gut where they undergo change in their morphology and reach salivary glands as described in its life cycle.

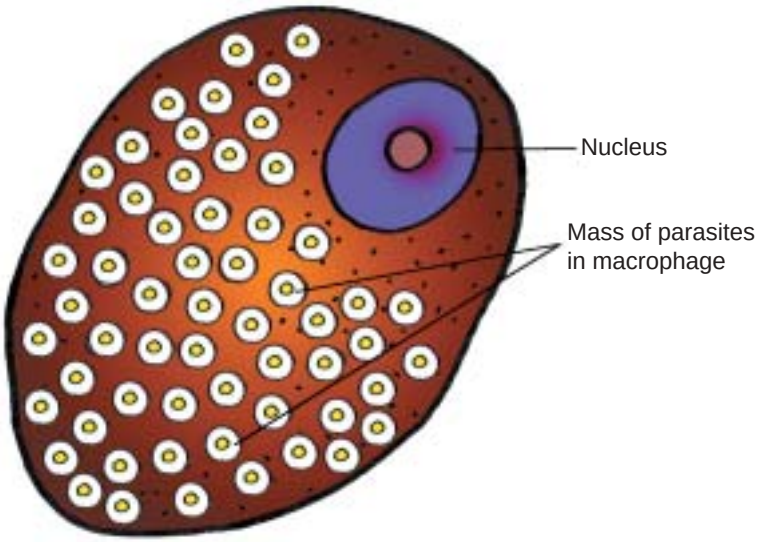
Laboratory Diagnosis

Trypanosomes are diagnosed by microscopic examination of stained and unstained peripheral blood smears, cerebrospinal fluid, bone marrow, secretions obtained from lymph nodes.

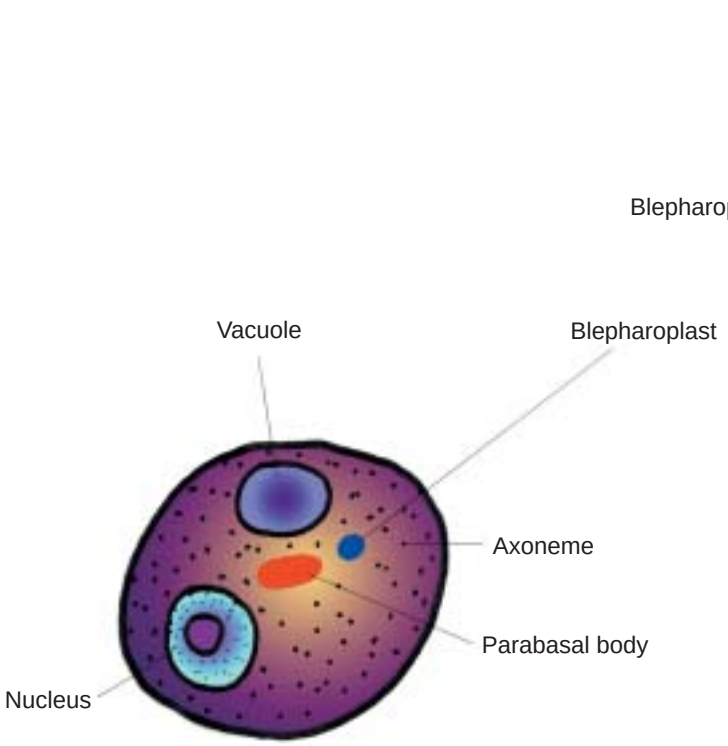
Leishmania

There are three *Leishmania* species which are parasite in man, viz. *L. donovani, L. tropica* and *L. brasiliensis.* There is not much morphological difference in these three species.

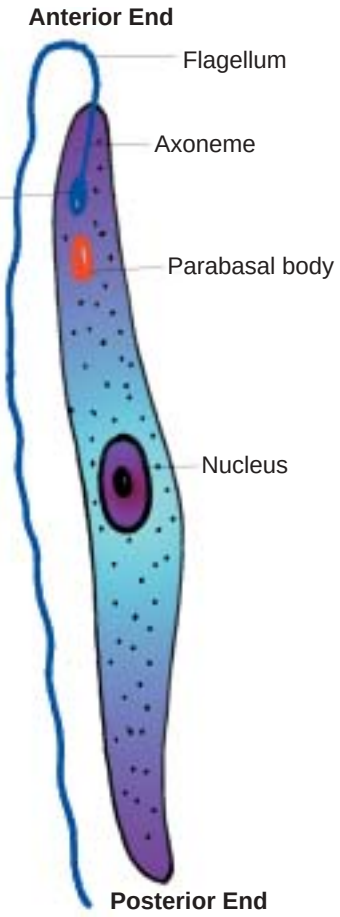
L. donovani: It causes Kala azar also known as visceral leishmaniasis. It is so called because the infection is distributed inside the internal organs. It is named after the discoverers Leishmania from London and Donovan from Madras. The parasite occurs in two forms; Leishmania and Loptomonad, both the forms divide by longitudinal binary fission. [Fig. 4.7(a,b,c)]



(a) Parasites in Macrophage



(b) Leishmanial form (Aflagellar type)



(c) Leptomonad form (Flagellar type)

Fig. 4.7 : ***Leishmania donovani***

Leishmanial Form (Aflagellar Stage): It is found as an intracellular parasite in the cell of endothelial system. It is round in shape, the blepharoplast and parabasal body are situated at right angles to the nucleus. From the blepharoplast, a delicate filament axoneme extends representing the root of the flagellum. Alongside the axoneme is a clear space vacuole.

Leptomonad Form (Flagellar Stage): It is found only in the insect vector sand fly. The undeveloped forms are small and pear shaped while the developed forms are long and spindle shaped. Blepharoplast and parabasal body are situated in front of the nucleus. A long flagellum sometimes longer than the body arises from the blepharoplast.

Life Cycle and Pathogenicity: The Leishmania parasites are found in the cells of the endothelial system of the spleen, liver, bone marrow, lymph nodes of the host, multiply continuously by longitudinal binary fission and form as many as 50 to 200 parasites. The host cell enlarges, ruptures and releases these parasites into the circulation which again attack fresh cells and the cycle is repeated. These leishmania forms heavily parasitize the viscera and cause Kala azar, also known as visceral leishmaniasis which is characterised by chill, fever, anaemia, enlargement of spleen and liver, pigmented skin, cutaneous lesions in the form of pigmented macules and nodules on the face. When these parasites are in circulation, some of them are phagocytosed by the neutrophils of the white blood corpuscles. When female blood sucking insect vector sand fly sucks the blood of an infected human being, it carries these neutrophils to its mid-gut where they divide and develop into leptomonad forms. The neutrophil ultimately bursts releasing these parasites in the lumen from where they reach buccal cavity. In certain sand flies the infection is so much that ocsophagus is completely blocked. When the infected female sand fly bites a healthy individual, it transmits these parasites into the blood stream from where they enter the endothelial cells and repeat the cycle.

Laboratory Diagnosis: Kala azar is diagnosed by microscopic examination of thick and thin blood smears from peripheral blood. It is also diagnosed by examination of sternal, spleenic or liver puncture.

***Plasmodium* (Malarial parasite)**

Plasmodium is an unicellular blood parasite and it causes malaria disease in humans. The word malaria means bad air (Italian words **malo** means bad and **aria** means air). Earlier it was believed that people inhaled bad air during night and became ill with malaria but it is not so. It is the mosquitoes which are likely to be out in the night air and spread malaria. Although malaria was known for a long time it was only in 1880 that Charles Laveran, a French Surgeon discovered malarial parasites in humans. In 1899, Sir Ronald Ross showed that *Plasmodium* is transmitted by female *Anopheles* mosquito and one year later Grassi worked out the complete life-cycle of human malarial parasite.

Life Cycle of *Plasmodium vivax*

Life cycle of *Plasmodium* is completed in two hosts, man and female mosquito *Anopheles*. The methods of reproduction in the two hosts are different; in man it is by asexual method (schizogony) and in mosquito it is by sexual method (conjugation followed by sporogony); both alternate with each other and the phenomenon is called as alternation of generation. (Fig. 4.8)

Human Cycle or Asexual Cycle

It is also called as schizogenous cycle or schizogony because in this cycle a stage schizont is formed. Human cycle starts with the introduction of malarial parasites by an infected female mosquito of the genus *Anopheles*.

When an infected female *Anopheles* mosquito bites a healthy person to suck the blood, it introduces along with its saliva thousands of malarial parasites into the human blood. These parasites are motile and spindle shaped and are known as sporozoites. The sporozoites remain in the general blood stream from a few minutes to half an hour and then migrate to the liver cells. The cycle in man is divided into four phases: pre-erythrocytic, exo-erythrocytic, erythrocytic and posterythrocytic.

***Pre-erythrocytic Cycle*:** Each sporozoite enters the liver cell by its pointed end, becomes round and is called as trophozoite which enlarges and forms pre-erythrocytic schizont. The nucleus of the schizont divides and ultimately gives rise to a large number of merozoites. When merozoites are formed in large number, the wall of the schizont and liver cell ruptures and merozoites are liberated in the spaces sinusoids between the liver cells. The first cycle in liver cells is called pre-erythrocytic cycle.

***Exo-erythrocytic Cycle*:** The merozoites again attack new liver cells grow into exo-erythrocytic schizonts and again form merozoites. This second cycle in liver cells is called exoerythrocytic cycle.

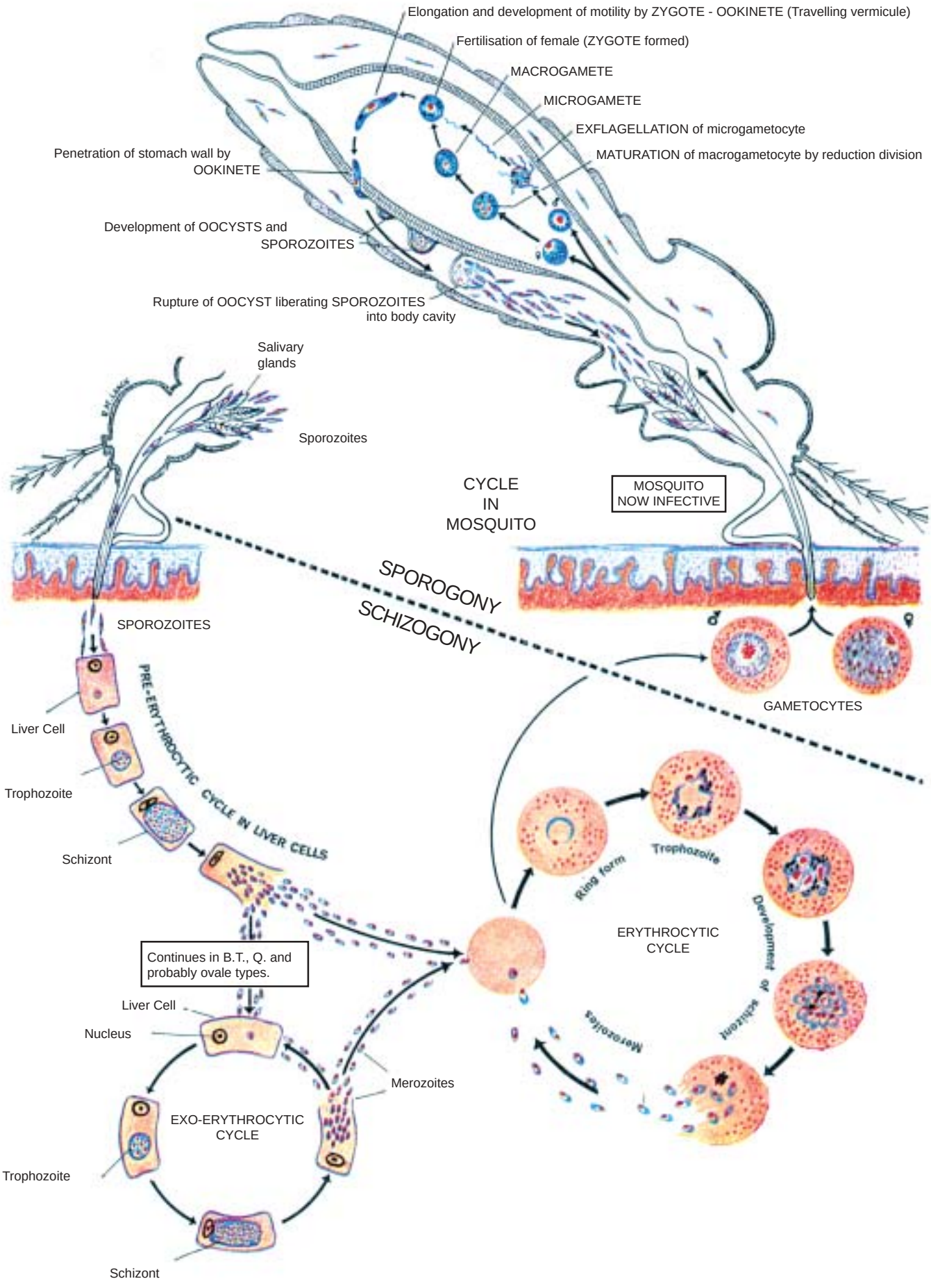


Fig. 4.8 : Life cycle of Malarial parasite (*P. vivax*)

***Erythrocytic Cycle*:** The merozoites from the liver space after two or more cycles in the liver may re-enter the blood stream and attack red blood corpuscles. Each merozoite in red blood cell forms trophozoite, and after forming a ring like stage forms schizont and merozoites. This ring like stage is a very important stage in blood cycle. The merozoites when formed in large number, the red blood cell ruptures and merozoites liberated in plasma repeat the erythrocytic cycle.

Post-erythrocytic Cycle: Sometimes merozoites after erythrocytic cycle may again enter the liver cells from the blood stream and multiply asexually. This cycle is known as post-erythrocytic cycle.

Frequent repetition of the asexual cycle in RBC produces millions of merozoite parasites in the blood stream. These parasites feed on haemoglobin of RBC and deposit black pigment melanin which is toxic to man. When corpuscles rupture, along with the merozoites toxins are also liberated into the blood, carried to all part of the body and are deposited on spleen, liver and under the skin. The accumulation of these toxins causes malaria fever in man. There is high temperature with chill and shivering followed by sweating. Thus these merozoites destroy a large percentage of RBC as a result of which parasite and host both suffer and become weak. It is here that the nature helps and merozoites after a certain number of erythrocytic cycles instead of forming schizonts form oval male and female gametocytes, which only in *P. falciparum* are long and bean shaped. Male is smaller than the female but it has a bigger nucleus than the female. These are sexual reproductive bodies, which do not develop further until they are transferred to the stomach of mosquito. The gametocytes occur in large number in the blood and if no *Anopheles* sucks them they die.

Mosquito Cycle

When a healthy female *Anopheles* mosquito bites a malarial patient, it sucks with the blood all the stages of malarial parasites including gametocytes. In the stomach of mosquito all the stages are digested including RBC except gametocytes. The cycle in mosquito is divided into two phases—conjugation and sporogony.

***Conjugation*:** In the male gametocyte nucleus divides and eight sperms are formed. In the female gametocyte, nucleus does not divide but a cone of attraction is formed through which one sperm enters and its nucleus fuses with the female nucleus and zygote is formed.

***Sporogony*:** The zygote elongates and forms a worm like stage ookinete (traveling vermicule) which penetrates the wall of stomach, settles below the outer epithelium, develops a cyst wall and forms occyst Within the oocyst the nucleus divides and forms a large number of sporozoites. The wall of the oocyst and stomach ruptures and the sporozoites are liberated in the body cavity (haemocoel) from where most of these sporozoites enter salivary glands. The mosquito is now infected and when it bites a man injects sporozoites in the blood and the cycle is again repeated.

Pathogenicity

The genus *Plasmodium* contains more than 40 species but only four—*P.vivax, P. ovale, P.falciparum* and *P.malariae*—are pathogenic to man. The incubation period is 10 to 14 days in the case of *P. vivax, P. ovale and P. falciparum* and 18 days to 6 weeks in *P. malariae*. The structure and life cycles of all these four species are almost alike yet they show some distinguishing characters and cause the following four types of malaria fever.

***Benign tertian malaria fever*:** It is caused by *P.vivax* and *P.ovale* and fever occurs after every 48 hours (every third day) but the death rate is not high.

***Malignant tertian malaria fever*:** It is caused by *P.falciparum* and here also fever occurs after every 48 hours but death rate is high. Blood corpuscles parasitized by this variety sometimes block small blood vessels and damage the essential organs.

***Quartan malaria fever*:** It is caused by *P.malariae* and fever occurs after 72 hours (every 4^{th} day).

***Quitodian malaria fever*:** It may result from mixed infection and there is continuously high temperature.

Control of Malaria

1) Treatment of patient by the use of anti-malarial drugs.
2) Prevention of infection by using protective measures such as mosquito nets, odomos cream, mosquito oil, good-night, mats etc.
3) Control of vector by filling ditches; killing larvae by spraying insecticides, kerosine oil, DDT and by introducing natural enemies like larvicidal fish into pond.

Laboratory Diagnosis

Malarial parasites are diagnosed by the microscopic examination of thick and thin peripheral blood smears stained with leishman or Giemsa stain. Thick blood smears are useful for examining larger quantity of blood quickly when the parasites are few in the peripheral blood. On the other hand thin blood smears are useful for examining the peripheral blood when the parasites are numerous. It is only in the thin blood smears that the species of malarial parasites and the morphological stages of the organisms such as ring stage, schizont stage, male and female gametocytes can be diagnosed.

Activity 4

Make blood smears from the patients suffering from malaria and look for ring shaped stages.

Check Your Progress 2

1) Give two important differences between trophozoite and cyst of *Giardia intestinalis*.

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2) State the function of sucking disc in *Giardia*.

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3) State the location of the three *Trichomonas* species.

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4) Differentiate between metacyclic form and Trypanosoma.

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5) Where would you look for Leishmania and Leptomonad parasites?

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6) Differentiate zygote from ookinete and male gametocyte of *P.vivax* from *P. falciparum*.

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7) What do you understand by the phenomenon “alternation of generation”?

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4.6 HELMINTH PARASITES PATHOGENIC TO HUMANS

Helminth parasites are multicellular. They are divided into three main classes: Trematoda, Cestoda and Nematoda. Trematodes are leaf shaped unsegmented animals called flukes. Cestodes are long segmented tape like animals called tape worms. The third class Nematoda includes intestinal and somatic nematodes. Intestinal nematodes are found in the intestine of man and somatic nematodes live in the tissues of man. (Table 4.2)

Table 4.2: Helminth Parasites Pathogenic to Humans				
Class	**Genus**	**Species**	**Habitat**	**Pathogene lesions**
TREMATODA	*Fasciola*	*hepatica*	Liver	Cirrhosis of liver (liver rot) Fascioliasis Persistent diarrhoea
	Fasciolopsis	*buski*	Intestine	Fascioliais, Gastro-intestinal irritation
	Clonorchis	*sinensis*	Liver	Chronic diarrhoea, Jaundice, enlarged liver
	Schistosoma	*haematobium*	Pelvic Venous plexus	Schistosoma haematobia, Eosinophil Urticaria, enlarged liver, palpable spleen, haematuria, lungs, brain, spinal cord, genital organs, etc. are also involved.
CESTODA	*Taenia*	*solium*	Intestine	Intestinal cestodiasis, cysticercus cellulosae in subcutaneous tissue and brain. Rarely, eyes are also involved.
	Taenia	*saginata*	Intestine	Intestinal cestodiasis, cysticercus cellulosae.
	Taenia	*echinococcus*	Intestine	Intestinal cestodiasis, cysticercus cellulosae
NEMATODA	*Ascaris*	*lumbricoes*	Intestine	Allergic reactions, haemorrhage lesions in heart, brain, spinal cord and rob the host of its nutrition.
	Trichuris	*Trichura*	Intestine	Trichuriasis, acute appendicitis, gastrointestinal disturbances, etc.
	Ancylostoma	*duodenale*	Intestine	Ancylostomiasis, infections in the form of lesions, etc.
	Enterobius	*vermicularis*	Intestine	Enterobiasis, inflammation, ulcer, haemorrhages, rise in eosinophil count. etc.
	Wuchereria	*bancrofti*	Lymphatic vessels	Elephantiasis in arms, legs, scrotum mammary glands, obstruction to the lymph flow, dilators of lymphatics, hyperplasia, allergy, secondary bacterial infections.
	Dracunculus	*medinensis*	Subcutaneous tissues	Dracunculosis, allergic reactions, septic complications.

4.6.1 Trematode Parasites Pathogenic to Man

***Fasciola hepatica* (Liver Fluke)**

It is a bisexual parasite found in the liver and bile ducts of herbivorous animals such as sheep, goat, ox, cattle etc. and sometimes in human. Anteriorly it is drawn into a blunt projection head lobe at the top of which is situated mouth, while the posterior end is rounded. There are two suckers—an oral sucker surrounding the mouth and a ventral sucker is situated a little posterior to the oral sucker. Between the two suckers is a genital pore. At the posterior end is a minute aperture excretory pore.

Life Cycle: The liver fluke occurs in two hosts, viz. man and snail. Adult is found in the liver or bile ducts of sheep or man. Eggs pass down into the intestine and are finally voided with the faeces. Eggs can remain alive outside the body for several months waiting for the favourable conditions. The egg is oval in shape with shell and an operculum. The egg hatches and the first stage larva comes out of the shell by forcing the operculum.

The first stage larva is covered by cilia. It swims in water, enters the snail, looses its cilia and forms a sac like second stage larva. However, if the first stage larva does not reach a suitable species of snail, it dies. The second stage larva gives rise to third stage larva and the latter develops into fourth stage larva in snail. Then stage larva has snail.

The fourth stage larva moves with the help of tail, leaves the body of snail, swims in water, looses its tail, gets attached to leaf, grass or some herb and forms cyst wall around its body. These encysted larvae are swallowed along with the grass or vegetables by herbivorous

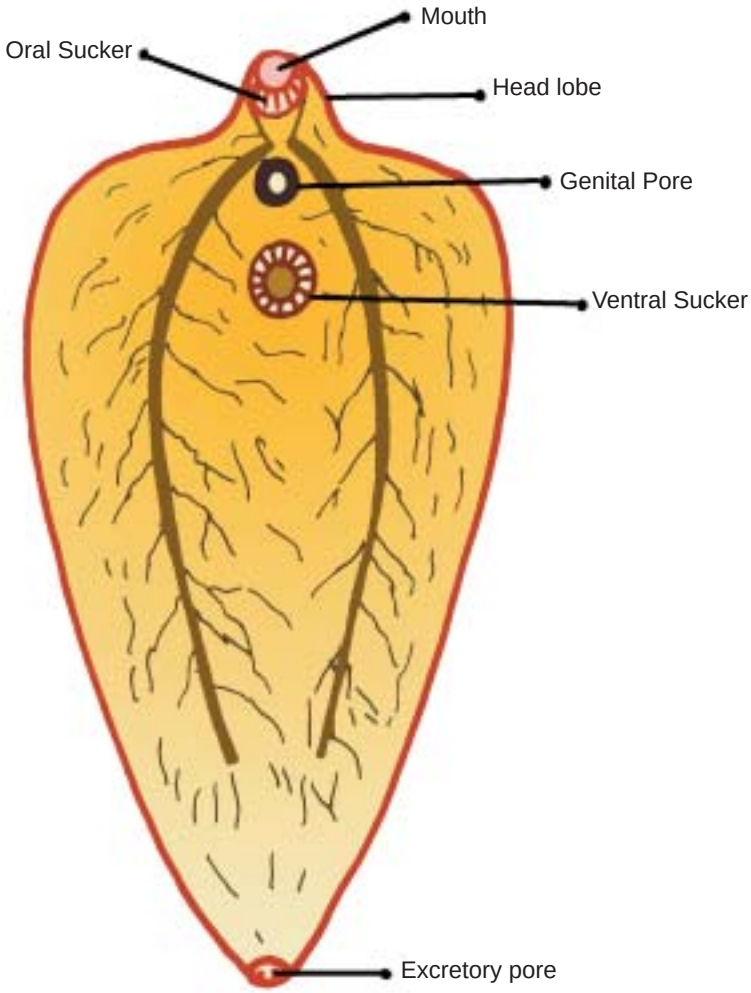
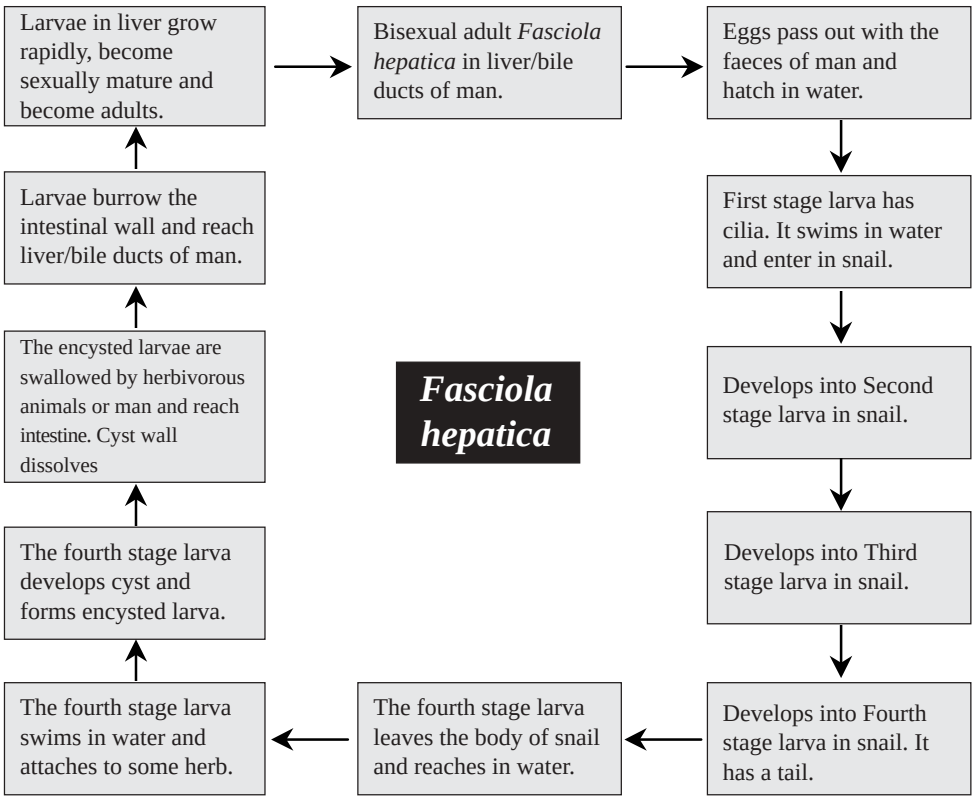


Fig 4.9 : *Fasciola hepatica*

animal or man, burrow the intestinal wall, reach the liver, grow rapidly and become adult. The whole life cycle takes a period of 30 to 60 days.



Summary: Life Cycle of *Fasciola hepatica* (Liver Fluke)

Pathogenicity: Human infection is normally very mild but sometimes it may cause extensive damage to the liver and produces a disease liver rot or cirrhosis of the liver which is often fatal. It may also cause fascioliasis with persistent diarrhoea.

Fasciolopsis buski

It is the largest trematode found in the intestine of man and pig. It is commonly called as giant intestinal trematode. Its life cycle is almost similar to *Fasciola hepatica*.

Pathogensis: It causes disease fasciolopsiasis which is caused by eating infected raw water plants such as water chest nut (trapa) and other aquatic vegetables. It may also cause gastrointestinal irritation, anaemia, nausea, chronic diarrhoea, ulcers etc.

Clonorchis sinensis

It is commonly called as Chinese liver fluke. It is found in the distal portion of the biliary tract of the liver. It causes the disease clonorchiasis which is caused by eating raw or improperly cooked dried fish. The worm passes its life cycle in three hosts. Primary host is man, dog, pig, cat, rat, etc. while two secondary hosts are snail and fish. These may cause chronic diarrhoea, recurring attacks of jaundice, enlargement of liver etc.

Schistosoma haematobium

It is commonly called as blood liver fluke of man. It is peculiar trematode in having separate male and female but the two remain together in pairs in pelvic venous plexus of veins. The disease caused by *Schistosoma* is called as Schistosomiasis haematobia characterised by body pain, dysentery, haematuria, anaemia, eosinophilia, urticaria, enlargement of liver, palpable spleen. Genital organs also may be involved. Eggs may be found in liver, rectum, appendix, lungs, brain spinal cord, skin etc.

Check Your Progress 3

Name one trematode which has two secondary hosts.

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4.6.2 Cestode Parasites Pathogenic to Humans

***Taenia solium* (Pork Tapeworm)**

It is one of the commonest tapeworms found in the intestine of man. It occurs in those parts of the world where raw or improperly cooked pork is eaten. It is a flat ribbon shaped bisexual animal and in adult stage may reach the length of several yards. The body of the tapeworm can be differentiated into three parts : (i) the head or scolex anterioly produced into rostrum; (ii) the neck; and (iii) the strobila. The scolex has four suckers and 28 hooks to attach the wall of the intestine while the rest of the body hangs freely in the intestine. The strobila is differentiated into few anterior immature, middle mature and posterior gravid proglottides.

Life Cycle: The parasite passes its life cycle in two hosts—man and pig. The adult worm lives in the intestine of man. The terminal gravid proglottids containing ripe eggs are detached from the worm and pass out with the faeces of man. The eggs are swallowed by pig, and hatch in the stomach. Embryos with six hooks, i.e. hexacanths bore through the stomach wall and via circulation reach liver, heart, settle down in the voluntary muscles of pig, become oval bladder like and are called bladder worms (cysticerci). The wall of the bladder worm invaginates and forms proscolex which develops 4 suckers and hooks. When man eats pork infected with bladder worms, i.e. measly pork, proscolex is everted with which the worms attach themselves to intestinal wall. The worms grow in the intestine, become sexually mature in 2 or 3 months and repeat the life cycle.

Pathogenicity: Humans acquire the infection by eating contaminated, uncooked or under cooked pig's flesh (measly pork). Humans may also become infected by swallowing eggs in any of the following ways:

a) By drinking contaminated water

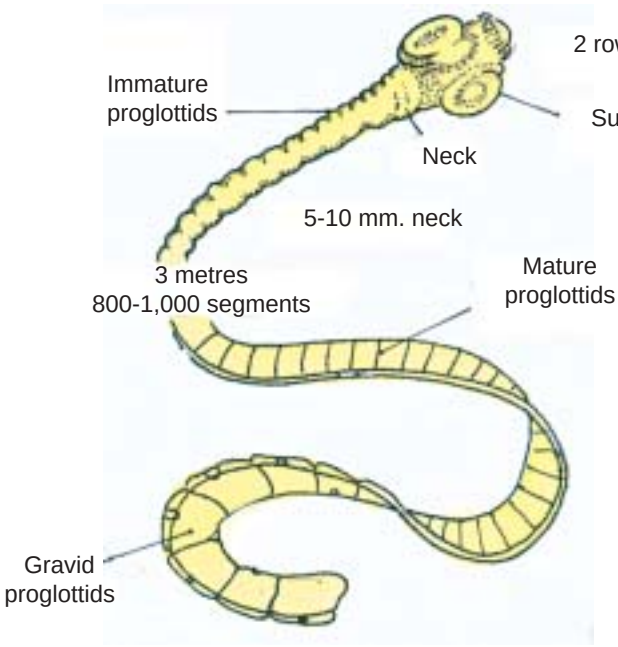


Fig. 4.10(a): *Taenia solium* (*Pork Tapeworm*)

Fig. 4.10(b): Armed head of *Taenia solium*

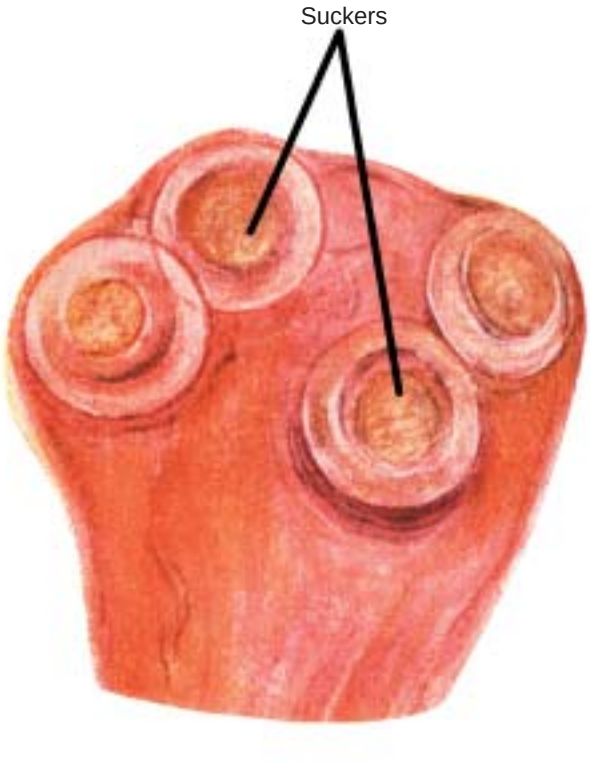


Fig. 4.10(c): Unarmed head of *Taenia saginata*

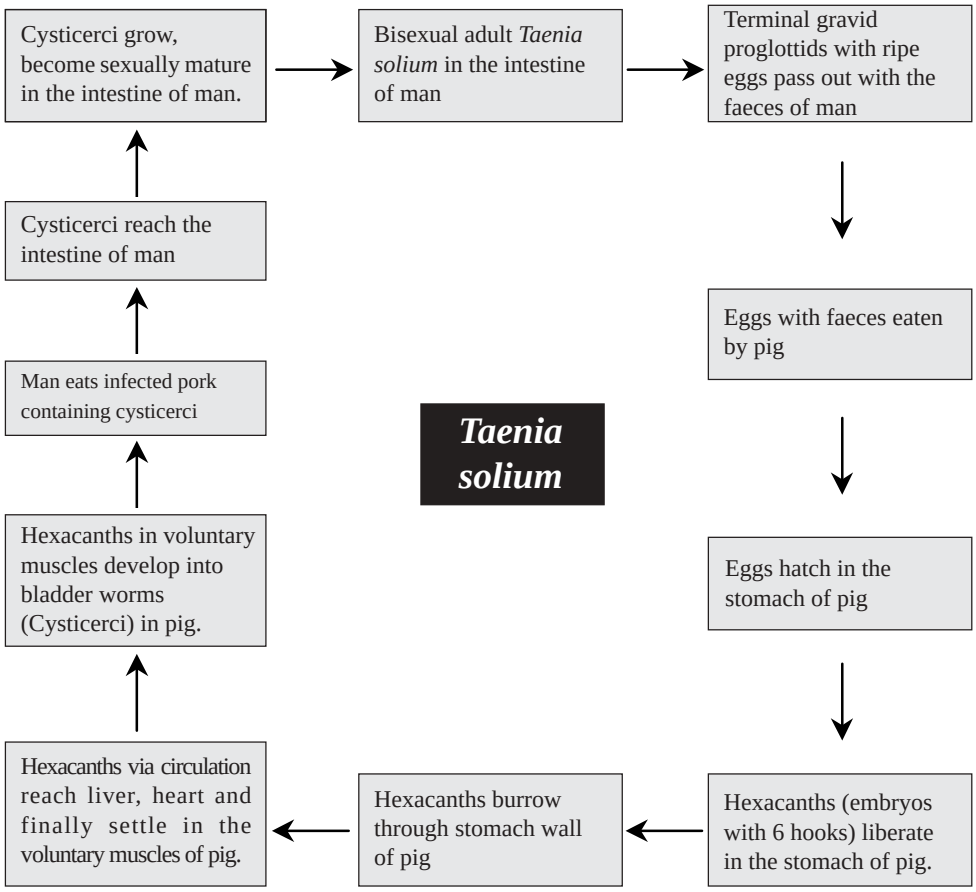
b) By eating infected raw vegetables

c) By auto-infecting himself with his own or another's gravid segment of pork tapeworm from contaminated hands or unclean habits.

d) By reversal of peristaltic movements of the intestine whereby the gravid segments from the intestine are thrown back to the stomach which is equivalent to swallowing thousands of eggs.

In human beings the larvae liberated from the eggs, penetrate the mucosa and by circulation usually get lodged in the voluntary muscles, subcutaneous tissue, brain and rarely in eyes. These larvae are known as bladder warms or cysticerci or cysticercus cellulosae. Living cysticerci are less dangerous than dead or degenerating cysticerci. As long as they are

alive, they do not cause much trouble. They begin to die and disintegrate within 3 to 5 years. While dying these cysticerci produce serious ill-effects which depend entirely on their location in the body. Those dying in the muscles and subcutaneous tissues become calcified while those dying in the brain cause disintegrating cellular changes resulting in very serious clinical manifestations such as meningoencephalitis, psychiatric disturbances or epileptic fits, mental disturbances etc. Finally these cysticerci become calcified. The calcification starts in the scolex and then extends to the entire cyst capsule. It may be remarked here that these cysticerci in certain cases by circulation may also be carried to other regions such as heart, liver, lungs, abdominal cavity where these may not be associated with any serious symptoms.



Summary: Life Cycle of *Taenia solium* (Pork Tapeworm)

***Taenia saginata* (Beef Tapeworm)**

The adult worm lives in the intestine of humans. The structure of *T.saginata* is almost similar to *T.solium* except it has no hooks or spines on the head. The eggs pass out with the faeces of humans. When the cow or buffalo grazes in the contaminated field, it swallows these eggs. The life cycle is same as *T.solium* except that the intermediate host is cow or buffalo.

Pathogenicity: Humans acquire the infection by eating improperly cooked or uncooked beef containing cysticercus bovis. A patient may have abdominal discomfort or even epileptic attacks.

***Taenia echinococcus* or *Echinococcus granulosus* (Dog Tapeworm)**

The adult worm is one of the smallest tapeworm. These worms are found in large numbers (hundreds or thousands) in the small intestine of an infected dog. The adult worm consists of only three rarely four segments. The life cycle is almost similar to *T.solium* except that the intermediate host is dog.

Pathogenicity: It causes the disease echinococcosis also known as hydatid disease. Humans acquire this infection by eating raw vegetables contaminated with infected dog's faeces or by direct contact with infected dogs.

Check Your Progress 4

1) Who are more likely to get tapeworms, vegetarians or non-vegetarians?

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2) Name any two tapeworms found in the intestine of man.

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4.6.3 Intestinal Nematode Parasites Pathogenic to Humans

Nematodes are unsegmented elongated unisexual worms. The male is generally smaller than the female and its posterior end is curved or coiled. In female the genital aperture is situated anteriorly and anus posteriorly but in males there is a single cloacal aperture with two pineal setae at the posterior end. This cloacal aperture functions as anus as well as genital aperture.

Ascaris lumbricoides

Salient Features

i) This is the largest intestinal nematode parasite of man found all over the world;

ii) The adult worm is white creamish or brown coloured animal tapering at both ends;

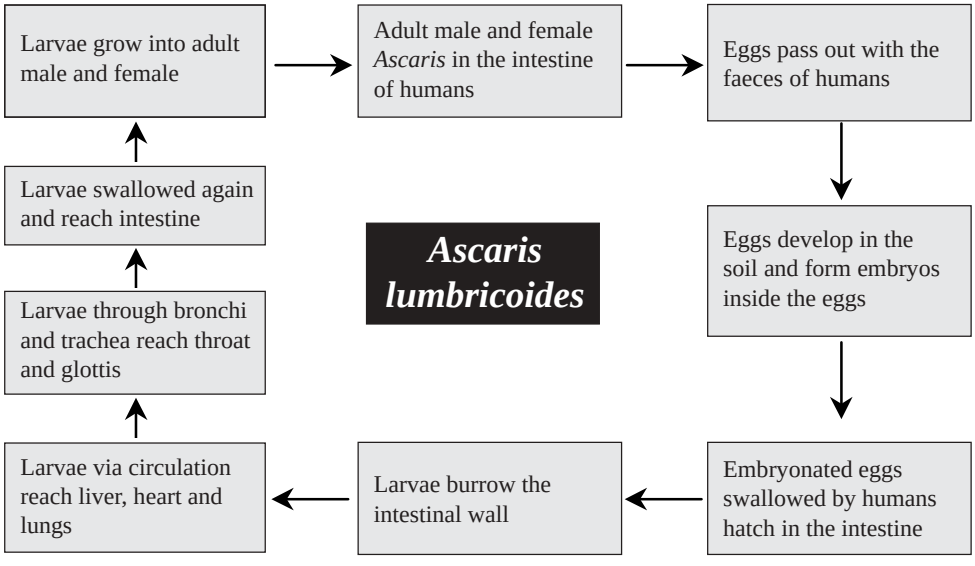
iii) The mouth is bounded by three fine toothed lips;

iv) At a distance of about 2 mm from the mouth is situated excretory pore;

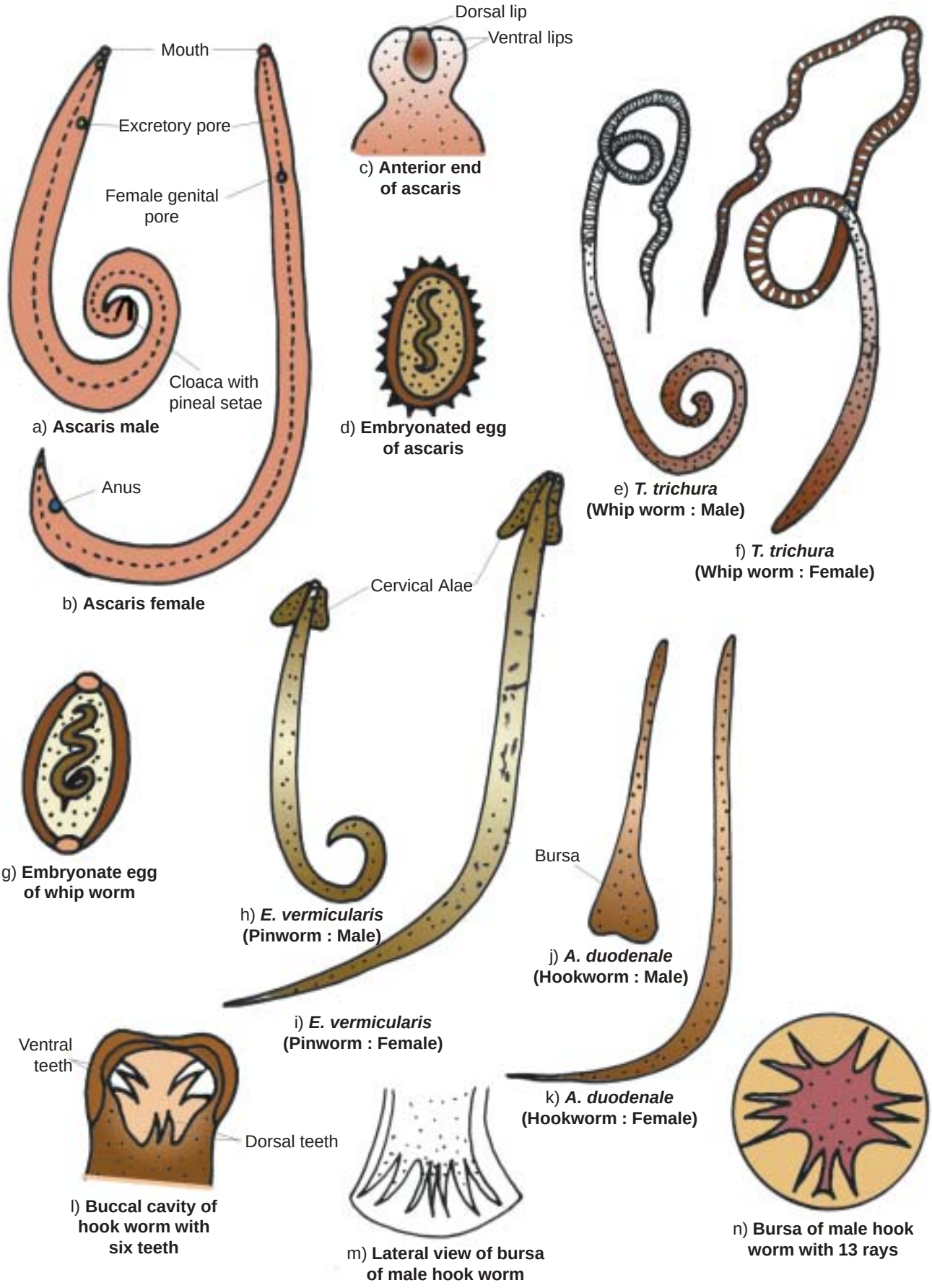
v) The body cavity contains toxic fluid ascaron or ascarase;

vi) The alimetary canal is complete but there are no digestive glands. The food which is already digested by the host is absorbed by the parasite through the wall of the intestine.

Life Cycle: Humans are the only definitive host. No intermediate host is necessary to complete the life cycle. Adult male and female live in the intestine of humans. Eggs pass out with the faeces and can withstand unfavourable conditions for several years. At this stage they are not infective to humans. These eggs develop in the soil and small embryos are formed in the eggs. These embryonated eggs are swallowed by humans with contaminated food, drinks, raw vegetables or by dirty hands and hatch in small intestine. The larvae burrow the intestinal wall and through hepatic portal vein enter the liver, then through post caval vein enter heart and through pulmonary arteries reach lungs. Then through bronchi and trachea come to the throat and glottis and are swallowed again into the oesophagus and enter small intestine for the second time. They grow into adult male and female within intestine, become mature and repeat the life cycle.



Summary: Life Cycle of *Ascaris lumbricoides*



a) **Ascaris male**

b) **Ascaris female**

c) **Anterior end of ascaris**

d) **Embryonated egg of ascaris**

e) ***T. trichura*** **(Whip worm : Male)**

f) ***T. trichura*** **(Whip worm : Female)**

g) **Embryonate egg of whip worm**

h) ***E. vermicularis*** **(Pinworm : Male)**

i) ***E. vermicularis*** **(Pinworm : Female)**

j) ***A. duodenale*** **(Hookworm : Male)**

k) ***A. duodenale*** **(Hookworm : Female)**

l) **Buccal cavity of hook worm with six teeth**

m) **Lateral view of bursa of male hook worm**

n) **Bursa of male hook worm with 13 rays**

Fig. 4.11(a–n): Intestinal nematodes

Pathogenicity: The adult worms secrete toxic fluid ascaron which may produce various allergic reactions. The adult worms also rob the host of its nutrition. Sometimes, they even perforate through peritoneum. The larvae may cause blockage, haemorrhages and even lesions in various organs such as heart, brain, spinal cord etc. In pregnant mother the larvae may even reach the foetus.

***Trichuris trichura* (Whip Worm)**

Salient Features

i) The adult worm is commonly called whipworm because of its resemblance to whip:

ii) The anterior whip like, three-fifth part, is very thin and remains embedded in the intestinal wall while the remaining posterior, two-fifth part, is much stouter and forms the handle of the whip;

iii) The long oesophagus consists of a single row of large secretary cells and looks like necklace.

Life Cycle: Adult male and female are present in the intestine of humans especially in the caecum and appendix and suck blood from the mucosal capillaries. Unsegmented non-infective eggs are voided with the faeces. Embryos develop inside the egg shells in damp soil. Embryonated eggs are swallowed by humans with contaminated food/drink, reach stomach where egg shells are digested by gastric juice and larvae emerge in the small intestine, grow into adult, become sexually mature and embedd their anterior parts in the intestinal wall and repeat the life cycle.

Pathogenicity: The infection is known as trichuriasis, causing gastro-intestinal disturbances accompanied by pain, nausea, vomiting, loss of appetite. They may enter appendix and give rise to acute appendicitis.

***Ancyclostoma duodenale* (Hookworm)**

Salient Features

i) *A.duodenale* commonly called as hookworm is more common among the miners and tea garden labourers who walk bare footed on damp soil;

ii) They are the most injurious intestinal nematode parasites of man because they suck blood through the intestinal wall;

iii) Freshly passed worms are reddish brown or blackish due to the ingested blood visible through the cuticle;

iv) They anteriorly taper and are slightly curved hook like;

v) The tail in male is expanded forming bursa or copulatory bursa supported by 13 chitinous rays or rib like thickenings;

vi) Buccal cavity has six teeth and pharynx has two teeth. The parasite with these 8 teeth attaches itself to intestinal mucosa;

vii) There are five glands (two cephalic, two cervical and one oesophageal) connected with the digestive system.

Life Cycle: The life cycle of hookworm like *Ascaris* and *Trichuris* includes only one host, i.e. humans. Male and female hookworms are present in the intestine. Eggs pass out with faeces, develop outside in the soil and if conditions are favourable, eggs hatch in 24 to 48 hours. The newly hatched larvae are known as first stage rhabditiform larvae.

They feed voraciously on faecal debris in the soil, moult twice and form second and third stage larvae. The third stage larva is called filariform larva which crawls up the grass, stops taking food and can remain alive for months in damp soil.

When a person walking bare footed or with bare hands comes in contact with the contaminated soil containing these filariform larvae, the larvae penetrate directly through the skin or hair follicles and reach the subcutaneous tissues and through lymphatics and small venules enter the circulation. Then through the general blood stream these larvae like *Ascaris* pass through different organs and again reach intestine and repeat the life cycle.

Pathogenicity: The disease caused by hookworm is called ancylostomiasis characterised chiefly by different types of anaemia. The larvae and adults produce infections in the form

of lesions. Rarely infection may also occur by the accidental drinking of water contaminated with filariform larvae.

***Enterobius vermicularis* (Threadworm or Pinworm)**

Salient Features

i) It is commonly known as thread or pinworm;

ii) The spindle shaped worms remain in small intestine and often migrate to appendix and females even enter the genitat tract and urethra;

iii) Reinfection of the patient from himself (auto-infection) is very common.

iv) The oral end has three lips and two wings like expansions cervical alae;

v) The entire body of female is packed with eggs;

vi) Female pinworms especially at night migrate down to the intestine and anus and lay eggs on the perianal region.

Life Cycle: Like *Ascaris* life cycle of pinworm is also completed only in one host. The adult male and female are found in the intestine of humans. The fertilized females at night lay eggs on the perianal skin and cause intolerable itching as a result of which the patient scratches the anal region. During the process of scratching several females are crushed and a large number of eggs adhere to the finger nails and are subsequently carried directly from anus to mouth. They may be even transferred to the food and swallowed or may be inhaled in dust. The eggs are not infective until embryos develop in them. The embryonated eggs are swallowed by humans. Egg shells are dissolved by digestive juice, the larvae develop in small intestine and become sexually mature. The male fertilizes the female and dies and the female moves to the large intestine and then to the perianal region to deposit eggs and repeat the life cycle.

Pathogenicity

i) Adult worms in the intestine cause inflammation or ulcers or haemorrhages;

ii) Females cause irritation around the anus;

iii) There is a rise in eosinophill count;

iv) Sometimes the females even enter the peritoneal cavity through fallopian tube.

Check Your Progress 5

1) Name the organs of human body through which an *Ascaris* larva passes.

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2) Why is the hook worm so called?

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3) How Female pinworm is much different as compared to the other nematodes?

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Activity 5

Examine the stool of patients suspected to be suffering from intestinal parasites and look for the eggs.

4.6.4 Somatic Nematode Parasites Pathogenic to Humans

***Wuchereria bancrofti* (Filaria Bancrofti)**

Salient Features

i) They are whitish long hair like transparent parasites of lymphatic vessels and lymph nodes of humans;

ii) Females are usually more numerous than the males and their tail ends remain coiled together which can be separated with great difficulty;

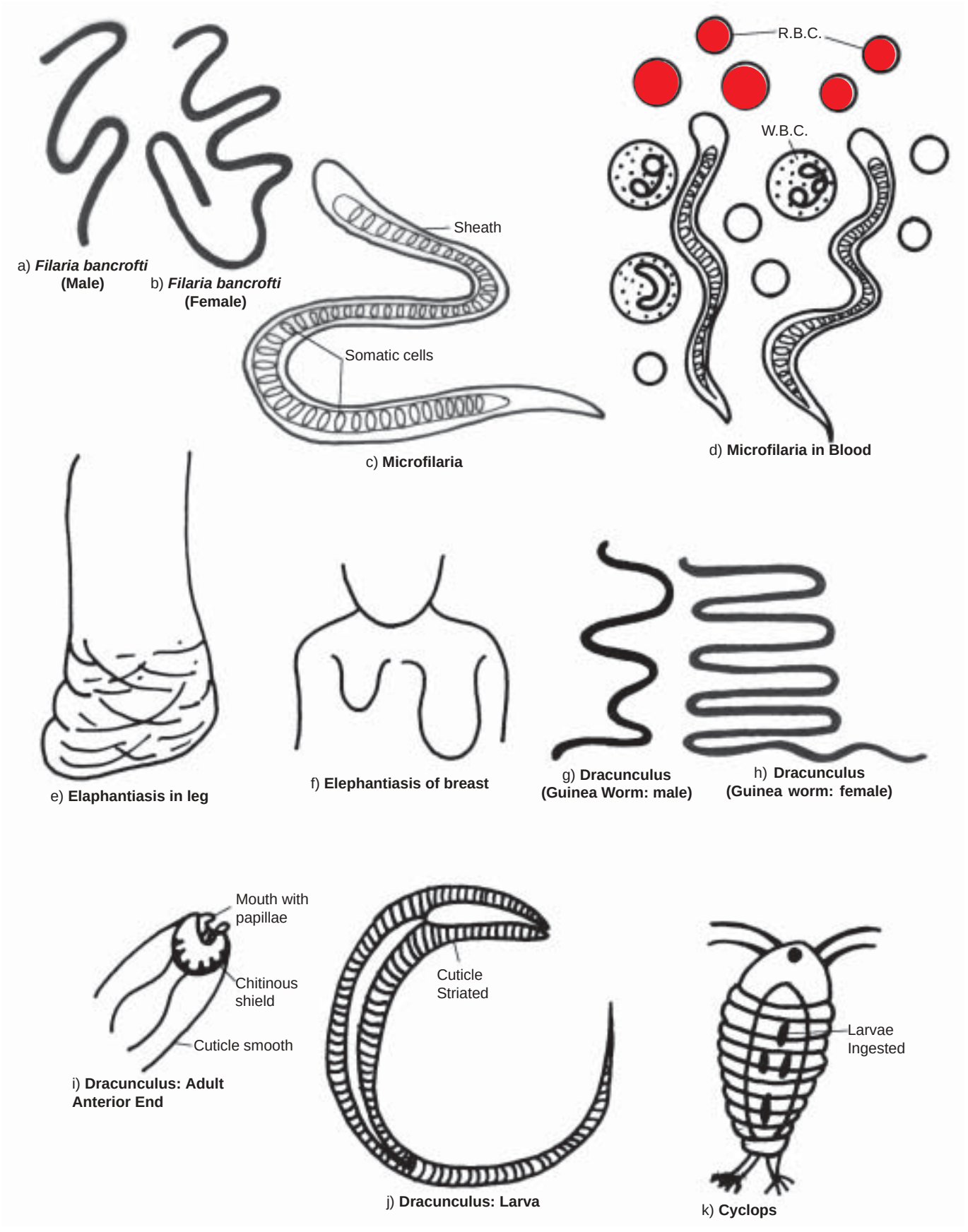

Fig. 4.12(a-k): Somatic nematodes

iii) Female is viviparous and gives birth to microfilariae which are crowded near the female genital pore;

iv) The microfilaria is enclosed in a delicate sheath which is much longer than the body;

v) The microfilaria in the entire body possesses somatic cells or nuclei looking like granules.

Life Cycle: Life cycle is completed in two hosts; humans (final host) and female mosquito (intermediate host). Adult male and female live in lymphatic vessels of humans and give birth to microfilariae, which during the day remain in deeper blood vessels and at night crown in the capillaries of the skin. They do not develop further unless sucked up by a mosquito of a right species, *Aedes* or *Culex*. When female mosquito sucks the blood of an infected person at night, the microfilariae pass into its mid-gut, penetrate its wall and migrate to thoracic muscle and then to the labium. When this infected female mosquito bites an individual the microfilariae either through the puncture wound or by penetrating through the skin reach the lymphatic vessels, settle down, become adult and repeat the cycle.

Pathogenicity: Males and females accumulate in large number, block the lymphatic vessels as a result of which there is an excessive growth of connective tissue resulting in the disease elephantiasis in arms, legs, scrotum, mammary glands etc.

***Dracunculus medinensis* (Guinea worm)**

Salient Features

i) It is the longest nematode of humans;

ii) The intestine in the female is compressed because of the double uteri packed with a large number of larvae;

iii) The head of these adult worms bears a thick chitinous shield; terminating in mouth surrounded by papillae;

iv) The larva differs from adult in two important characters;

a) It has no chitinous shield, and

b) Cuticle has transverse striations.

Life Cycle: Guinea worm completes its life cycle in two hosts: humans (final host) and an arthropod cyclops (intermediate host). The female is found in the subcutaneous tissues of humans especially legs, arms and back. Female is viviparous and the larvae remain coiled and packed in its double uteri. The female reaches the skin surface, secretes toxin and forms blister on the skin.When a person comes in contact with water, the blister bursts, the larvae are released in water, swallowed by cyclops, penetrate the intestinal wall of cyclops and enter the body cavity. Larvae loose their striated cuticles and develop chitinous shields, become mature and are infective to humans. The cyclops containing these infective larvae are swallowed by humans with contaminated water and in the stomach, cyclops are digested and larvae are liberated. These larvae reach the intestine, penetrate the intestinal wall and reach the retroperitoneal tissue and become adult.

Pathogenicity: The infection in man is called as dracunculosis commonly called as guinea worm disease. The pathogenicity in humans is produced in one of the following ways:

a) The parasite liberates toxic substance which may cause allergic reactions such as rash, nausea, vomiting, diarrhoea, giddiness, eosinophilia and blister formation;

b) Sometimes due to septic complications amputation of that particular region is necessary.

Check Your Progress 6

1) Differentiate adult filaria worm from larva.

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2) What is elephantiasis or filariasis?

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3) Differentiate Guinea worm larva from adult.

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4.7 LABORATORY DIAGNOSIS OF HELMINTHS

Trematodes

Trematodes such as *Fasciola hepatica*, *Fasciolopsis buski* are diagnosed by direct microscopic examination of stool for eggs and also by serological or immunological tests.

Cestodes

Cestodes such as *Taenia solium* and *Taenia saginata* are diagnosed in two ways:

i) By macroscopic examination of freshly passed stool of humans for white gravid proglottids,

ii) By microscopic examination of stool for ova and scolex of the adult worm. The most important criteria for diagnosis of tapeworm is repeated examination of stool for the scolex/head of tape worm. If the scolex is not removed, proglottids develop again from the scolex.

Nematodes

Intestinal Nematodes (*Ascaris*, whipworm, hookworm, pinworm etc.) like tapeworms are diagnosed by:

i) Macroscopic examination of stool for adult worms after administration of drugs.

ii) Microscopic examination of stool for ova.

Somatic nematodes (Filaria worm and Guinea worm) are diagnosed by direct examination of thin blood smear for larvae. Adults are observed in tissues.

4.8 VECTORS

In this unit so far we have discussed about protozoon and helminth parasites. Now, we will make you familiar with the different vectors.

Definitions

***Vector*:** It is an agent capable of transferring a pathogen from one organism to another.

***Inanimate Vectors*:** These may be food, discharges (faeces, saliva, secretions from nose, eye etc.), water, bandages, instruments, beddings, fomites, eating utensils contaminated with infectious discharges.

***Animate Vectors*:** These are mostly arthropods viz. mosquito, housefly, tse tse fly, sand fly, louse, flea, tick, cyclops etc. Humans are regarded as one of the most dangerous vectors of several diseases such as syphilis, gonorrhoea, AIDS, hepatitis B etc. These animate vectors (carriers) transmit infection from one human to the other or from animals to humans. These are the carriers of the diseases.

Arthropod Vectors

Now, we will discuss arthropod vectors of medical importance. These are winged (mosquito, housefly, sand-fly, tse-tse fly) and wingless (flea, louse, bed bug) insects, ticks, mites and cyclops.

Mosquitoes

They are the most important vectors of all the insects. They are small insects found all over the world. They have round head with prominent eyes, two antennae and a proboscis which

contains all the mouth parts. The life cycle consists of 10 to 14 days. Male mosquitoes live on vegetable matter while females can pierce the human skin, suck blood and transmit the disease. Male mosquitoes have short bushy antennae with numerous long bristles while females have long slender antennae with only a few bristles. The male lives for 1 to 3 weeks. There are three important genera of mosquito viz. *Anopheles, Culex* and *Aedes*. The life cycle in all the three is almost similar.

Anopheles: Adult is grey or black in colour and in resting position keeps the proboscis and body in straight line, the length of the body and proboscis is almost equal. *Anopheles* sits at an angle in the resting position. Copulation takes place while the male and female are on the wings. Female lays 150 to 250 boat shaped eggs singly in places of stagnant water. The eggs hatch in 2 to 3 days or a few days depending upon the conditions of temperature and moisture. The larva has biting and chewing mouth parts and feeds on solid food. It lies horizontally parallel to the surface of water. The larval life lasts 3 to 14 days and during this period it casts its skin 3 to 4 times, reaches its full size and enters the next stage pupa. Pupa is dark brown comma shaped structure and it does not take any food. The eggs, larvae and pupae develop in water. Within the pupa remarkable changes take place and the body of the adult is formed within the pupa. Now the pupal skin splits and the adult mosquito emerges out, sits on the pupal case for a while and then flies away. Female *Anopheles* spreads malaria disease. (Fig. 4.13)

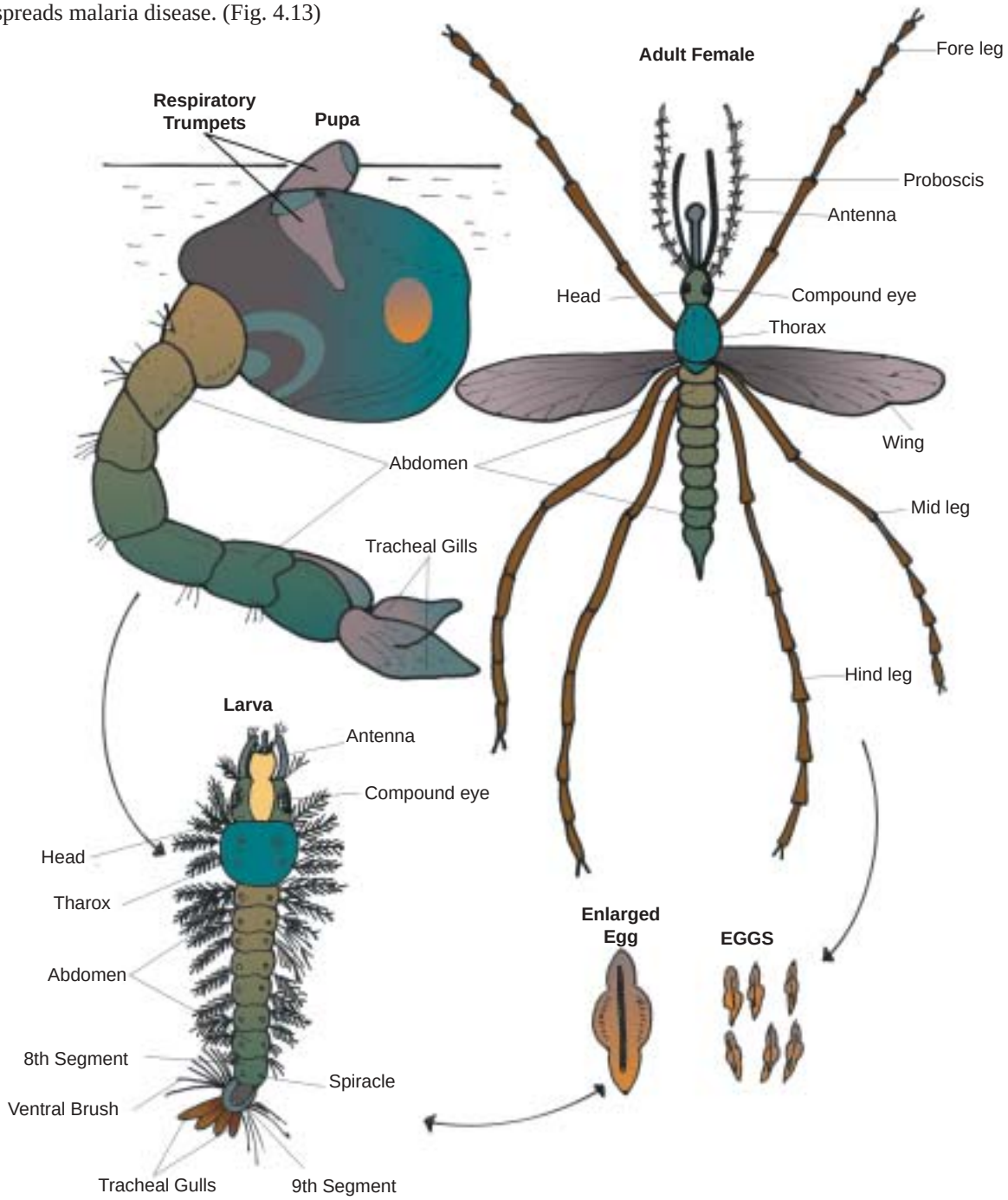

Fig. 4.13: Life History of Female *Anopheles*

Culex: Adult *Culex* is grey or brown in colour and in resting position keeps the proboscis and body at an angle and not in straight line. The body is humped and shorter in length than the proboscis. Female *Culex* lays cigar shaped 200 to 500 eggs in clusters in dirty water collection such as drains around houses. *Culex* transmits filarial and viral encephalitis in man.

Aedes: *Aedes aegyptii* is commonly known as tiger mosquito. It has black and white stripes with scales over head and abdomen. Adult *Aedes* is brown in colour and like *Culex* in resting position keeps the proboscis and body at an angle and not in straight line. The body as in *Culex* is hunch backed. *Aedes* sits curved with head and tail touching the wall. Female lays singly oval shaped eggs in water collected in artificial receptacles like flower pots, bottles, utensils etc. *Aedes* transmits dengue fever, yellow fever and haemorrhagic fever.

Housefly

Like mosquito housefly is also two winged insect. The head in housefly is as broad as the thorax and its greater part is occupied by a pair of compound eyes which in males are much larger as compared to females. The mouth parts (proboscis) in housefly are suited only for sucking the liquid and not for piercing the tissues. The housefly feeds on any organic liquid food. The proboscis is extended and by the suctorial action of the pharynx fluid is sucked up into the mouth. Housefly also feeds on solid substances such as sugar and sweets. It produces its proboscis, regurgitates a drop of liquid from the alimentary canal and saliva from the salivary glands on the solid food. Thus the solid food is liquified and sucked. The fly cannot swallow solid food as such. (Fig. 4.14)

The flies generally come to the earth for copulation and female lays oval pearly white eggs 6 to 8 days after the copulation. Eggs are laid in groups of about 100 to 150 at a time on horse manure, cow dung, faeces or any decaying vegetable or animal matter. A single female in its life time may lay eggs 4 to 6 times. The larvae while growing cast their skin twice and the last larval skin is not shed, instead it forms an airtight pupal case or puparium. Fully mature larva crawls away from its original moist home and travels a few yards to some dry sheltered crevice. Here it rests for some time and the body of the larva contracts and the colour changes from creamish to dark brown and now it forms the pupa within the puparium. Pupa has no mouth or anus. Within the pupa the organs of the adult fly are formed. When the fly is ready inside the puparium, it breaks the puparium and comes out. After emergence, the fly is white in colour but soon it becomes dark and hard. Flies become sexually mature in about 14 to 15 days and start laying eggs. Fly lives for about two months.

***Pathogenicity*:** Apart from the annoying habits, fly when flies over cup of tea or walks over any other food material, it leaves behind a mark of filth, bacteria or protozoa which can cause serious disease. Typhoid germs are distributed in this way. Houseflies feed on garbage, manure, faeces and also visit all such places for laying eggs. They pick up disease germs on their legs and leave them on our uncovered food in kitchen, restaurants etc. At times, these flies also deposit eggs on decaying and cut fruits, exposed sweets and when such fruits or sweets are eaten by man the young larvae enter the alimentary canal, cause intestinal disorders such as typhoid, para typhoid, diarrhoea, both bacillary and amoebic dysentery, gastroenteritis, cholera and can even cause food poisoning. They also carry eggs of intestinal worms such as *Taenia solium* (pork tapeworm), *Ascaris lumbricodes* (roundworm), *Ancylostoma duodenale* (hookworm), *Trichuris trichura* (whipworm). Some of the other diseases transmitted by houseflies are trachoma, opthalmia, leprosy, anthrax, gangrene, poliomyelitis, infective hepatitis, tuberculosis.

***Control*:** Flies and filth go together. If the filth is removed, the flies are automatically reduced. The best method to control the menace of flies is to attack them before they are able to fly. All breeding places of flies should be eliminated by the removal of the filth so that they are not able to breed and increase in number. Until proper steps are available to elminate these flies, everyone should protect one's own food supply by special care and should keep one's own house and premises clean and free from these insects.

***Sand Fly* (*Phlebo tomus*)**

It is a small yellowish brown hairy delicate insect a bit smaller than mosquito. It has two wings and legs are longer than the body. The proboscis is fairly long and it is not bent during feeding. Sand fly does not fly but jumps from one place to another. Female sand fly

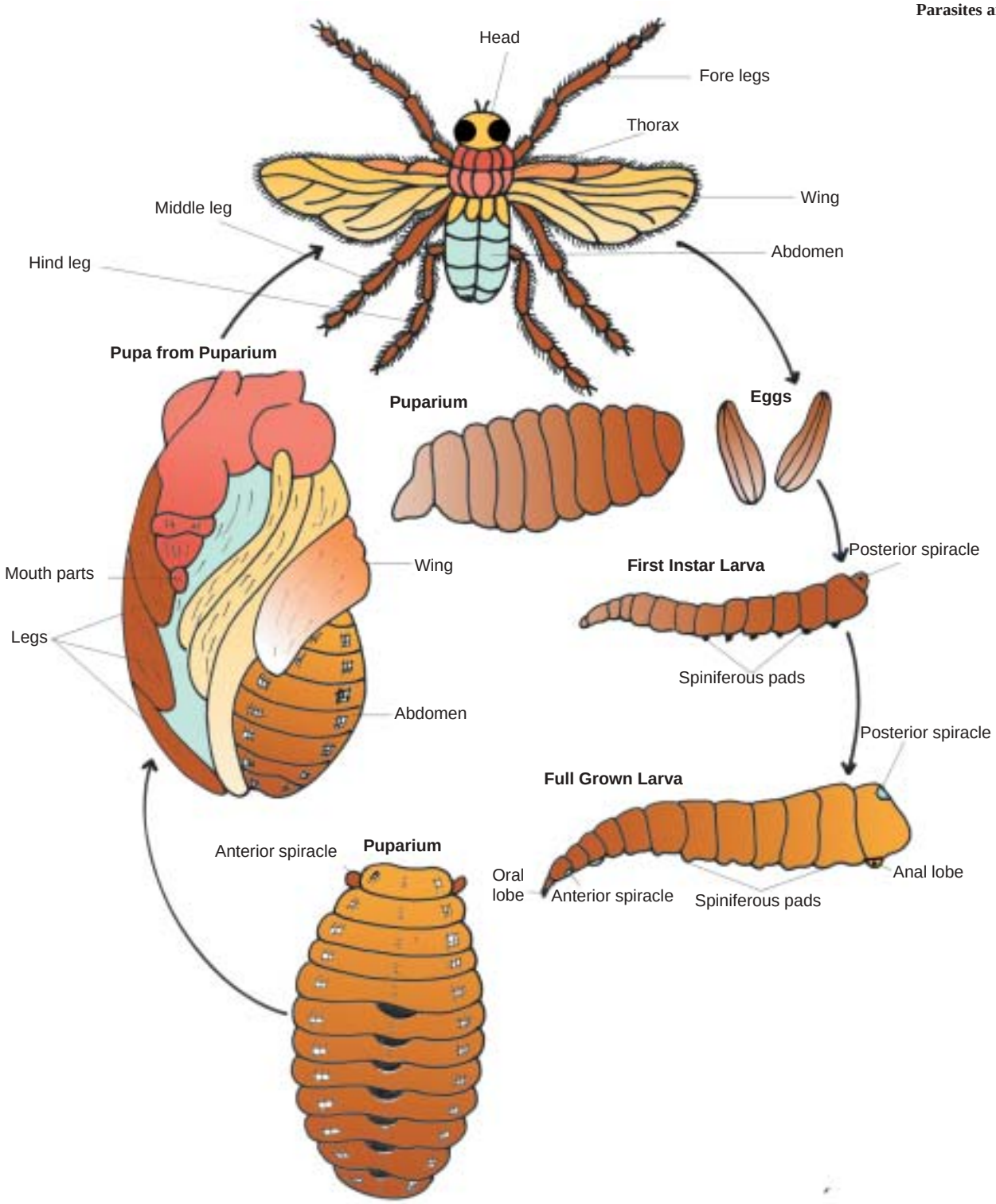

Fig. 4.14 : Life History of House Fly

sucks the blood usually at night and bites are very painful. Males live on vegetables. Average life of a sand fly is about two weeks. Sand fly transmits Kala azar (Lishmaniasis) and sandfly fever which is a viral disease resembling dengue and influenza.

Tse-Tse Fly (*Glossina*)

Tse-tse fly is confined to Africa and not found in India. It is slightly larger than housefly and has an elongated, brownish coloured body with its proboscis projecting in front of the head. The average life of tse-tse fly is about 3 months. They are vectors of trypanosomes which are injected in the blood and lymph glands of man. They finally enter in the cerebrospinal fluid and cause sleeping sickness resulting in comma and death (For details, refer sub-section 4.5.4). [Fig. 4.15(d)]

Fleas

They are small wingless laterally compressed insects. The adults are small dark brown coloured blood sucking ectoparasites mostly on mammals like rat, squirrel, dog and only one species viz. *Xenopsylla cheopis*, in the absence of rat when starved bites man. They have piercing and sucking type of mouth parts. They transmit the disease plague from rat to rat or from rat to man. They also transmit typhus fever. [Fig. 4.15(a)]

Lice

These are small wingless flat dark pale coloured insects found on the body of animal and man and they live on host throughout their life. *Pediculus humanus capitis* is found on the head clinging to the hairs of the host and *Pediculus humanus corporis* is found on the clothes next to the skin. They have piercing and sucking type of mouth parts. They have dark markings on the sides and each of the six legs has a large curved claw adapted for clinging to the hair of the host. Female lays eggs on hair or clothes and adult lives for about 30 to 40 days. Infestation is by direct contact through combs, brushes and clothes. They transmit disease such as louse borne typhus fever, louse borne relapsing fever, trench fever and staphylococcal infections. [Fig. 4.15(b)]

Bed Bugs

These are small oval flat reddish brown wingless insects. During the day, they hide in cervices, cracks in the bed, furniture, carpets etc. but at night they move about and suck human blood.The larger part of the body including legs is covered by a large number of bristles. They live for about a year. Normally they do not cause any disease but are mechanical vectors of human pathogens. [Fig. 4.15(c)]

Ticks

These are small coloured oval or spherical eight-legged exclusively blood sucking arthropods found on dogs, cats, cattle etc. They can transmit rickettsiae, spirochaetal and bacterial infections. They can also transmit viral infections such as yellow fever, encephalitis etc. [Fig. 4.15(e)]

Mites

They are closely related to ticks. These are very small red, orange or black coloured skin parasites. Like ticks they also have four pairs of segmented walking legs. The adults feed on vegetables and lay eggs on grass. The larvae enter the hair follicle of humans and cause irritating dermatitis. An example is itch mite also known as scabmite. Some types of mites spread mite borne rickettsiae infections. [Fig. 4.15(f)]

Cyclops

It is a small microscopic aquatic arthropod mostly found in stagnant freshwater ponds, pools, ditches etc. It is a pear shaped animal with five pairs of swimming legs. Female cyclops has a pair of sacs on the abdomen. It is an intermediate host of guinea worm (*Dracunculus medinensis*).

Check Your Progress 7

1) Differentiate between male and female mosquito.

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2) Name the common arthropod vectors.

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4.13 LET US SUM UP

- Parasites and Vectors play very important part in our life.
- Parasites may be permanent, temporary, non-pathogenic, pathogenic, obligatory and facultative.

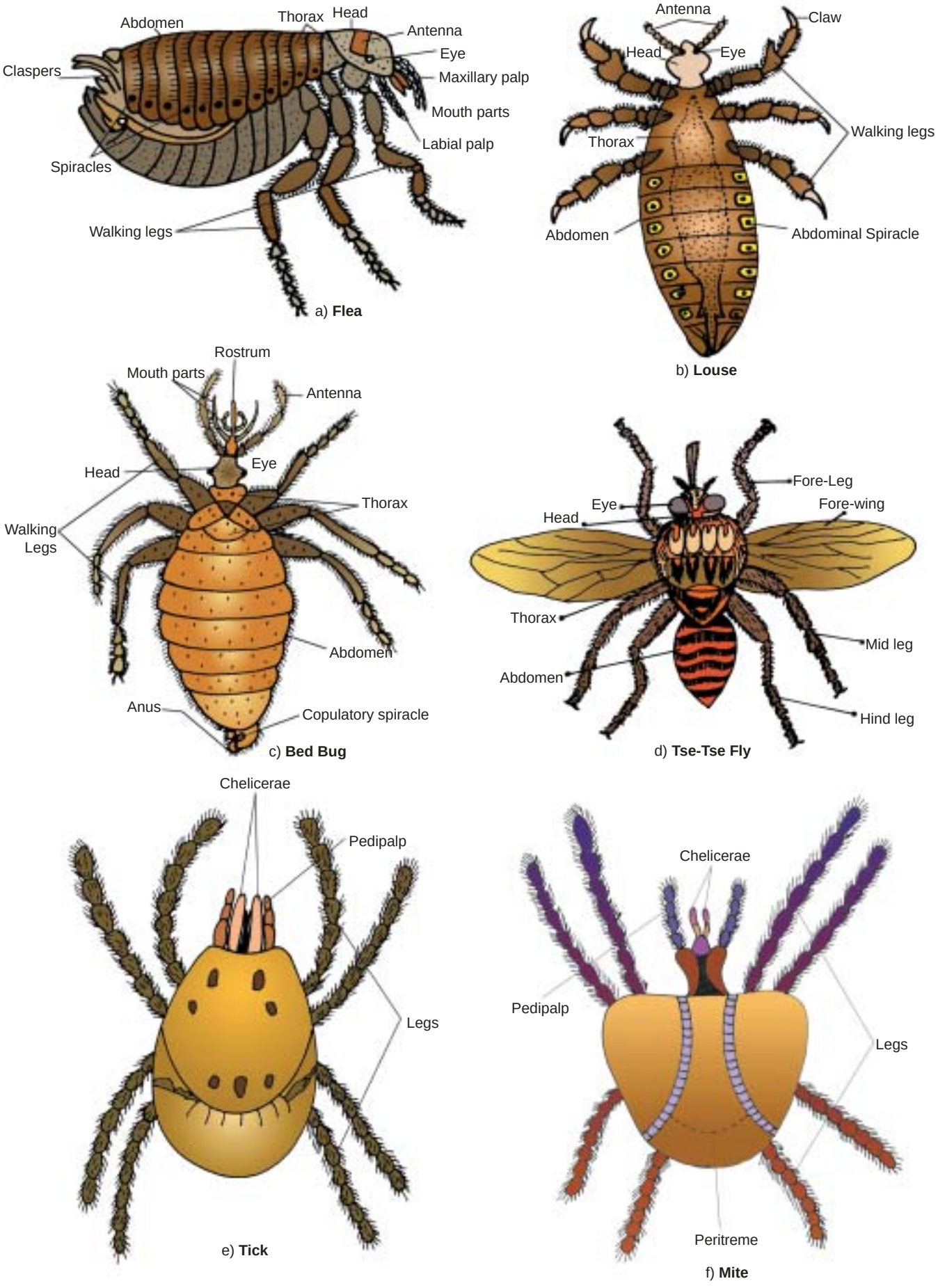

Fig. 4.15(a–f): Arthropod Vectors

- Parasites pathogenic to man may be unicellular protozoa or multicellular helminths.
- The morphology and life cycle of some of the well known human pathogenic protozoa are described in this unit. Diseases caused by these protozoa such as amoebic or giardial dysentery, diarrhoea, malaria, sleeping sickness, kala azar, etc. are also stated at appropriate places.
- Human helminth parasites include trematodes, cestodes and nematodes.
- Trematodes include leaf shaped unsegmented parasites called as flukes and cestodes include long segmented parasites called as tapeworms.
- Nematodes include intestinal and somatic nematodes.
- Brief life cycles of liver fluke tapeworm, *Ascaris*, whipworm, hookworm, pinworm, filarial worm, and guinea worm parasites are stated in this unit.
- Vectors may be inanimate or animate and they transmit the diseases from one human being to the other.
- Arthropod vectors include mosquito, housefly, sandfly, tse-tse fly, flea, louse, bed bug, mite, tick and cyclops.
- Some of the diseases transmitted by the vectors are also mentioned in this unit.

4.14 KEY WORDS

Ameboma : A tumor caused by amebiasis.

Arthropoda : It is one of the phylum of the animal kingdom which includes animals with jointed legs.

Cyclops : It is an animal belonging to phylum Arthropoda.

Granuloma : It is a granular tumour or growth, usually, of lymphoid and epithelioid cells.

Haemocoel : Body cavity.

Insects : These are six-legged forms of arthropods.

Leukorrhea : It is white or yellow mucous discharge from the vagina.

Macrophage : Phagocytic cells widely distributed in a vertebrate animal.

Macule : It is a decolourished spot or patch on the skin neither elevated, nor depressed.

Pruritis : It is an eczematous condition around the anus.

Ticks : These are eight-legged forms of arthropods.

Vertebrate : It is one of the divisions of animal kingdom which includes animals with backbone (vertebrae).

4.15 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Parasite is an organism which derives its nourishment at the cost of another organism.

   Parasitism is the relation which exists between the parasite and the host.

2) Obligatory parasite is a parasite which entirely depends on the host for its existence.

   Facultative parasite is a parasite which leads parasitic life but is also capable of independent existence.

Check Your Progress 2

1) Trophozoite is a feeding stage and it has no cyst wall. Cyst is a non-feeding stage and it is covered by a thick cyst.
2) With the help of the sucking disc the parasite attaches itself to the wall of the intestine.
3) *T.hominis* is found in the intestine; *T. tenax* is found in mouth and *T.vaginatis* in the genitalia of male and female.
4) Metacyclic forms are similar to Trypanosomes except they are short and stumpy.

5) Leishmania parasites are found in the cells of endothelial system and leptomonad parasites are found in the insect vector sand fly.

6) Zygote is the fusion of sperm nucleus and the female nucleus. Ookinete is the wormlike stage formed by the elongation of zygote. Male gametocyte in *P.vivax* is oval in shape while in *P. falciparum* it is long bean shaped.

7) Alternation of generation is a phenomenon in which asexual and sexual cycle alternate with each other.

Check Your Progress 3

The trematode *Clonorchis sinensis* has two secondary hosts: snail and fish.

Check Your Progress 4

1) Non-vegetarians.

2) *Taenia solium* and *Taenia saginata.*

Check Your Progress 5

1) Intestine, liver, heart, lungs, bronchi, trachea, throat, glottis, oesophagus. Sometimes the larvae also reach brain and spinal cord.

2) Anteriorly it tapers and is slightly hooklike hence called hookworm.

3) All the other female intestinal nematodes lay eggs in the intestine but female pinworms especially at night migrate down to the anus and lay eggs on the perianal skin.

Check Your Progress 6

1) The Larva differs from adult in two main respects:

   a) Larva is enclosed in a delicate sheath much longer than the body.

   b) Larva in the whole body possesses somatic cells or nuclei looking like granules.

2) Elephantiasis is a disease caused by *Wuchereria* or *filaria bancrofti*. It occurs in arms, legs, scrotum, mammary glands etc. In this disease lymphatic vessels get blocked and connective tissue grows resulting in the disease elephantiasis.

3) Larva has no chitinous shield. The cuticle in larva has transverse striations.

Check Your Progress 7

1) Male mosquito has short bushy antennae with numerous long bristles while female mosquito has long slender antennae with only a few bristles.

2) Arthropod vectors are housefly, mosquito, louse, bed bug, flea, mite, tick and cyclops.

Pseudopodia

Nuclear Binary Division in Progress

Cystic Stage: It is almost similar to precystic stage with the difference that it has a thick cyst wall and there is no pseudopodium. The cytoplasm of the cyst contains oblong chromatid bars and sometimes in the early stages a distinct glycogen mass is also seen. The glycogen mass and the chromotid bars gradually disappear. The single nucleus multiplies in two successive divisions into two and ultimately four daughter nuclei are formed. Thus, a cyst may be uninucleate, binucleate and tetranucleate.

Fig. 4.10(a): ***Taenia solium*** **(*Pork Tapeworm*)**

i) ***E. vermicularis***
(Pinworm : Female)

a) ***Filaria bancrofti***
(Male)

b) ***Filaria bancrofti***
(Female)

h) **Dracunculus**
(Guinea worm: female)

Fig. 4.12(a-k): Somatic nematodes

Cuticle
Striated

Egg

a) **Flea**

f) **Mite**

c) **Bed Bug**

Fig. 4.15(a–f): Arthropod Vectors

Primary Lymphoid Organs

Secondary Lymphoid Organs

Walking Legs