MINISTRY OF THE PUBLIC HEALTH OF UKRAINE
ZAPOROZHYE STATE MEDICAL UNIVERSITY
DEPARTMENT OF MEDICAL BIOLOGY

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POPULATION - SPECIES, BIOGEOCENOTIC AND BIOSPHERICAL LEVELS OF LIVING THINGS ORGANIZATION

TEXT-BOOK FOR MODULE II

for the first year training students
of the medical faculty

Zaporizhzhia
2017

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Medical Parasitology is a fundamental discipline within the medical sciences. Study of the structure, organization and life-cycles of different parasites gives the doctors strong knowledge about parasitizm for searching the most effective methods of treatment.

The present Text Book for the first year training students of the Medical faculty has been written in accordance with the Academic Curriculum on Medical Biology accepted by all Medical University of Ukraine. Efforts have been made to provide latest material facts. Improved illustration wherever necessary are provided, for a better understanding of the subject by the students. Detailed discussions, a range of test questions continue to be the main attractions of the book.

SCHEDULE

of the practical lessons for Module 2

#	THEMES	Hours of study
	Submodule 4 Medical Protozoology	
20.	Phylum Sarcomastigophora. Class Lobosea	2
21.	Phylum Sarcomastigophora. Class Zoomastigophora	2
22.	Phylum Apicomplexa. Phylum Rimostomata	2
23.	**Test of Submodule 4**	**2**
	Submodule 5 Medical Helminthology	
24.	Medical Helminthology. Phylum Platyhelminthes. Class Trematoda: *Fasciola hepatica, Opisthorchis felineus, Dicrocoelium lanceatum, Schistosoma mansoni, Schistosoma haematobium, Paragonimus westermani*	2
25.	Phylum Platyhelminthes. Class Cestoidea: *Taenia solium, Taeniarhynchus saginatus, Hymenolepis nana, Echinococcus granulosus, Alveococcus multilocularis, Diphyllobothrium latum*	2
26.	Phylum Nemathelminthes. Class Nematoda: *Ascaris lumbricoides, Enterobius vermicularis, Necator americanus, Strongyloides stercoralis, Trichocephalus trihiurus, Ancylostoma duodenale*	2
27.	Phylum Nemathelminthes. Class Nematoda: *Trichinella spiralis, Dracunculus medinensis, Filariidae*. The laboratory diagnostic of Helminthes	2
28.	**Test of Submodule 5**	**2**
	Submodule 6 Medical Arachnoentomology	
29.	Phylum Arthropoda. Class Crustations. Class Arachnida	2
30.	Phylum Arthropoda. Class Insecta. Orders: Anoplura, Aphaniptera, Heteroptera, Blattoidea	2
31.	Phylum Arthropoda. Class Insecta. Order Diptera: Mosquitoes and flies	2
	Submodule 7 Individual and historical development. Biosphere and Humans	
32.	The Theory of Evolution.	2
33.	Phylogenesis of the main systems of Vertebrates	2
34.	Biosphere	2
35.	**Test of Module 2**	**2**

Submodule 4

TOPIC 20: PHYLUM SARCOMASTIGOPHORA. CLASS LOBOSEA (SARCODINA).

Key concepts:

1) Protozoa in general.
2) Taxonomy of the most important human parasitic Protozoa.
3) Phylum Sarcomastigophora. Class Lobosea.

The main features of Protozoa:

– Protozoa are very small, microscopic animals, whose bodies are made of single cells ***(unicellular organisms)***. Their single-celled bodies are complete organisms which perform all the activities of higher multicellular forms.

– The protozoan body is covered by ***elastic plasmalemma*** (outer limiting coat, ex. Amoeba) or by a thin elastic ***pellicle*** which is a double membrane (ex. Euglena, Paramecium).

– Jelly-like mass of protoplasm is differentiated into an outer ***ectoplasm*** which is clear, dense and firm, and an inner more fluid but granular ***endoplasm.*** The ectoplasm performs: protection, locomotion, ingestion of food, excretion and respiration. The endoplasm is concerned with metabolism.

– In the endoplasm are many ***food vacuoles.*** Each vacuole contains a morsel of food. The endoplasm secretes enzymes into the vacuoles which digest proteins and carbohydrates.

A clear space arises in the endoplasm and grows, being filled with water. It's ***a contractile vacuole*** which is excretory for discharging some waste substances; it is also performs the respiratory function because it removes some dissolved CO_2. Its primary function is hydrostatic or osmoregulation, it continuously removes an excess of water from the animal. Thus it controls the osmotic balance.

– Stored food (fat and glycogen) are also found in the endoplasm.

– Suspended in the endoplasm is a nucleus (one or two). It performs life activity of Protozoa, including: nutrition, respiration, locomotion, excretion, encystment, growth and reproduction.

Nutrition: absorption the liquid food through the body surface, or ingestion the solid particles by the help of pseudopodia or through the cytostome.

Respiration: either aerobic or anaerobic.

Locomotion by: pseudopodia, flagella or cilia.

Reproduction: a) Asexual reproduction: division of cell by ***binary fission*** (into two organisms) or ***multiple fission*** (into many cells).

b) Sexual reproduction: either by gametes formation (Plasmodium) or by conjugation (Paramecium).

Encystment. When unfavorable condition of food and temperature arise in a pond the Protozoan becomes rounded, streaming movements of protoplasm stop and a covering is secreted. It hardens into ***a cyst***. The cyst is a resting stage and it protects the animal from death due to drying or freezing; it also serves as a means of dispersal, because the cysts are blown about by the wind. When the cyst is blown into another pond, or the pond is again filled with water, the cyst bursts, the protoplasm flows out to re-form the animal which resumes its normal mode of life.

Protozoa includes three Phyla's:

Sarcomastigophora: Class Lobosea (Amoeba)

Class Zoomastigophora (Euglena)

Apicomplexa: Class Sporozoa (Plasmodium)

Ciliophora: Class Rimostomatea (Paramecium)

Phylum Sarcomastigophora. Class Lobosea.

Entamoeba histolitica is a protozoan parasite in the colon part of large intestine of man that has a world-wide distribution. It can be found in the three forms:

- minuta form – precystic form, non-pathogenic;
- magna form – pathogenic;
- Quadrinucleated cyst.

The small vegetative form ***(minuta form)*** is 12-15 microns in diameter. It stores plenty of food reserves before secreting a cyst. It feeds on bacteria, detritous in the lumen of large intestine and reproduces by binary fission.

The fully grown form (trophozoite, magna form) is more or less rounded and about 30 microns in diameter. It has outer ***clear ectoplasm*** and inner ***granular endoplasm*** with a large round nucleus. The advancing end consists of a single blunt pseudopodium.

It ingests red blood corpuscles which may be seen in the endoplasm numbering up to ten or more. It also feeds on tissue cells of the intestine.

Cyst is moveless, colorless, transparent, has a round form and 4 nuclei.

Life cycle. Entamoeba histolitica is an agent of amoebiasis ***(amoebic dysentery)***. Infection takes place by ingestion of mature cysts with contaminated food or water. The cysts are capable of infecting fresh hosts for 3 months. The infective cysts may reach man through house-flies which pick up cysts on their legs and wings and drop them on food.

The infective cysts, containing metacystic entamoebae upon reaching a fresh host, go unharmed through the stomach. The intestinal enzymes succeed in dissolving the cyst wall. In the lumen of large intestine the nuclei divide again forming 6-8 nuclei. Protoplasm surrounds each nucleus giving rise to six to eight entamoebae. They inhabit the cavity of large intestine, feeding on bacteria detritus and reproduce. After several rounds of binary fission, encystment takes place.

Cysts pass out of the host's body with the faeces. They are found in the faeces during the period of remission in chronic amoebiasis or in the healthy-carries.

In some cases: changing of intestinal microflora, dehydration, changing of Ph medium, blindness, forma minuta changes into forma magna. Forma magna penetrates into the wall of the small intestine, produces proteolytic enzymes which may cause the ulcers formation on the intestinal mucosa. In heavy infection, the intestinal mucosa and submucosa are dissolved away by the enzymes of the parasite. Small nodules are formed on the wall of the large intestine. The nodules let out large amounts of mucus and blood in acute cases. Faeces then become loose and slimy leading to amoebic dysentery or ***amoebiasis***.

In chronic amoebiasis, the parasites bore into the mesenteric blood vessels of the large intestine and are carried to the liver. While in the liver, the parasites cause serious damage to the capillary walls and produce ***abscesses***. Such abscesses become infected by bacteria, leading to more complication.

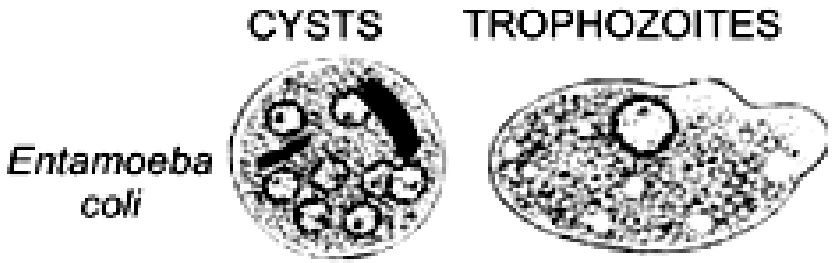
Diagnosis: Investigation fresh faeces should be made. In the chronic amoebiasis or in cyst-carries cysts and small vegetative forms (minuta form) are found.

For diagnostic non- intestinal forms of amoebiasis (abscesses of liver, lungs, etc), the contents of internal organs should be microscoped.

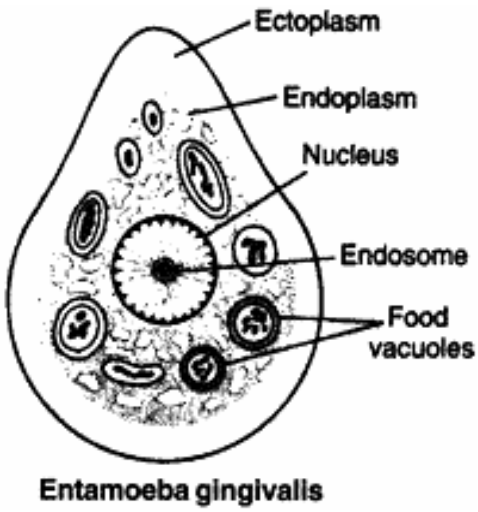
Prevention: Follow the hygienic rules.

- Protection of food and water from contamination with cysts.
- Control of flies and other insects as cockroaches.
- Examination people with gastrointestinal diseases.
- Revealing and treatment patients and cyst-carries.

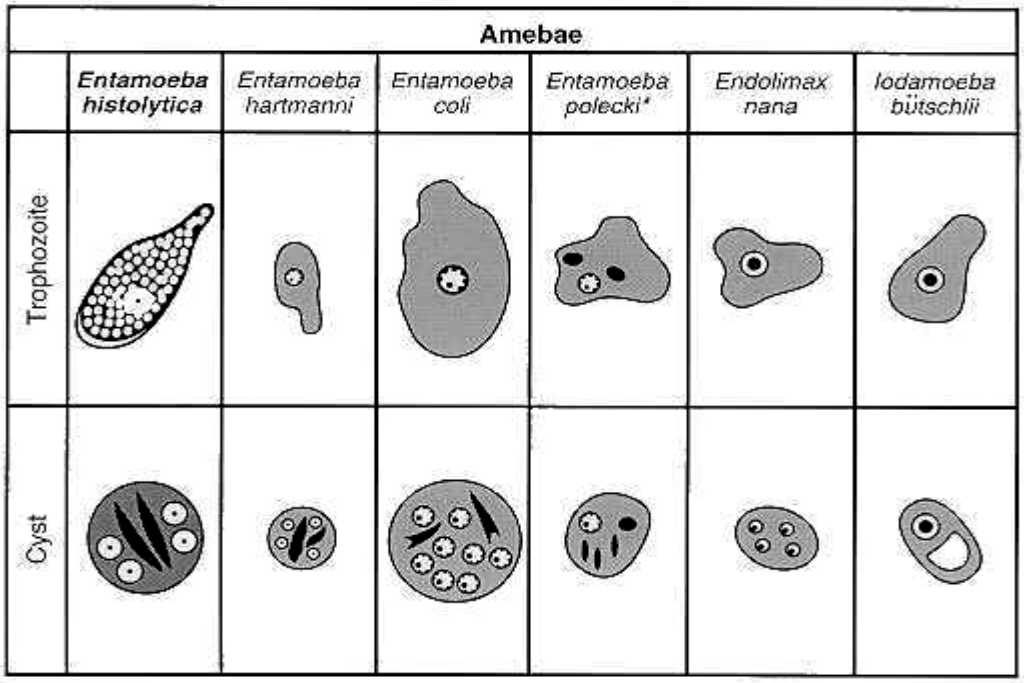
Entamoeba coli is a commensal (no pathogen) in the upper part of the large intestine of man. It is large-sized (15-30microns) with very little ectoplasm. There are a number of food vacuoles, and a large round nucleus. It exists in the forms: ***trophozoite*** and ***cyst***. The encysted amoebae have eight nuclei each. Each cyst thus produces eight young trophozoites.



Entamoeba gingivalis (12-20 microns) inhabits the mouth. It has clear cytoplasm with fluid-filled food vacuoles. Pseudopodia are a few, short, broad and round. It produces pus in gums and often aggravates already present pyorrhoea. Infection is direct through saliva or through kissing. No cysts are produced.



Free-living pathogenic amoebae are ***Naegleria fowleri, Acanthamoeba <u>castellany</u>*** and species of ***Hartmanella***. They inhabit polluted water, damp soil, manure, feed on bacteria and form cysts. Primary amoebic meningoencephalitis is caused by amoebic invasion of the brain. Most cases develop in children who were swimming and diving in contaminated pools. The amoebae, primary N. fowleri, enter via the nose passing directly into brain tissue and cause extensive haemorrhage. In most cases, death ensued in less than a week.



Diagnosis

In most cases rests on the characteristics of the cyst, since trophozoite usually appear only in diarrheic faeces in active cases and survive for only a few hours. Stools may contain cysts with 4 nuclei.In the case of N. fowleri the microscopic examination of the cerebrospinal fluid, which contains trophozoite, should be done.

Practice.

Assignment 1. Entamoeba histolitica.

1.Study and draw diagram of the life cycle of Dysenteric amoeba. Label forma minuta, forma magna and cysts.

2.Study and sketch the vegetative forms of Entamoeba histolitica, examining permanent slides. Label nucleus and pseudopodia.

Assignment 2. Cysts of Amoeba.

Study cysts of Entamoeba histolitica and E. coli. Draw cysts and label their nuclei.

TOPIC 21: PHYLUM SARCOMASTIGOPHORA.
CLASS ZOOMASTIGOPHORA

Key concepts:

1) Main features of Zoomastigophora.
2) Morphology, life-cycle, pathogenesis of the parasites:

– Lamblia intestinalis, Trypanosoma, Leishmania, Trichomonas.

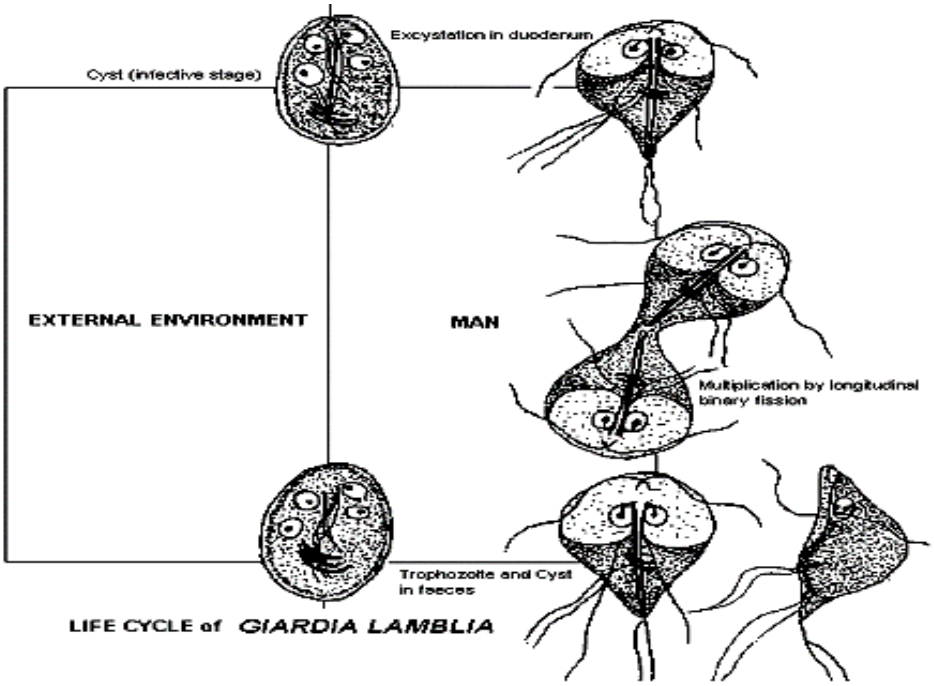
3) Diagnosis of diseases that are caused by these parasites. Prevention.

Zoomastigophora are flagellates with one or more whip-like flagella and, in some species, with an undulating membrane (ex. Trypanosomes).This class includes:

-Parasites of tissues and blood (Trypanosomes, Leishmania). They are transmitted by Insecta.

-Parasites of the alimentary canal and genitals (Lamblia, Trichomonas). They are not transmitted by insects or other biological vectors.

Giardia lamblia (synonym Lamblia intestinalis) is a flagellated protozoan parasite that colonises and reproduces in the small intestine, causing ***lambliasis (gardiasis).*** The parasite attaches to the epithelium by a ventral adhesive disc, and reproduces via binary fission. It exists in two phases: ***trophozoite*** and ***cyst***.



Trophozoite: shape tennis or badminton racket like. It has convex dorsal surface with concave ventral surface and with a sucking disc. It is bilaterally symmetrical and all parts of the body are paired. Thus there are two axostyles, two nuclei and four pairs of flagella. Cyst is oval-shaped with four nuclei.

Life-cycle.The life cycle begins with a noninfective cyst being excreted with the faces of an infected individual. The cyst is hardy, providing protection from various degrees of heat and cold, desiccation, and infection from other organisms. A distinguishing characteristic of

the cyst is ***four nuclei*** and a ***retracted cytoplasm***. Once ingested by a host, the trophozoite emerges to an active state of feeding and motility.

Giardia infection can occur through ingestion of dormal cyst in contaminated water, food, or by the faecal-oral route (through poor hygiene practices). The Giardia cyst can survive for weeks to months in cold water, and therefore can be present in contaminated wells and water systems, especially stagnant water sources such as naturally occurring ponds, storm water storage systems, and even clean-looking mountain streams. Zoonotic transmission is also possible, and therefore Giardia infection is a concern for people camping in the wilderness or swimming in contaminated streams or lakes.

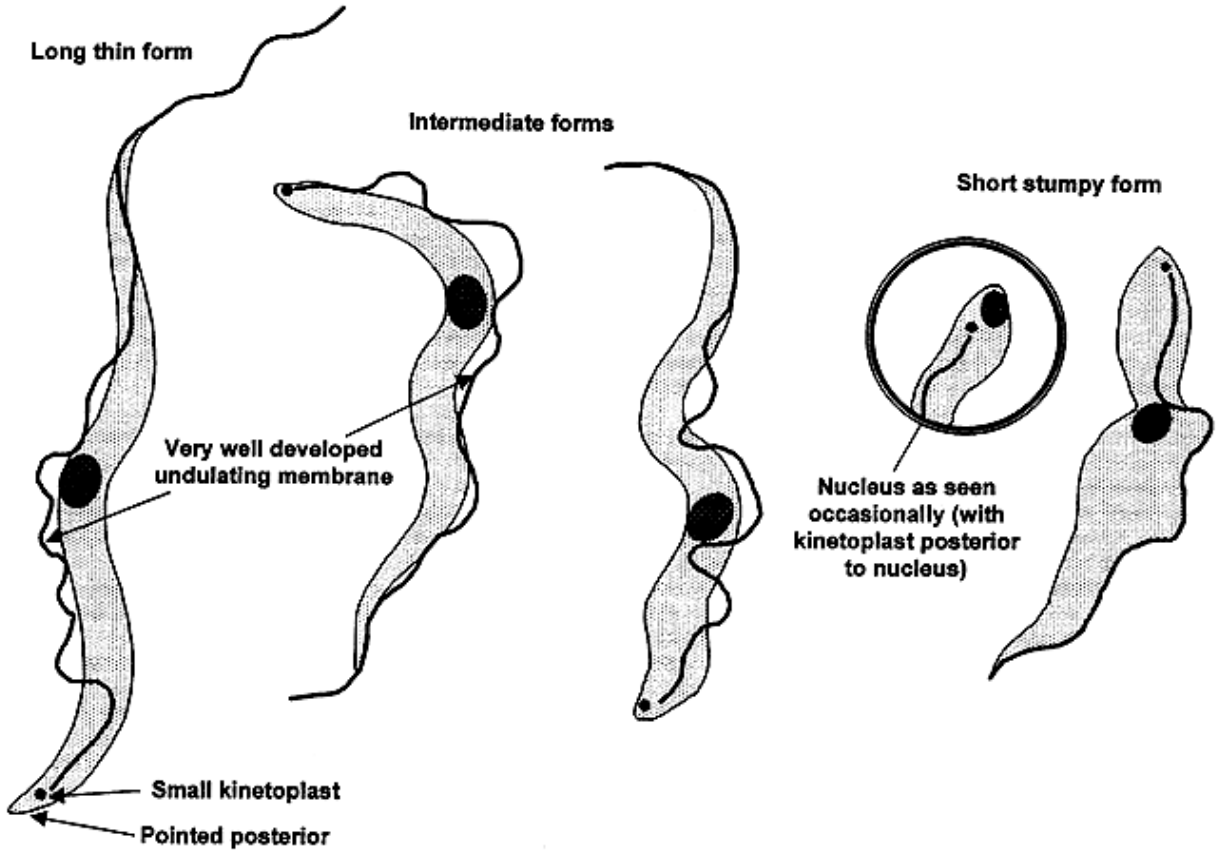
Manifestation of Disease.Colonization of the gut results in inflammation and villous atrophy, reducing the gut's absorptive capability. In humans, infection is symptomatic only about 50% of the time. Symptoms of infection include diarrhea, malaise, excessive gas steatorrhoea (pale, foul smelling, and greasy stools), epigastria pain, bloating, and nausea, diminished interest in food, possible vomiting which is often violent, and weight loss. Pus, mucus and blood are not commonly present in the stool. Not all Giardia infections are symptomatic, and many people can unknowingly serve as carriers of the parasite.

Prevention:

- Follow the rules of personal hygiene.
- Reveal and treat patients.
- Disinfection of children's toys and other personal thinks.
- Cleaning drinker water.
- Elimination of flies and cockroaches that are mechanical carriers of disease.

Trypanosoma

Trypanosomes are parasites in the blood, lymph and tissues of many vertebrates. The adult form has a fusiform body pointed at both ends and covered with a firm pellicle. Arising from the hinder end is a long thread-like ***axoneme***, which is continued along and beyond the body as a flagellum. The axoneme is joined to the cell by an undulating membrane which is formed by the cytoplasm. There is a large nucleus in the middle of the cell. At the base of the flagellum is a granule called ***blepharoplast*** and close to it is a ***parabasal body*** or ***kinetonucleus***. It is derived from the nucleus and controls the movements of the flagellum. The blepharoplast and parabasal body are together called ***kinetoplast.*** They form no cysts.



The trypanosomes swim freely in plasma by wriggling of the body and by movements of the undulating membrane and flagellum.

Three species are parasitic in man:

–Trypanosoma gambiense

–Trypanosoma rhodesiense

–Trypanosoma cruzi.

Trypanosomes are agents of ***African trypanosomiasis*** (or sleeping sickness) in humans, most common in central and western Africa ***(T. gambiense)*** or in southern and eastern Africa ***(T. rhodesiense)***. These ***obligate parasites*** have two hosts – ***an insect vector*** and ***mammalian host***. The insect vector is ***tsetse fly***. The parasite lives in the midgut of the fly, whereupon it migrates to the salivary glands for injection to the mammalian host on biting.

Trypanosomes are found in the blood of ante lops from where they are transmitted to humans by tsetse flies (Glossina palpalis or G. morsitans). Patient's central nervous system and internal organs are affected. The parasite causes trypanosome fever, increasing the lymphatic nodes, liver and spleen transformations, inflammation of brain and cerebral membranes (meningoencephalitis). One may die if disease is not cured.

Diagnosis: microscopic analysis of blood smear, punctuate of lymphatic nodes. In the case

of suspicion that central nervous system is affected, microscopic examination of spinal fluid should be done. Sometimes serological reactions are used.

Prevention: following the hygienic rules, elimination of carries, finding and treatment the patients.

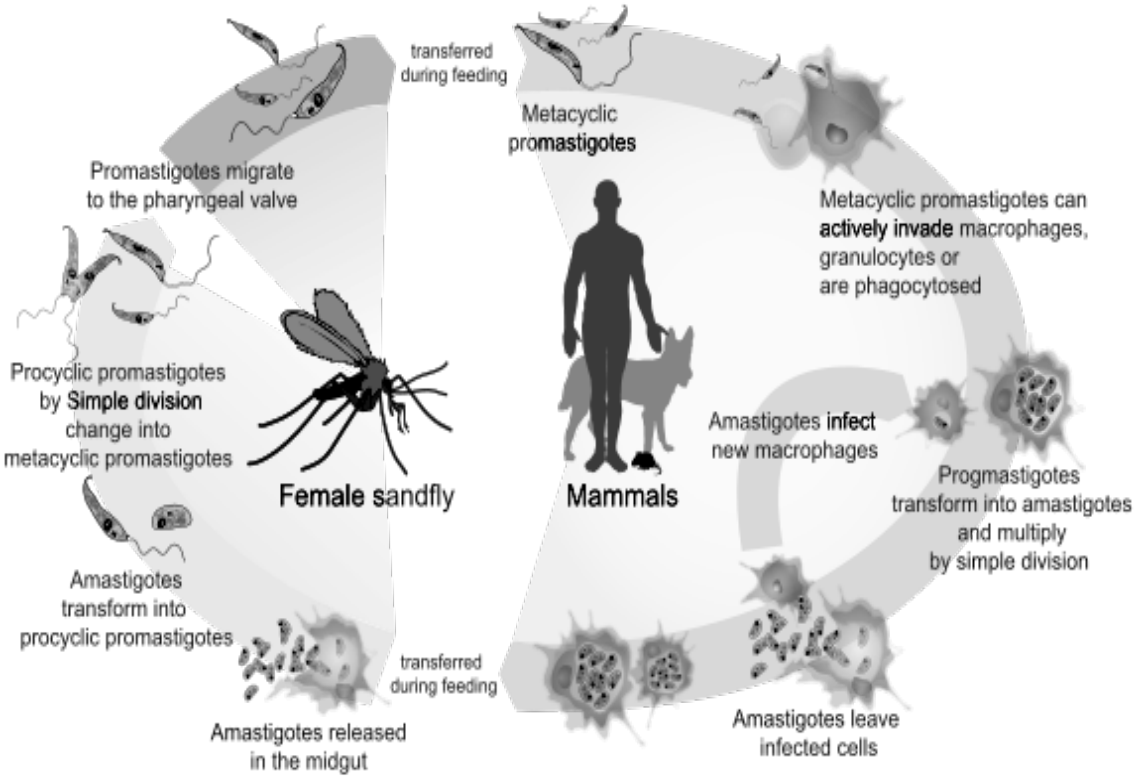
Trypanosoma Cruzi. It's a parasite of many mammals of South America and Central America. It is transmitted to humans by bugs like Triatoma megista and it causes ***Chagas disease*** characterized by fever, enlarged glands, and anemia. The parasite penetrates into blood, lymph and finally comes into internal.

Diagnosis and ***prevention*** are the same as in the case of African trypanosomiasis.

Leishmania

Leishmania is a parasite responsible for the disease ***leishmaniasis.*** The definitive hosts in the life cycle of the parasite responsible: canids, rodents and humans. The vectors are various sand flies of Phlebotomies genus.

Leishmania have two morphological forms: ***promastigote*** (formerly called leptomonas form, with an anterior flagellum) in the insect host (sand fly), and ***amastigote*** (formerly called leishmanial form, without flagella) in the vertebrate host (man). Infections are regarded as cutaneous, mucocutaneous, or visceral.



Cutaneous leishmaniais is caused by ***L. braziliensis***. Infection will start off as a reaction at bite, and can go via ***metastasis*** into the mucous membrane and become fatal.

Mucocutaneous infections are most common in Bolivia, Brazil and Peru. Cutaneous infections are most common in Afghanistan, Brazil, Iran, Peru, Saudi Arabia and Syria.

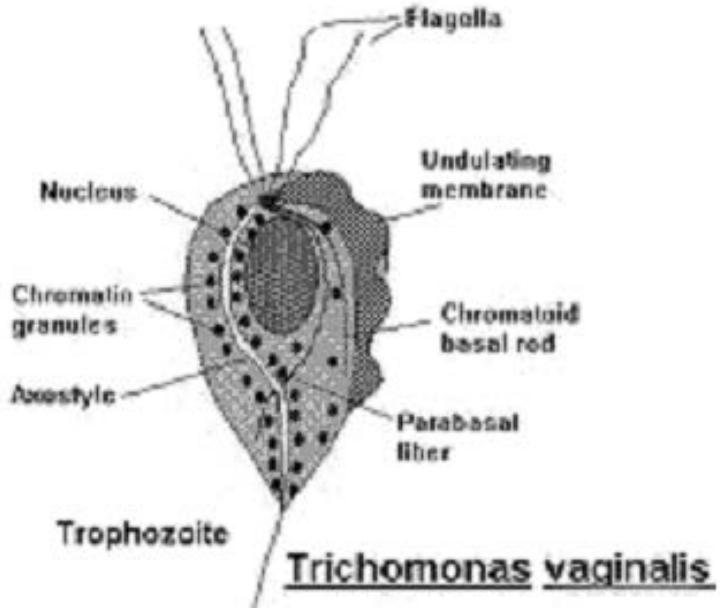
Visceral leishmaniais is caused by species of the L. donovani complex ***(L. donovani, L. infantum).*** Found in tropical and subtropical areas of all continents except Australia, most common in Bangladesh, Brazil, India, Nepal and Sudan.

The infections are often recognized by fever, swelling of the liver and spleen, and anemia. The parasite attacks the endothelial cells of blood vessels and lymphatic and is also found in spleen, liver and bone marrow.

Prevention is the same as in the case of trypanosomiasis.

Trichomonas vaginalis

The T. vaginalis ***trophozoite*** is oval and flagellated protozoan. Five flagella arise near the cytostome. A conspicuous barb-like ***axostyle*** projects opposite the four-flagellum bundle; the axostyle may be used for attachment to surfaces and may also cause the tissue damage noted in ***trichomoniasis*** infections. T. vaginalis does not have a cyst form; organisms can survive for up to 24 hours in urine, semen, or even water samples.



T. vaginalis is a cause of ***urethritis*** in men and both ***urethritis*** and ***vaginitis*** in women. The parasite is most commonly transmitted during sexual intercourse.

Diagnosis:

- microscopic examination of vaginal and urethral discharges or
- serologic reactions.

Prevention:

- avoid occasional sexual contacts;

- disinfection of urologic and gynecologic instruments, rubber gloves;
- reveal and cure patients;
- sanitary-and-instruction work.

Practice.

Assigment 1. Trypanosoma gambiense.

Study and draw the structure of T. gambiense and its life – cycle. Label the main structures of the parasite, definitive, reservoir and vector hosts.

Assigment 2. Leishmania donovani.

Study flagellated and nonflagellated forms of Leishmania on the slides. Draw these forms and label nucleus axostyle, undulating membrane, kinetoplast and flagellum in the flagellated forms.

Assigment 3. Trichomonas vaginalis.

Study structure of trichomonas vaginalis on the slides. Draw it and label: nucleus, axostyle, flagella, undulating membrane.

Assigment 4. Lamblia intestinalis and its cysts.

Study the vegetative form of Lamblia. Draw it and label 2 nuclei, axostyle, flagella, sucking disks. Study and draw Lamblia's cysts.

Assigment 5. Flagellates as parasites of man.

Copy and complete the table:

#	Parasite	Disease	Maine symptoms	Preventive measures
1.				

TOPIC 22: PHYLUM APICOMPLEXA. CLASS SPOROZOA PHYLUM CILIOPHORA.CLASS RIMOSTOMATA

Key concepts:

1. The main features of Phylum Apicomplexa and Class Sporozoa.
2. Plasmodium species and types of malaria caused by them.
3. A detailed account of the life cycle of Plasmodium vivax in man.
4. The live-cycle of Plasmodium in the female Anopheles mosquito.
5. Pathogenicity of the parasite. Diagnostics and prevention of malaria.
6. Toxoplasma gondii: morphology and live-cycle.

7. General characters of Ciliophora, class Rimostomata.
8. Balantidium coli: morphology, live-cycle, pathogenicity. Prevention of balantidiasis.

Class Sporozoa

Sporozoa have the following distinguishing characteristics:

– definite and constant shape;
– digestive and contractive vacuoles are absent, no organelles for locomotion.
– they have a special organelles for the penetration into the host cell: conoid and robrios.
– members of sporozoa reproduce asexually and sexually at the complex live cycles , changing hosts.

Sporozoa was so named due to the presence of a special stage in the live cycles called sporozoite. Member of Sporozoa are parasitic in nature. Sporozoa includes the following orders: Haemosporidia (Genus Plasmodium) and Eucoccidiorida (Genus Toxoplasma).

Genus Plasmodium

Plasmodium vivax is a ***protozoan parasite*** and a human ***pathogen***. The most frequent and widely distributed cause of recurring (tertian) ***malaria***, P. vivax is one of four species of malarial parasite that commonly infect humans. It is less virulent that P. falciparum, which is the deadliest of the four, and seldom fatal. P. vivax is carried by the female ***Anopheles*** mosquito, since it is the only sex of the species that bites.

The stage of Plasmodium infective to man is called ***sporozoite.*** The sporozoite is sickle-shaped and is slightly bent on one side. The cell body is spindlike with a swollen middle part and pointed ends. It measures about 15 microns in length and one micron in width.

The life cycle includes two phases, sexual and asexual, which are completed in two different hosts, the female Anopheles mosquito and human being respectively. The sexual phase of the life cycle is completed in the female Anopheles mosquito, which is considered as the ***definitive host.*** The asexual phase of the life cycle is completed in man. Hence man is considered as the ***intermediate host.*** Mosquito is also termed a ***vector***, as it transmits the parasite from one person to another. Monkey is the ***reservoir*** host.

Life cycle of Plasmodium vivax

A. Human phase

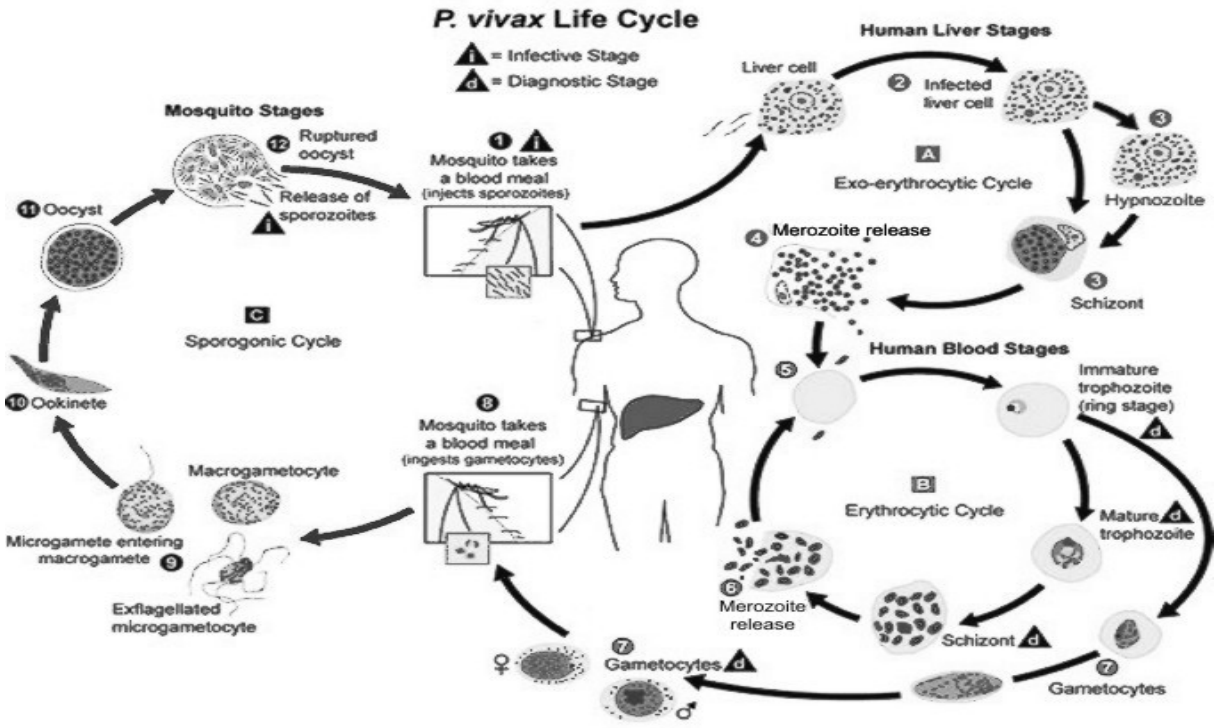
P. vivax reproduces by asexual multiple fission called schizogony in man. It is completed in the hepatic cells of the liver and the erythrocytes in the blood. Thus two cycles of schizogony take place in man. These two cycles are referred to ***exoerythrocytic schizogony***

and ***erythrocytic schizogony*** respectively.

I. ***Exoerythrocytic schizogony***

Sporozoites are the stages infective to man. When mosquito bites and injects saliva, along with the saliva, the sporozoites enter into the blood of man. Within half-an-hour, the sporozoites enter the liver cells from the blood and transform into ***trophozoites.*** They begin the first generation, or the ***preerythrocytic generation.*** These trophozoites feed on the hepatic cells of the liver and increase in size. The nucleus of the trophozoite divides several times and the parasite becomes a ***multinucleate schizont***. Within eight day the liver cell breaks and the cell membrane of the schizont ruptures releasing large number of (about 12.000) ***cryptozoites***, or ***first generation merozoites*** are released into the liver sinusoids. The cryptozoites may either enter erythrocytes of the blood to continue the erythrocytic cycle or may again invade a liver cell to produce the second generation.

The cryptozoite enters the liver cell and feeds on it. It increases in size, as in the first generation, and becomes the schizont. Schizogony takes place in the liver cell and the ***metacryptozoites***, or ***second generation merozoites*** are released into the liver sinusoids. On the basis of the size the metacryptozoites are distinguished into bigger ***macrometacryptozoites*** and smaller ***micrometacryptozoites.*** The smaller metacryptozoite enter the erythrocytes of the blood and begins the erythrocytic phase of the life cycle. The macrometacryptozoites enter a fresh liver cell and produces another batch of second generation merozoites.



The time interval between the initial infection by the sporozoites and the first reappearance of the parasites in the blood of man is called ***prepatent period***. It is about eight days in P. vivax during which period the parasite increases in its number, and the host does not exhibit the symptoms of the disease.

II. ***Erythrocytic schizogony***

It begins with the entry of merozoites (cryptozoites or micro metacryptozoites) in RBC, where they become ***trophozoites***. The trophozoites develop in the RBC, passing through some stages: signet ring stage, amoeboid stage (late trophozoite). Fully-grown trophozoite fills the entire erythrocyte and becomes the schizont. It undergoes schizogony called ***erythrocytic schizony***. The nucleus divides repeatedly and each bit of the nucleus is surrounded by a mass of cytoplasm to form ***erythrocytic merozoites.*** In P. vivax 15 to 20 merozoites are generally formed and irregulary arranged in the red blood cells. Endoerythrocytic cycle in P. vivax is completed in 48 hrs.

In this cycle, the parasite feeds on the hemoglobin of the red blood corpuscles. Appearance of brown-colored ***haemozoin granules*** is a result of digestion. Haemozoin is toxic and causes symptoms of malaria. In P. vivax, haemozoin is released into the blood every 48 hours along with the merozoites. Fever recurs every third day. Such a type of fever is called ***tertian fever***. The time interval between the entry of sporozoites into the body and the onset of malarial fever is called the ***incubation period***. It is about 10 to 14 days in Plasmodium vivax.

After a few cycles of erythrocytic schizogony, some merozoites, on entering the RBC develop into sexually differentiated forms, ***the gametocytes.*** The mature gametocytes are of two different types:

1) the larger, ***macrogametocytes,*** or female gametocytes and 2) the smaller, ***microgametocytes***, or male gametocytes. The gametocytes continue to remain in the blood and do not change any further in man. They undergo further development only in the stomach of female Anopheles mosquito. They degenerate and die if they are not transferred to the invertebrate host, the mosquito with a week.

B. ***The mosquito phase***

When a female Anopheles mosquito bites a person suffering from malaria, the gametocytes, present in the ingested blood alone survive the digestive action in the stomach of the mosquito.

The mosquito phase of Plasmodium includes:

1. Formation of gametes from the gametocytes undergoes a rapid nuclear division producing 8 flagellated ***microgametes*** and female gametocyte produces female ***macrogamete***.

2. Fertilization: the flagellated microgametes fertilize the female macrogamete. The resulting ***ookinete*** traverses the mosquito gut wall and encysts on the exterior of the gut wall as a ***oocyst***.

3. Sporogony: it's a formation of sporozoites from oocyst. Soon the oocyst ruptures, releasing hundreds of sporozoites into the mosquito body cavity where they eventually migrate to the mosquito salivary glands. When this infected mosquito bites a person, the sporozoites enter the host along with the saliva.

In the life cycle of Plasmodium the asexual phase alternates with the sexual phase and this phenomenon is described as ***alternation of generation***.

Pathogenecity. P. vivax causes benign tertian malaria (tertian, because the fever recurs after intervals of 48 hours or every third day; benign, as it is less dangerous). Clinical features of malaria include series of febrile paroxysms (bouts of fever) followed by anemia and splenomegaly (enlargement of spleen). A febrile paroxysm includes three stages: cold stage, hot stage and sweating stage. ***In the cold stage*** the symptoms are chills, headache and giddiness.

The symptoms of the ***hot stage*** are high fever (body temperature rising up to 106°F), increased breathing rate and the pulse rate. In the ***sweating stage***, profuse sweating is observed in the patient and temperature recedes to normal.

Some of the stages of P.vivax may survive for a long period in liver as dormant stages called ***hypnozoites***. Reactivation of these hypnozoites leads to initiation of fresh erythrocytes cycles and new attacks of malaria. This is referred to as ***relapse of malaria***.

Diagnosis:The preferred method to diagnose malaria and determine which species of Plasmodium is causing the infection is by examination of a ***blood film*** under microscope in a laboratory. Each species has distinctive physical characteristics that are apparent under the microscope. In P. falciparum, only early (ring-form) trophozoites and gametocytes are seen in the peripheral blood. It is unusual to see mature trophozoites or usually sequestered in the tissues.

Prevention. Malaria can be controlled by the following methods:

1. Protection against adult mosquitoes: spraying of insecticides in the houses to kill the

mosquitoes, using of mosquito nets and repellents.

2. Destruction of mosquito larvae: kerosene and Pyrethrum oil are sprayed on stagnant waters in sewage gutters and ditches, where mosquitoes lay eggs. Insecticides are used in the breeding place to kill the larvae. Biological control by using the larvivorous fishes such as Gambusia is also in practice.

P. vivax is one of four species of malarial parasite that commonly infect humans. It is less virulent than Plasmodium falciparum and seldom fatal. P. vivax is found mainly in Asia, Latin America and in some parts of Africa.

Plasmodium ovale is closely related to P. vivax and causes tertian malaria in humans. It has been reported from Cambodia, India, Thailand and Vietnam, in West Africa, Philippines, eastern Indonesia.

Plasmodium malariae causes ***fevers*** that recur at approximately three-day intervals (a quartan fever), longer than the two-day (tertian) intervals of the other malarial parasites, hence its alternate name ***Quartan malaria***. It is widespread throughout sub-Saharan Africa, much of Southeast Asia, Indonesia, on many of the islands of the western Pacific.

Plasmodium falciparum is the most dangerous of these infections as malignant malaria has the highest rates of complications and mortality.

Genus Toxoplasma

Toxoplasma gondii is a species of parasitic protozoa in the genus Toxoplasma. The definitive host of T. gondii is the cat, but the parasite can be carried by many warm-blooded animals (birds, mammals and humans). ***Toxoplasmosis***, the disease of which T.gondii is the causative agent, is usually self-limiting but can have serious or even fatal effects on a fetus whose mother first contacts the disease during pregnancy or on an immune-compromised human.

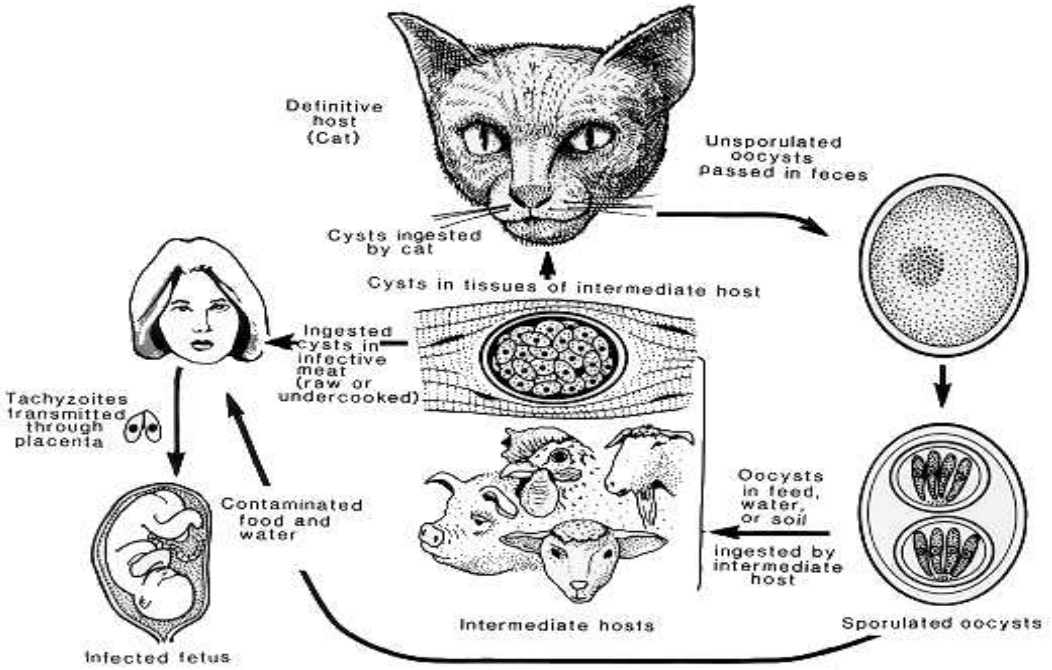
Life-cycle. The life cycle of T.gondii has two phases. The ***sexual*** part of the life cycle (coccidia like) takes place only in members of the ***Felidae*** family (domestic and wild cats), which makes these animals the parasite's ***primary host***.

The ***asexual*** part of the life cycle can take place in any warm-blooded animal, like other mammals (including humans) and birds.

In the intermediate host, the parasite invades cells, forming intracellular endozoites, the slowly replicating form of parasite. They multiply by endopolygony division into 12-32 cells. That number of endosoids inside the cell is named ***tissue cysts*** or ***pseudocysts***. The capsule of

pseudocyst is a thin cellular membrane, which is destroyed as the parasite grows. Endosoids penetrate into the new cells and multiple within these cells again. The parasites get into such organs as liver, spleen, brain, lymphatic nodes, eyes and muscles, mainly affecting brain and muscles. Protecting themselves from host's immune system, endosoids form comparatively thick capsules. These formations are known as ***true cysts***.

Formation of pseudocysts is characteristic for the ***acute period*** of disease – toxoplasmosis. Since they are within cells, the host's immune system does not detect these cysts. Resistance to antibiotics varies, but the cysts are very difficult to eradicate entirely. They are usually efficiently cleared by the host's immune response, although some manage to infect cells and form endosoids, thus maintaining the infection.



When toxoplasmosis is chronic, the congestion of toxoplasms in the cell may reaches 100 and even more. One can often observe the chronic form of disease without typical symptoms. About 10-30% among the population is clinically healthy, but they are carries of toxoplasmosis.

Very dangerous is the transplacental infection, because the immune system of embryo is not mature. The infection may cause embryo's death or birth of a crippled child. When an embryo gets invaded at the second half of pregnancy he will suffer from toxoplasmosis with the typical symptoms: high temperature, rashes, jaundice, swelling, convulsions, and symptoms of ***toxoplasmic encephalitis***. If infection with T.gondii occurs for the first time during pregnancy, the parasite can cross the placenta, leading to ***hydrocephalus*** or

microcephaly, intracranial calcification and chorioretinitis, with the possibility of spontaneous abortion (miscarriage) or intrauterine death.

Tissue cysts are ingested by a cat (e.g., by feeding on an infected mouse). The cysts survive passage through the stomach of the cat and the parasites infect epithelial cells of the small intestine where they undergo sexual reproduction and ***oocyst*** formation. Oocysts are shed with the feces. Animals and humans that ingest oocysts (e.g., by eating unwashed vegetables etc.) or true cysts in improperly cooked meat become infected. The parasite enters macrophages in the intestinal lining and is distributed via the blood stream throughout the body.

T. gondii infections have the ability to change the behavior of humans. The infected people showed different personality traits to uninfected people and that the differences depended on sex. Infected women were more likely to become more outgoing and showed of higher intelligence, while men became aggressive, jealous and suspicious.

Human beings can be infected with toxoplasmosis by the following ways:

- using row meat or consuming insufficiently cocked meat;
- through dirty hands, fruits and vegetables contaminated with oocyst;
- through injured skin of hands, while taking off the animal's skin;
- due to the direct contact with cats;
- trans-placental invasion.

Diagnosis. Revealing toxoplasma in slides which are making from the punctate of lymphatic nodes, cerebro-spinal liquid, endometria's scrub, pieces of placenta, etc.

- Serologic reactions: anty-body tests.
- Intra-skin allergic test with toxoplasmine.

Prevention.Following the hygienic rules, cook meat properly, don't use raw meat, wash fruits and vegetables thoroughly.

- Avoid the contacts with ramble cats and dogs.

Phylum Ciliophora. Class Rimostomata

The members of Ciliophora are of cosmopolitan distribution being found in isolated bodies of fresh water having some decaying organic matter. They are also found in the sewage water, rice fields, in decaying organic matter, some of them are parasites.

The body of animal (ex. Paramecium, Balantidium) is covered with a thin elastic pellicle, which is a double membrane; it maintains the shape of the animal. The oral surface of the body bears oral groove that opens through the cytostome into the cytopharynx. Cillia are present all over the body surface. Endoplasm contains two nuclei (macronucleus that controls metabolic activities and micronucleus – controls reproductive activities), two contractile vacuoles and some food vacuoles.

Ciliophora feed on bacteria, algae, diatoms. Some of them are parasites of other animals. Respiration and excretion occur by general body surface. Reproduction: asexual by binary fissions, and sexual by conjugation.

Balantidium coli is a parasite, that causes the disease ***balantidiasis.*** It is the only member of the ciliate phylum known to be pathogenic to humans. Balantidium coli have two developmental stages: ***a trophozoite stage*** and ***a cyst stage***. In trophozoites, the two nuclei are visible. The ***macronucleus*** is long and sausage-shaped and the spherical ***micronucleus*** is nested next to it, often hidden by the macronucleus. The opening, known as the peristome, at the pointed anterior end leads to the cytostome, or the mouth.

Cysts are smaller than trophozoites and are round and have a tough, heavy cyst wall made of one or two layers. Usually, only the macronucleus and sometimes cilia and contractile vacuoles are visible in the cyst. Living trophozoites and cysts are yellowish or greenish in colour.

B. coli live in the ***caecum*** and ***colon*** of humans, pigs, rats and other mammals. It is not readily transmissible from one species of host to another because it requires a period of time to adjust to the symbiotic flora of the new host. Once it had adapted to a host species, the protozoan can become a serious pathogen, especially in humans. Trophozoites multiply and encyst due to the dehydration of faeces.

Infection occurs when the cysts are ingested, usually through contaminated food or water. Balantidium infection in immune-competent individuals is not unheard of, but it rarely causes a serious disease of the gastrointestinal tract. It can thrive in the gastrointestinal tract as long as there is a balance between the protozoan and host without causing dysenteric symptoms. Infection most likely occurs in people with malnutrition due to the low stomach acidity or people with immune compromised systems.

In acute disease, explosive diarrhea may occur as often as every twenty minutes. Perforation of the colon may also occur in acute infections which can lead to life-threatening

situations. Balantidium causes ulceration of the large intestine which may cause hemorrhage, but usually it causes diarrhea which may become chronic.

Diagnosis: Stool examination. Trophozoites are found in diarrheic stools and cysts in formed stools.

Prevention.Follow the hygienic rules of personal hygiene. Reveal and cure patients. Elimination of flies (flies are mechanical carries of cysts).

Practice.

Assignment 1. Plasmodium.

a). Study the development of malarial parasites and their stages. Make a labeled diagram of Plasmodium's life – cycle. Draw attention at prerythrocytic schizogony, erythrocytic schizogony and beginning of gamogony in man, gamogony and sporogony in mosquito.

b). Copy and complete the table:

Four types of malaria

#	Type of malaria	Pathogen	Duration of cycle in blood stream
1	Benign tertian		
2	Quartian		
3	Subtertian		
4	Ovale tertian		

Assignment 2. Toxoplasma.

Study Toxoplasma on the slides. Draw endozoite of the parasite and label its main structures.

Assignment 3. Balantidium coli and its cysts

Examine cysts and vegetative forms of the parasite under the microscope. Make a diagram of the parasite and its cysts. Label cilia, cytostome, two nuclei, food and contractile vacuoles.

TOPIC 23. TEST OF SUBMODULE 4.

Teaching objectives: Checking the student's knowledge of Medical Protozoology. Practice.

Assignment 1. Revise morphological features of the parasites and their life-cycles by using drawings, pictures, diagrams and slides, texts of books.

Assignment 2. Test.

Submodule 5

TOPICS 24: PHYLUM PLATYHELMINTHES

CLASS TREMATODA

Key concepts:

1. Platyhelmintes in general.
2. The main features of Trematodes.
3. Structure, life-cycle and pathogenesity of the following parasites: Fasciola hepatica, Opisthorchis felineus, Dicrocoelium lanceatum, Paragonimus westermani, Schistosoma haematobium, Schistosoma mansoni.
4. Diagnostics, control and prophylaxis of diseases caused by these parasites.

General characters of the phylum

1. Platyhelminthes have dorso-ventrally compressed bodies. They show bilateral symmetry and the body parts are arranged on either side of central axis.
2. They are triploblastic organisms. They produce embryonic ***mesoderm***, a third germinal layer that contributes to the development of the true muscle tissue.
3. They do not possess a body cavity and the space between the gut and the body wall is filled with ***parenchyma.*** Hence, they are described as ***acoelomates.***
4. They show moderate ***cephalization*** and unidirectional movement associated with the bilateral symmetry.
5. First animals to have organ system organization.
   a. The digestive system (not present in all) has only one opening, the mouth, and the anus is absent. The mouth serves in ingestion and also egestion.
   b. Excretion is performed by specialized cells (protonephridia) called flame cells, that help in maintaining osmotic balance between the animal and its surroundings.
   c. Respiratory and circulatory systems are absent.
   d. Nervous system consists of ***ganglia*** in the cephalic region representing a primitive brain and ***nerve cords*** forming a ladder-like system in some. Sense organs occur in the free-living forms.
   e. They are mostly hermaphrodites and fertilization is internal.
   f. Life history is either simple or complex with one or more intermediate hosts and many types of larval stages (miracidium, sporocyst, redia, cercaria etc.)

6. Platyhelminthes is divided into 3 classes: Turbellaria, Trematoda, and Cestoda. Trematoda and Cestoda are parasitic on other animals.

Class Trematoda

Adult flukes are leaf-shaped flatworms. Prominent oral and ventral suckers help maintain position in situ. Flukes are hermaphroditic except for blood flukes, which are bisexual. The life-cycle includes a snail intermediate host.

Life-cycle is complex with many types of larval forms. The most videly spread parasites of this class are:

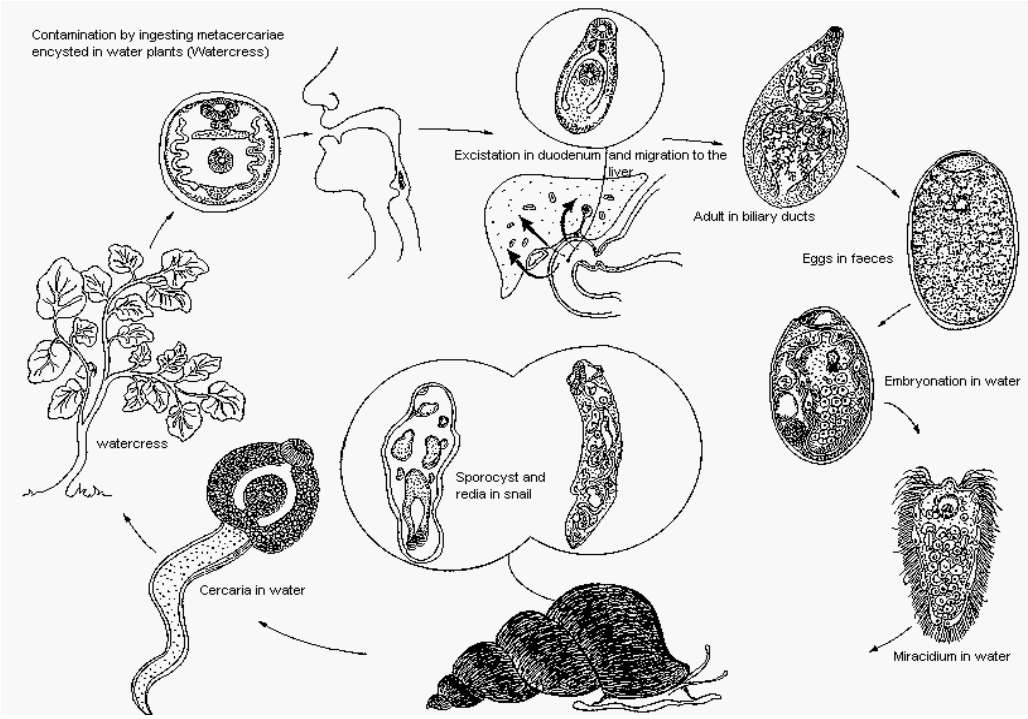
- Fasciola hepatica (liver fluke)
- Opistorchis felineus (cat fluke)
- Paragonium westermani (lung fluke)
- Schistosomes (blood flukes)
- Dicrocoelium lanceatum

Fasciola hepatica*:* also known as the ***liver*** fluke is a parasitic flatworm of the class Trematoda, phylum Platyhelminthes that infects liver of various mammals, including humans. The disease caused by the fluke is called ***fascioliasis*** (also known as fasciolosis). Also cause hepatitis and inflammation.

Structure: body is flattened dorsoventrally, leaf shaped, elongated and oval. Length is 25 to 30 mm, breadth- 4-12 mm. Anterior end with mouth and surrounded by an oral sucker. About 3 to 4 mm of oral sucker is a large ventral sucker (or acetabulum). Both suckers help in attachment. Body is covered by a thick protective cuticle.

Life-cycle.Eggs is fertilized in the oviduct and they pass into the uterus where development starts. Some larval stages are formed during the life history. Liver fluke locates in liver and in human gall-bladder ducts. Its final hosts are grass-eating animals (cattle, pig, and horse) and human being.

Eggs of the parasite pass out from the body of the primary host with faeces. In water, miracidium develops and hatches within 2 weeks. It swims in water and penetrates the soft tissue of the snail Lymnea truncatular (intermediate host). The miracidium drops its ciliated epidermis, loses its sence organs and changes in shape to form a ***sporocyst***. Its germ cells develop into a third type of larva called ***redia larva***, which produces the fourth larval stage, the ***cercaria larva*****.** The cercarias leave the snail and swim in water 2-3 days, and then they lose their tails and get enclosed in a cyst. The encysted cercaria is called a ***metacercaria*****.**



Further development of the parasite takes place only if it is swallowed by the final host. In the stomach of the man the cyst wall is digested by the acidic gastric juice and a young fluke emerges. Before gastric juice can cause any damage to the young fluke, the latter slips into the intestine where acid enzymes are neutralized. It bores through the wall of the intestine to enter the body cavity of the host. After about three days it enters the liver. The young flukes stay in the liver for seven or eight weeks and then they enter the bile duct and bile passages, where they grow and become sexually mature adults.

The effects of liver fluke are referred to as fascioliasis, and include anemia, weight loss, gall bladder and liver inflammation, colitis and mechanical jaundice. If invasion rate is great, liver cirrhosis may occur.

Diagnosis. Liver fluke is diagnosed by yellow-brown eggs in the faeces.

Prevention and control. Elimination of water vegetation

- Snail control
- Safe water supplies
- Proper washing or cooking of water plants before consumption
- Treatment of affected organisms (cattle, humans)

Opistorchis felineus is the agent of opistorchosis.

Morphology. Adult worms are flat, slender leaf-shaped between 10 and 25 mm in length, and two branched testes are located in posterior one third part of the body. Intestine is

shaped as two non-branched tubes. In the middle of the body there is uterus filled with eggs. Eggs are yellow or light brown colour with the operculum on one side.

Life-cycle. The adult worms live in the bile ducts, gall bladder, pancreatic ducts of the final hosts. The important final hosts are human, dogs, cats, pigs.

Embryonated eggs are discharged in the biliary ducts and in the stool. Eggs are ingested by a suitable snail intermediate host. Each egg releases a miracidia, which go through several developmental stages (sporocysts, rediae, and cercaria). The cercariae are released from the snail and after a short period of free-swimming time in water, they come in contact and penetrate the flesh of freshwater fish, where they encyst as metacercariae. Infection of humans occurs by ingestion of undercooked, salted, pickled, or smoked freshwater fish. After ingestion, the metacercariae excyst in the duodenum and ascend the biliary tract. Maturation takes approximately 1 month. The adult flukes (measuring 10 to 25 mm by 3 to 5 mm) reside in small and medium sized biliary ducts. In addition to humans, carnivorous animals can serve as reservoir hosts.

Pathology. The mechanical irritation and toxic metabolites of the parasite cause inflammatory responses in biliary epithelium, obstruction of biliary tract.Cholangitis, pancreatitis, and liver cirrhosis may be induced as the result of heavy and chronic infection.

Diagnosis. Detection of eggs in faeces makes definite diagnosis. Radiological techniques can provide indirect evidences of opistorchosis.

Prevention: Avoiding ingestion of raw fresh-water fish.

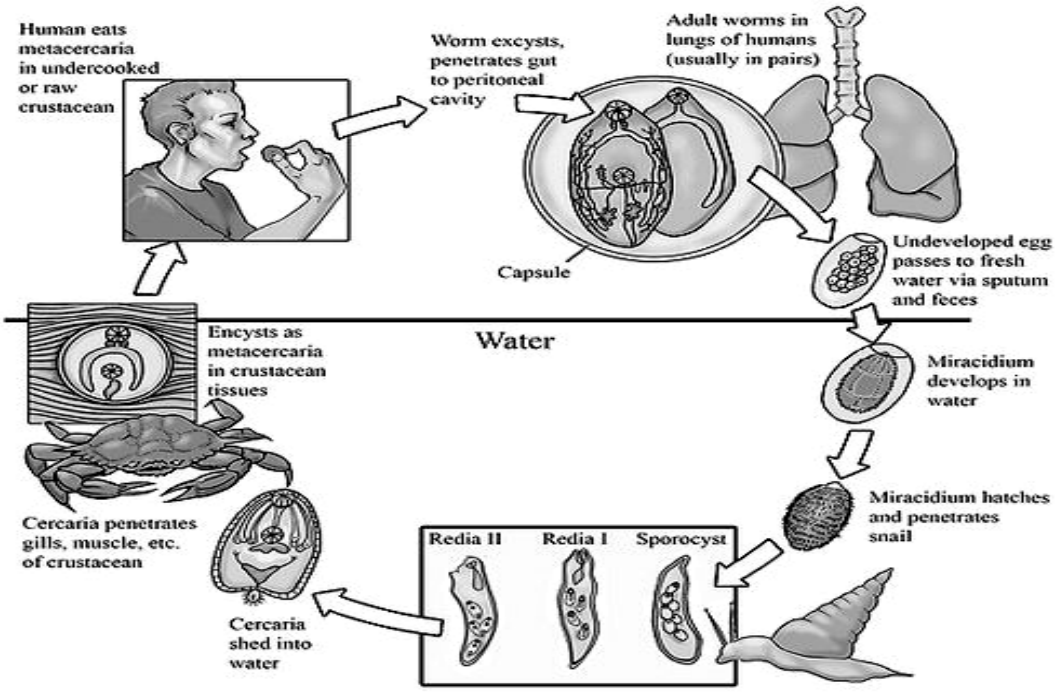
Paragonium westermani (lung fluke) is the agent of paragonimosis.

Morphology: Adult helminthes are grain shaped form about 7.5-12.6 mm in length. Intestine is branched and closed. Two testes are present in the posterior end of the body. Yolk glands are located near the uterus. The eggs are about 50-62 μm in size, golden-greenish colour.

Life-cycle. Paragoniums westermani is a biohelminth that affects lungs, liver, spleen, intestine, muscles, brain, etc. Its life-cycle requires 3 hosts. The definitive hosts are man, dogs, cats, pigs and rodents. Humans is invaded by eating contaminated crabs (Exam the diagram). De-
veloped eggs pass to fresh water via sputum and faeces.Miracidium develops in water,hatches and penetrates snail. Sporocyst, redia and cercaria develop in the snail.Cercaria shed into the

water,penetrates gills,muscles of crustacean and insysts as metacercaria.Human eats metacercaria in undercooked or raw crustacean.

Pathology. Lung-fluke affects the host mechanically and toxically thus weakening immune system. Connective tissue capsules develop around the parasites in the lungs.



Diagnosis of infection is confirmed by the identification of eggs in sputum and in stools. The diagnosis may be improved by serological test.

Prevention: cooking crabs and crayfish properly.

Dicrocoelium lanceatum.

Morphology: the worms are 1 cm long with lanceolate form of the body. They have the intestine with two nonbranched channels in the lateral part of the body and two round testes in the front of the body (the diagnostic sign).It is very common biliary parasite of humans in Europe, Middle East and China.

Life-cycle. Embryonated eggs are shed in the feces. Eggs are ingested by a snail intermediate host. Miracidium, sporocyst, cercariae develop in the snail. Cercariae are released from the snail via respiratory pore in a slim ball. Cercaria becomes metacercaria after being eaten by an ant (second intermediate host). Humans get infected when they accidentally eat the ants.

Clinical features: Most infections are light and asymptomatic. In heavier infections, symptoms may include cholecystitis, liver abscesses and upper abdominal pain.

Diagnosis: Microscopic identification of eggs in the stool or duodenal fluid.

Schistosomes

Schistosomes are atypical trematodes in that the adult stages have two sexes and are located in blood vessels of the definitive host. Most other trematodes are hermaphroditic and are found in the intestinal tract or in organs, such as the liver.

The life cycle of schistosomes includes two hosts: a definitive host (i.e. human) where the parasite undergoes sexual reproduction and a single intermediate snail host where there are

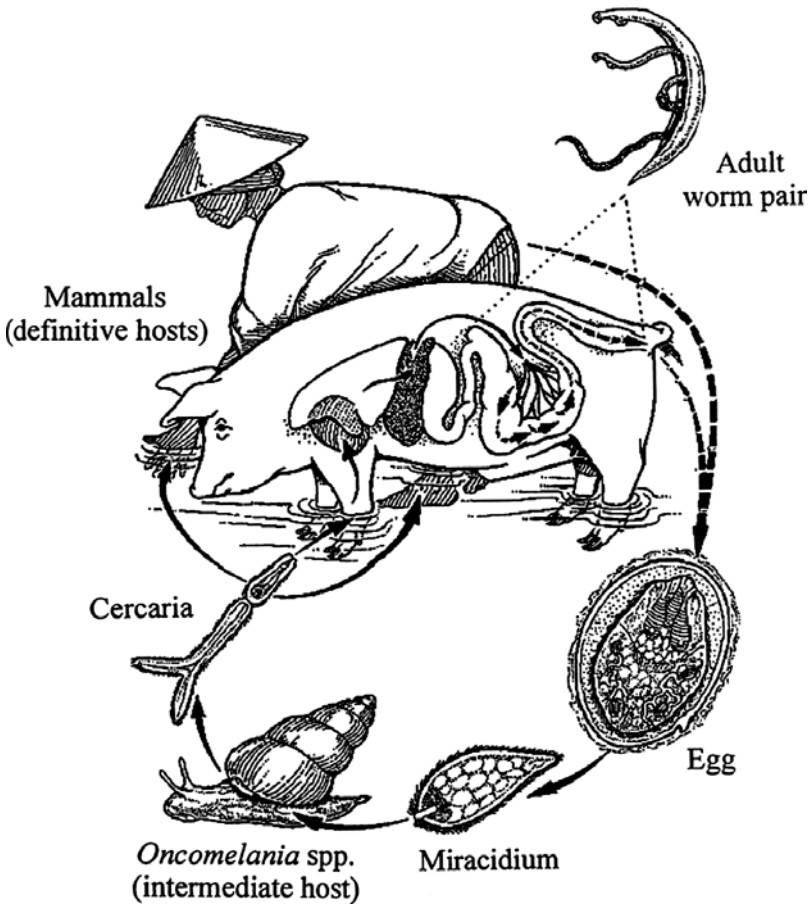
Schistosomiasis is caused by digenetic blood trematodes. The three main species infecting humans are ***Schistosoma haematobium***, ***S. japonicum***, and ***S. mansoni***.

Morphology. Schistosomes are long and slim worms. The males are approximately 1 cm long and is 0,1 cm wide. The female has a cylindrical body, longer and thinner than the male (1,6cm – 2cm long, 0,016 cm-wide).

Geographic distribution: Schistosoma mansoni is found in parts of South America and the Caribbean, Africa, and the Middle East; ***S. haematobium*** in Africa and the Middle East; and ***S. japonicum*** in the Far East.

Life-cycle. The life cycles of these parasides are very similar.After the eggs of the human-dewelling parasite are emitted in the faeces and into the water, the ripe ***miracidia*** hatch out of the eggs. The hatching happens in response to t^0, light and dilution of faeces with water. The miracidium searches for a suitable freshwater snail to act as an intermediate host and penetrates it. Inside the snail the larva undergoes asexual reproduction through a series of stages called sporocysts. After the asexual reproduction stage ***cercaria*** (another free-swimming larva) are generated in large quantities, which then leave the snail and must infect a suitable vertebrate host.

Once the cercaria penetrates the skin of the host (ex. human skin) it loses its tail and becomes a ***schistosomule***. The worms then migrate through the circulation ending at the mesenteric veins where they mate and start laying eggs. The eggs are moved progressively toward the lumen of the intestine (S.mansoni and S.japonicum) and of the bladder and ureters (S.haematobium), and are passed with faeces or urine, respectively.



Pathology: S. mansoni and ***S. japonicum*** are agents of schistosomiasis which include: Katayama fever, portal hypertension, hepatic perisinusoidal egg granulomas, liver fibrosis, liver cirrhosis and ascites. Some eggs may pass the liver and enter lungs, nervous system and other organs where they can adversely affect the health infected individual. Pathology of S. haematobium schistosomiasis includes: hematuria, scarring, calcification, squamous cell carcinoma, and occasional embolic egg granulomas in brain or spinal cord.

Diagnosis. Microscopic identification of eggs in stool or urine is the most practical method for diagnosis. Stool examination should be performed when infection with ***S. mansoni*** or ***S. japonicum*** is suspected, and urine examination should be performed if ***S. haematobium*** is suspected. Eggs can be present in the stool in infections with all ***Schistosoma*** species. Tissue biopsy (rectal biopsy for all species and biopsy of the bladder for ***S. haematobium***) may demonstrate eggs when stool or urine examinations are negative.

Prevention and Control: Human waste should be hygienically disposed of and should never be used for nightsoiling (fertilization of crops with human waste).

Unsanitary conditions should be improved. To avoid infection, individuals should avoid contact with water that is contaminated by human or animal waste. If necessary to enter potentially infected water, cercarial repellents can be applied to the skin before entering the water.

Control against infection of Schistosomes requires multiple efforts consist of:

- education
- eliminating the disease from infected individuals
- controlling the vector
- providing a protective vaccine

Individuals at risk to infection from Schistosomes are farmers who often wade in their irrigation water, fisherman that wade in stereams and lakes, children that play in water, and people who wash clothes in streams.

Practice.

Assignment 1. Life – cycle of the liver fluke

Use charts and study the main stages of the liver fluke development. Make a label diagram and pay attention to the larval forms: miracidium, sporocyst, redia, cercaria, metacercaria (adolescaria)

Assignment 2. Morphology of cat fluke

Use charts and slides and study the structure of the parasite Opisthorchis felineus (cat fluke). Make label diagrams of this parasite.

Assignment3. Morphology of blood flukes

Use charts and slides and study the structure of the parasites Shistosomas. Make label diagrams of these parasites.

Assignment 3. Trematoda's eggs.

Study morphology of Trematoda's eggs on slides and charts. Make label diagrams of the eggs of the following parasites: Opisthorchis felineus, Clonorchis sinensis, Paragonimus westermani, Schistosoma haematobium, Schistosoma mansoni.

TOPIC 25: PLATYHELMINTHES. CLASS CESTODA

Key concepts:

1. The main features of tapeworms. Adaptive features for parasitism.
2. Structure, life-cycle and pathogenecity of the tapeworms: Taenia solium, Taeniarhynchus saginatus, Hymenolepis nana, Echinococcus granulosus, Alveococcus multilocularis, Diphyllobothrium latum
3. Treatment, control and prophylaxis of Taeniosis, Cysticercosis, Taeniarhinchosis, Hymenolepidosis, Echinococcosis, Alveococcosis, Diphyllobothriosis.

General features. .

The Cestoda or tapeworms are highly modified for a parasitic existence. They are all endoparasitic and almost all of them live as adults in the digestive tract of vertebrates and as larvae in the tissues of vertebrates and invertebrates.

– Most cestodes are shaped like a band or ribbon and consist of many segments called ***proglottids.***

– The adults are often several meters in length and consist of a small head or ***scolex***, a ***short neck,*** and a ***strobila*** or long chain of proglotids. The scolex usually bears suckers, or acetabula, and is sometimes armed with hooklets. The neck is the growing region, from the posterior end of which proglottids are budded of. The proglottids increase is size as they are pushed back and various systems or organs develop in them.

– The body is covered with a cuticula and the internal organs lie in a mass of parenchyma cells. Within the cuticle is a layer of ***circular muscle,*** followed by a layer of ***longitudinal muscle***. Deeper in the parenchyma is a ***transverse*** band of muscle.

– Cestodes lack of digestive system and nutriment is absorbed through the surface of the body.

– The nervous system of Cestodes is represented by nerve bundles in the scolex from which begin longitudinal nerve cords.

– The excretory system is represented by the protonephridiums.

– Tapeworms are hermaphroditic. The reproductive organs vary in different groups. Male reproductive system contains ***testes*** which are shaped roundly, ***seminal canals*** opened into a convoluted ***vas deferens*** which passes through a ***cirrus*** surrounded by a ***cirrus sac*.**

Female organs have ***ovary, oviduct,*** a lobular ***vitelline gland*** with vitelline duct leading to the oviduct, ***ootype*** where the egg is shaped, ***uterus*** lying in the middle of the proglottides and ***vagine.***

In some species the eggs are continually being discharged through a uterine pore, but in most species they are stored up in the proglottids which become “gravid” separate from the chain and pass out in the faeces of the host. The eggs in these proglottids, contain embryos that, when fully developed are called ***onchospheres.*** These are able to continue their development only when ingested by a proper host. The onchospheres escape from the egg and burrow through the intestinal wall into the body cavity or vascular space or into certain tissues.

The onchospheres of the lower Cestodes become ***spindle-shaped, hooked procercoids,*** which develop in a second intermediate host into ***wormlike, hookless plerocercoids.***

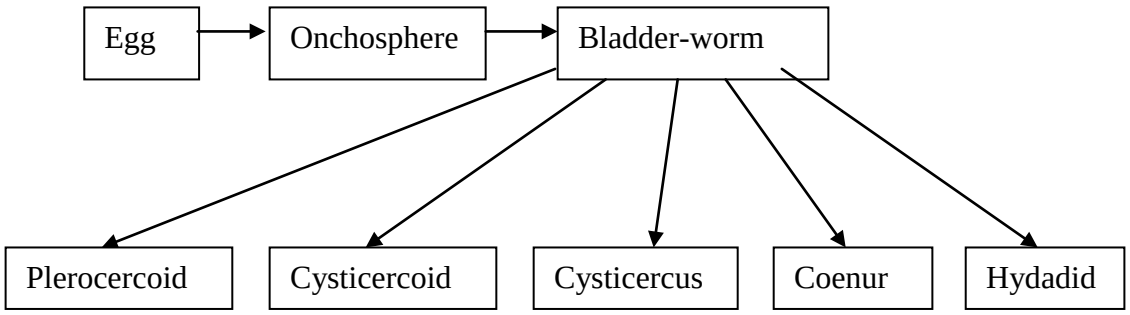
The larve of certain higher Cestodes are called ***cysticercoids;*** they have a ***rudimentary bladder*** and may possess a ***tail.***

The true bladder-worms are:

1. the ***small cysticercus*** which gives rise to one scolex
2. the large ***coenures*** from which many scolices arise
3. the echinococcus or ***hydadid,*** which gives rise to daughter and granddaughter cysts in which many scolices are developed from brood pouches

The bladder-worms are the stage infective to the definitive host and each scolex may give rise to a tapeworm. Tapeworms, when alive, successfully resist the digestive juices of the host, but soon disintegrate when dead.

Stages of the Parasite Life-cycles



Taenia* solium.** Taenia solium is a parasite in the intestine of man in those parts of the wold where pork is eaten raw or without thorough cooking. It is long, flat, and ribbon-like and is of opaque white colour. It is 1,80-3,00 miters long. The anterior end has a knob-like ***scolex, 1mm in diameter with 4 cup-like muscular ***suckers***, and an anterior roud prominence, the ***rostellum,*** having hooks in two circles. The scolex with its suckers and hooks is an organ of attachment to the intestinal wall of the host.

There is a small unsegmented ***neck*** which produces proglottides by transverse fission or budding.

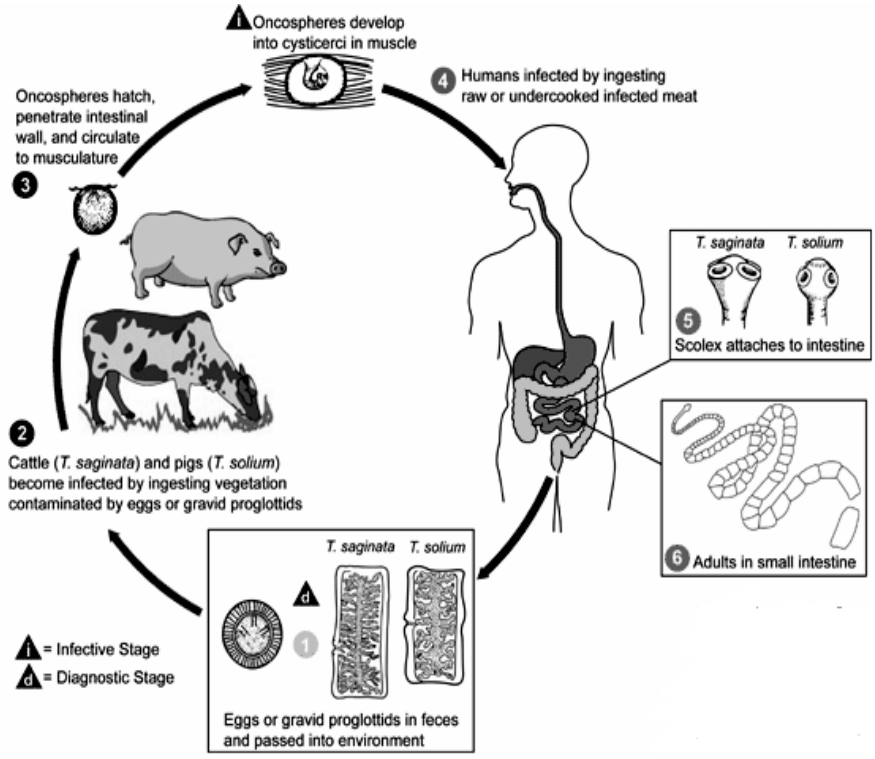
The body or ***strobila*** consists of many segments, ***the proglottides*** (800-900). The ***youngest proglottides*** are nearest the neck. They are broader than long and devoid of sex organs. The middle region has squarish proglottides, and in them, first the male organs develop, next 200 have both male and female organs. These are called ***mature proglottides.***

The oldest proglottides are towards the end, they are longer than broad are filled with fertilized eggs and are called ***gravid*** or ***ripe proglottides.***

The most striking feature is a complete lack of mouth, alimentary canal, and anus in all stages of development. They absorb digested food in the form of nitrogenous substances from the mucous membrane of the host and also absorb carbohydrates and vitamins as liquids from the alimetary canal of the host.

Life-cycle. The gravid proglottides are passed out in groups with the human faeces. They contain six-hooked embryo known as an ***oncosphere.*** The proglottides disintegrate, but the oncospheres remain infective for some time. The gravid proglottides or oncospheres may be eaten by an ***intermediate host,*** which is generally a pig, but the intermediate host may also be a dog, camel, monkey or even man.

In the stomach of the pig, the egg shells are digested and hexacanth is released. It bores through the intestine and enters blood vessels and passes through the heart and finally comes to lie in the muscles in any part of the body. In the muscles the hexacanths lose their hooks, increase in size encysted and become bladder worms. The bladder worm of T.solium is named Cysticercus. The cysticercus (plural-cysticerci) is oval, whitish, and about 6 to28 mm long. Pork containing these cysticerci is called “measly”, because cysticerci appear as measles.



A cysticercus has a bladder wall which invaginates as a hollow knob. Inside the invagination, suckers and hooks are formed and then it is called ***a proscolex***.

If insufficiently cooked pork, containing cysticerci, is eaten by man, ***the final host***, the bladder is digested in the stomach and the proscolex gets evaginated or turned inside out, so that the suckers and rostellum come to lie on the outer surface, thus a scolex and a small neck are formed. The scolex anchors itself to the wall of the intestine and the neck buds off a chain of proglottides to from a tapeworm which becomes an adult in two to three months.

In man, infection by larval stage is more common than by the adult tapeworm, in whom self-infection can take place with eggs through contaminated hands and by gravid proglottides being pushed into the stomach by reverse peristalsis, where development starts (in the case of cysticercosis).

Diagnosis: Helminthoscopy-finding proglottides, scolex in the faeces of a sick person or ovoscopy finding onchospheres in the faeces. In the case of cysticercosis serological reactions should be done.

Control and prevention: reveal and dehelminthise the invaded individuals

- prevent the pollution of environment with pig's and human faeces
- perform sanitary examinations of meat at meat factories, markets.

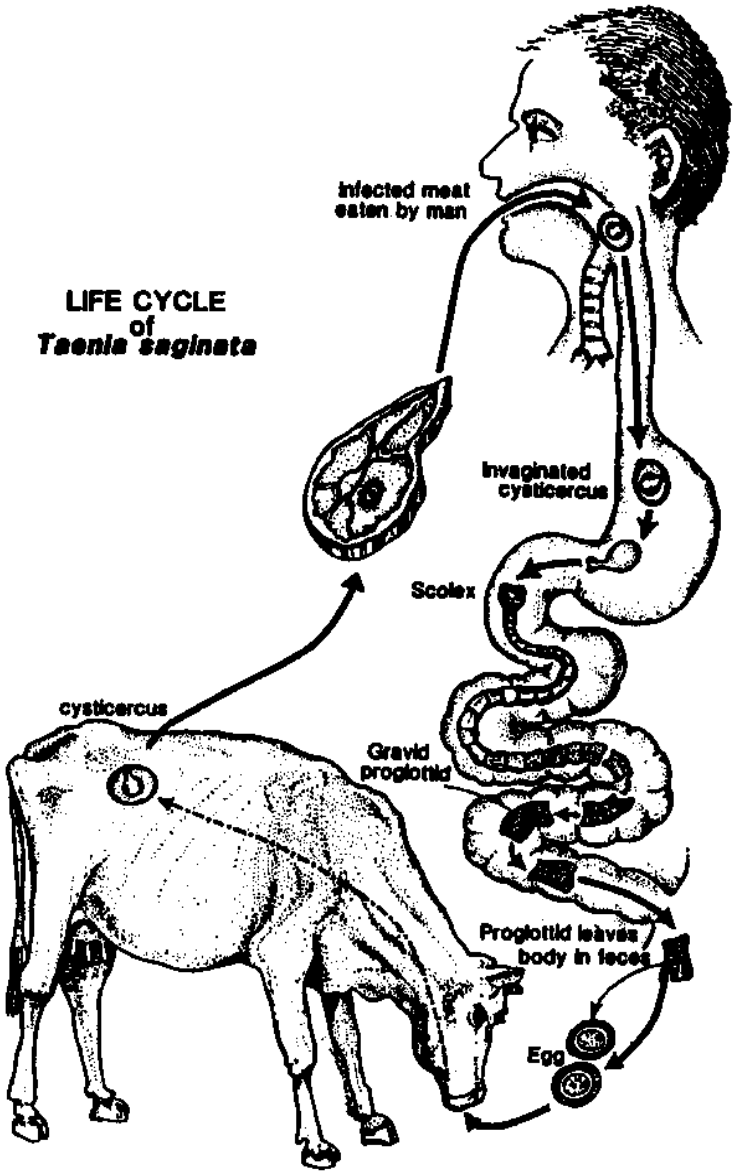
Taeniarhychus saginata, the beef tapeworm of human. It's a cosmopolitan in distribution. It has a length of 4 go 6 metres. The scolex has four large cone-shaped suckers, but has no rostellum and hooks. The average worm has over a thousand proglottides which are larger than those of T.solium. ***Ovary*** has ***two lobes*** instead of ***three like in T.solium*****.**

The gravid proglottides are passed out singly and are very active. The uterus in gravid proglottides has 16-20 lateral branches on each side. The onchospheres of T.saginata are not different from the ones of T.solium neither in size no in shape. The life-history is like that of T.solium. The intermediate hosts are cows and buffaloes, and cystecerci are most abundant in the muscles of jaws, tongue, and heart.

Pathogenesis, diagnosis and prevention. Humans get infected while eating insufficiently cooked flesh of cattle with cysticerci. After getting into small intestine the parasite reaches maturity within 4 months. It causes dysfunction of the digestive system, anaemia, general weakness, loss of weight and appetite.

Microscopic examination is usually made by identifying proglottid segments, or characteristic eggs in the faeces.

The preventive measures include: revealing and dehelminthising sick individuals; performing veterinary control at markets, shops, factories, cooking meat properly (cysticerci perisch while being boiled for 2 hours).

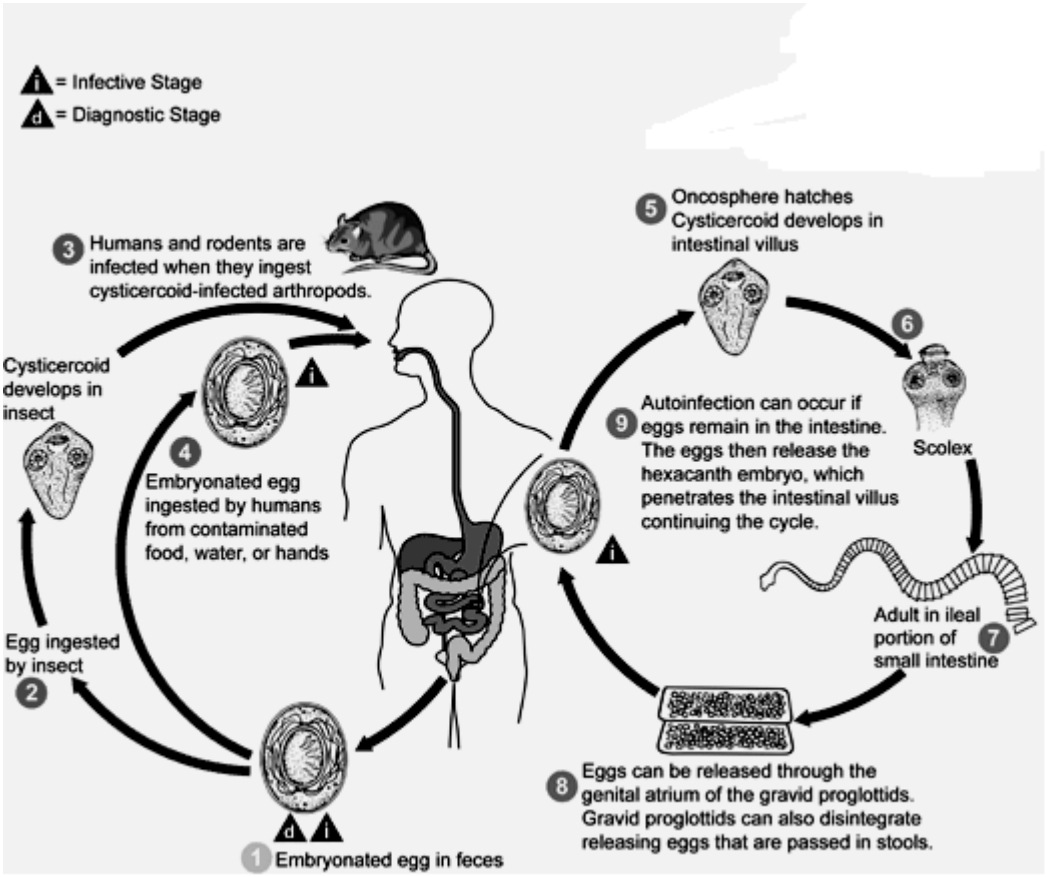


<u>Hymenolepis Nana (Dwarf tapeworm).</u>

Morphology. A tapeworm consists of scolex, neck and segments, which form strobile. Scolex has 4 suckers and rows of hooks, neck is long and thin. Hermaphrodic segments contain 3 rounded seminifers, lobed ovary and numerous yolk glands. New proglottids are continuously differentiated near the anterior end in a process called strobilation. Each segment moves toward the posterior end as a new one takes its place and, during the process, becomes sexually mature. The proglottid can copulate with itself, with others in the strobila, or with those in other worms. When the segment reaches the end of its strobila, it disintegrates on route, releasing eggs in a process called ***apolysis.***

Eggs of dwarf tapeworm are oval shaped, transparent and colourless. Each egg contains onchosphere and filaments inside which are thread-like bodies located around the onchosphere. Phynn is ***cysticercoidus.***

Life-cycle, diagnosis and prevention. Hymenolepis nana is a biohelminth. Human being is a primary intermediate and a final host of it. Humans and other animals become infected when they intentionally or unintentionally eat material contaminated by insects. In an infected person, it is possible for the worm's entire life-cycle to be completed in the bowel, so infection can persist for years if left untreated. H.nana causes ***hymenolepiasis.***



In addition to being spread by insects, the disease can be spread directly ***from person to person by eggs in faeces.*** When this happens, H.nana ***oncosphere*** larvae encysted in the intestinal wall and develop into cysticercoids and then adults. Autoreinvasion also occurs.

H. nana infections can grow worse over time because, its eggs can hatch and develop without ever leaving the definitive host.

Symptoms of ***hemenolepiasis*** include abdominal pain, diarrhea, vomiting, headache, weight loss, fatigue, allergic reactions.

Diagnosis is made by identifying proglottid segments, or characteristic eggs in the faeces (ovoscopy). Examine fresh faeces only, because eggs are quickly destroyed in the environment.

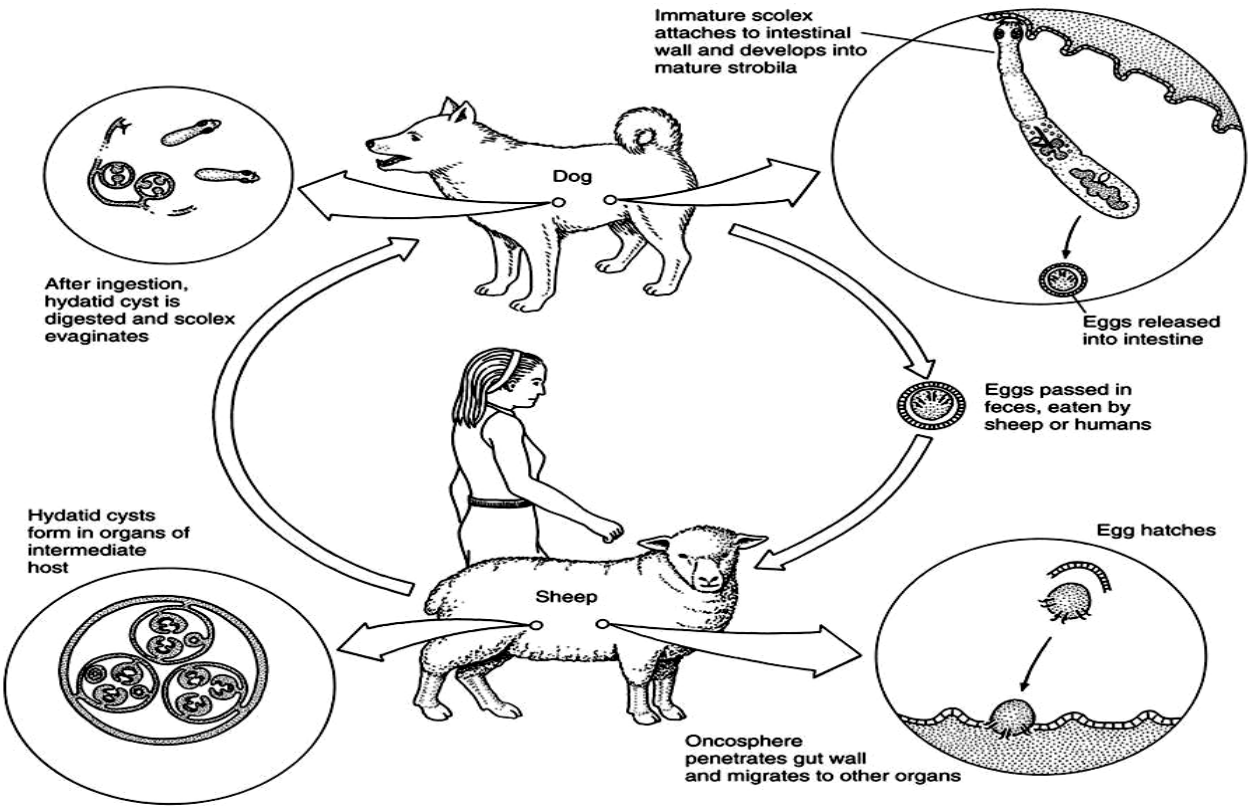
Prevention*:* follow the hygienic rules (wash hands, vegetables and fruits before eating, boil water before drinking)

- reveal and treat the sick persons
- insect elimination.

Echinococcus granulosus also called the ***Hydatid worm*** is a parasite of the small intestine of canids as an adult. Its larval stages can be found in the intermeadiate hosts such as livestock and human, where it causes ***hydatid disease.***

Morphology and life-cycle. The adult tapeworm is about 5 mm long and has scolex (head) with four suckers and a rostellum with hooks. Its body consists of three proglottids (segments) when intact.

In canids, E.granulosus causes a typical tapeworm infection, and produces eggs that are passed with the dog's faeces. In the intermediate host, eggs hatch into oncosphere larvae through the blood and form hydatid cysts in the host's tissues. These cysts can grow to be the size of a softball or basketball and may contain several smaller «balloons» inside the main cyst.



If the outer cyst ruptures, new cysts can form at a different location in the body. Each smaller section contains several juvenile worms, and dogs may eat millions of them, resulting in very heavy infections. Hydatid cysts occur in organs like the liver, brain and lungs. Infected animals make easier prey for canids.

Diagnosis and prevention: E. granulosus is a pathogen of echinococcosis. Symptoms can include liver enlargement, hooklets in the sputum and possible anaphylactic shock when the immune system reacts to ruptured cysts. The cysts can be determined by ultrasound or immunoelectrophoresis.

Hydatid disease (echinococcosis) is treated with surgery, taking special care to leave the cyst intact so new cysts do not form.

The best way to avoid human infection is to avoid ingesting food or other substances contaminated with dog feaces. The best way to keep dogs from being infected is to prevent them from eating infected offal.

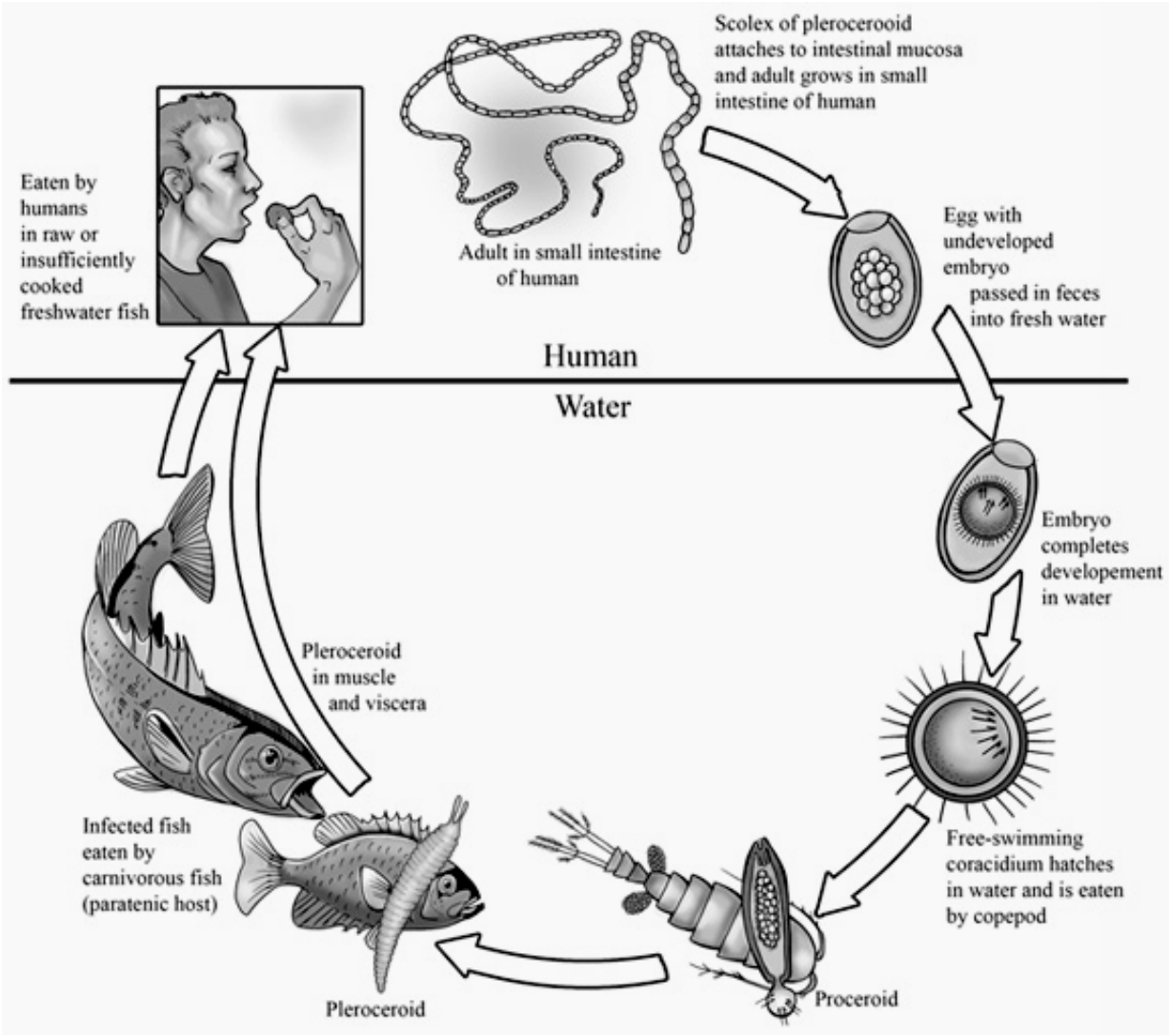
Diphyllobothrium latum (Broad or Fish tapeworm). The adult is an agent of Diphyllobothriasis.

Morphology and life-cycle. The adult worm is composed of three fairly distinct morphological segments: the scolex, the neck and the lower body. The scolex is equipped with a slitlike grove (botrium) for attachment to the intestine. The scolex attaches to the neck, or proliferative region. From the neck, grow many proglottid segments which contain the reproductive organs of the worm. D. latum is the longest tapeworm in humans, averaging ten meters long (hence the name broad tapeworm).

Adult tapeworms may infect humans, canids, felines. Broad tapeworm is a biohelminth. It has three hosts in its life-cycle: one definitive host- human being and two intermediate hosts: the first intermediate host is a ***copepod;*** the second one is ***freshwater fish***.Immature eggs are passed in faeces of the mammal host (the ***definitive host***, where the worms reproduce). Eggs are wide and shaped as ovals. One egg pole contains a cover, another small hillok. Its phynn is worm-shaped, 1-5cm in length, named plerocercoid. Eggs require water for further development. In water eggs hatch into ***coracidium larva.*** After ingestion by a suitable freshwater ***crustacean*** such as a ***copepod*** (the first intermediate host), the coracidia develop into procercoid larva. Following ingestion of the copepod by a suitable ***second intermediate host*** typically a minnow or other small freshwater fish, the procercoid larvae are released from the crustacean and migrate into the fish’s flesh, where they develop into a

plerocercoid larvae. The plerocercoid larvae are the infective stage for the definitive host (including humans). After ingestion of the infected fish, the plerocercoids develop into mature adult tapeworms which will reside in the ***small intestine.***

The adults attach to the intestinal mucosa by means of the two bilateral grooves (bothria) of their scolex. The adults can reach more than 10m in length with more than 3.000 proglottids. One or several of the tape-like proglottid segments regularly detach from the main body of the worm and release immature eggs in fresh water to the start the cycle over again. The incubation period in humans, after which eggs begin to appear in the faeces is typically 4-6 weeks, but can vary from as short as 2 weeks to as long as 2 years. The tapeworm can live up to 20 years.



Pathogenesis, diagnosis and prevention*.** Symptoms of ***<u>diphyllobothriasis</u> are generally mild, and can include diarrhea, abdominal pain, vomiting, weight loss, fatigue, constipation and discomfort. Approximately four out of the five cases are asymptomatic and may go many years without being detected. This leads to severe vitamin B_{12} deficiency due to the parasite

absorbing 80% or more of the host's B_{12} intake and anemia.

Diagnosis is usually made by identifying proglottids or characteristic eggs in the faeces.

People at high risk for infection have been those who regularly consume raw fish, including fishemen and women preparing and tasting foods that contain raw fish.

The most viable interventions include:

- prevention of water contamination both by raising public awareness of the dangers of defecating in recreational bodies of water and by implementation of basic sanitation measures;
- screening and successful treatment of people infected with the parasite;
- prevention of infection of humans via consumption of raw, infected fish.

Practice

Assignment 1. Morphology of parasites:

1) Taenia saginata.Use constant slides of Taenia saginata and examine: scolex, mature and gravid proglottides. Pay attention that scolex has four large suckers but has no rostellum and hooks. The ovary consists of 2 lobes only and the number of womb's branches in gravid segment is 17 – 35 on each size. Draw them and label sucking organs, lobes of ovary and number of womb's branches.

2) Taenia solium.Use charts and diagrams and study the structure of the parasite. Examine slides of mature and gravid proglottides of Taenia solium. Draw and label:scolex with 4 cup – like muscular suckers; the rostellum with hooks in two circles; reproductive organs in mature proglottid, paying attention to a single ovary with two lobes jointed by a bridge; uterus with 7 to 10 lateral branches on each side, gets filled with eggs in gravid proglottid.

3) Hymenolepis nana: Use slides and charts and study the structure of Hymenolepis nana. Draw and label: scolex, suckers, proboscis with hooks, neck and gravid proglottid with uterus.

4) Diphyllobothrium latum Use slides and charts and study the structure of Diphyllobothrium latum. scolex with suckers, hooks or botriums, mature segments with reproductive organs (testis, vas deferens, cirrus, ovary, vitelline glands, uterus and ootype), gravid segments with uterus, filled with eggs.

Assignment 2. Life – cycle of Cestodes.

Use charts and study the main stages of the tapeworm's life – cycles. Make a label diagram and pay attention to the types of larval forms.

TOPIC 26: PHYLUM NEMATHELMINTHES. CLASS NEMATODA I

Key concepts:

1. Nematodes in general.
2. Morphology, life cycle, pathogenecity of the parasites: Ascaris, Enterobius vermicularis, Ancylostoma duodenale, Trichocephalus trichiurus.

The Nematodes are called wire-worms or roundworms. They are found free living in fresh and marine waters and the soil; they are also parasite of animals and plants.

General characters of the phylum

- They are triploblastic animals with the bilateral symmetry
- Body is long, cylindrical and does not show segmentation
- Body is covered by a transparent tough, collagenous protective cuticle
- Body wall contains ***longitudinal muscles*** only.
- Body cavity is a pseudocoel. Mesoderm lines the body wall only and is absent in the wall of the gut. Since the body cavity is not entirely enclosed by mesoderm, the body cavity is not considered as a true coelom. It is a pseudocoelom; it is fluid filled cavity which provides a ***hydrostatic skeleton*** to the organism. This fluid distributes food and collects wastes.

Nematodes have some systems. There are: digestive, nervous, excretory, and reproductive and sense organs. Alimentary canal is a simple, straight tube with a mouth at the anterior end and anus at the posterior end. Digestive system is divided into three parts: ***fore gut*** (begins with the mouth→pharynx→oesophagus), ***mid gut*** and ***hind gut*** (includes rectum with rectal glands).

There are no ***respiratory organs,*** but parasites carry on anaerobic respiration and obtain their energy by the breakdown of glycogen into CO_2, fatty acids, and the energy.

Nervous system consists of a circum-enteric nerve ring with ganglia and nerves extending anteriorly and posteriorly. Sense organs like ***amphids*** (chemoreceptors of the anterior region of the body) and ***phasmids*** (glandulosensory structures in the posterior region of the body) occur.

Nematodes have no blood-vascular system. Excretory system is formed of ***canals*** and ***gland-like structures*** (renette gland). The two longitudinal canals are joined by a much branched transverse canal from which starts a short common excretory canal or terminal duct to open by excretory pore just behind the lips.

Sexes are separate and nematodes exhibit sexual dimorphism. Males are generally smaller and they usually have a curved posterior end. They have a cloacal aperture and one or two ***copulatory spicules or penial setae.*** Females are longer and the genital pore is separate from the anus.

Male organs are: a single long, thread-like, coiled ***testis,*** which pases into a ***vas deferens.*** The vas deferens joins wide ***seminal vesicle*** which a load into a muscular ejaculatory duct opens into cloaca.

Female's organs are double: two long thread-like coiled ***ovaries*** are continued into ***oviducts*** which lead into broad and muscular ***uteri.*** The two uteri unite and open into a short muscular vagina which opens by a transverse ***gonopore or vulva.***

Fertilization is internal and eggs are laid in large numbers. A majority of them are ***oviparous*** (e.g. Ascaris) but a few are ovoviviparous (e.g. Wuchereria). Growth into adult forms involves four moultings of the cuticle.

One of the world-wide parasites chiefly of man but also in cats, pigs and cattle is Ascaris. It's the most common human helminth, with worldwide distribution. It's most common in tropical and subtropical regions, and areas with inadequate sanitation.

Ascaris lumbricoides

Morphology. Ascaris are largesized, the female is 20 to 40cm long but the male is smaller being 15 to 30 cm. The cylindrical body has four longitudinal ***epidermal chords*** visible externally.

The triangular mouth is bounded by three lips. Behind the lips there is an excretory pore ventrally. Near the posterior end is a transverse anus.

Life-cycle. The fertilization occurs in the uterus. The fertilized egg is ovoid and has three layers. They are laid by female ascaris in the small intestine of the host and pass out with the faeces. One female may lie from 15.000 to 200.000 eggs in a day.

Eggs fall on the ground and can remain alive for months in moist soil but drying kills them. In order to develop they require ***oxygen,*** some ***moisture*** and a temperature lower than that of the human body. They also require a period of incubation outside the human body. Segmentation starts in the soil and ***larvae*** or ***first stage juveniles*** are formed within the shell in about 9 days. The juvenile's I-stage continues to grow within the eggs moult to produce the II-stage juveniles. In this stage they are infective and if they are swallowed by man accidentally with mud, water or vegetables, various layers of the egg are dissolved away by

the enzymes in the ***stomach*** of the host. Free II-stage juveniles reach the ***small intestine;*** they do not develop further in the intestine but go on a typical wandering tour of about 25 days. First the freed juveniles bore through the intestinal wall and enter the mesenteric circulation and pass through the hepatic portal vein to enter the ***liver,*** from where they enter to the ***heart.*** From here they are carried into the ***lungs.*** In the lungs the juveniles rupture the capillaries and enter the ***alveolar space*** where they line for the second time forming III-stage juveniles. From the alveoli of the lungs the IV stage juveniles make their way through the ***bronchioles and bronchus*** into the ***trachea*** and then to the ***throat,*** from where they are swallowed into the oesophagus and reach the small intestine for the second time. During this 24 day tour, the juveniles have grown about ten times and are 2 to 3 mm long. In the intestine the final molting takes place and they grow into adult organisms.

Parasitic effects. Ascaris may cause abdominal discomforts and colic pains.

- They may block the intestine and appendix.
- They may enter the bile or pancreatic ducts and interfere with digestion or they may injure the intestine and cause peritonitis.
- They produce toxins which irritate the mucous membrane of the gut or prevent digestion of proteins by the host by destroying trypsin.
- Their juveniles cause hemorrhage in the lungs which results in pneumonia.

Diagnosis and prevention: Microscopic identification of eggs in the stool is the most common method for diagnosing intestinal ascariasis.

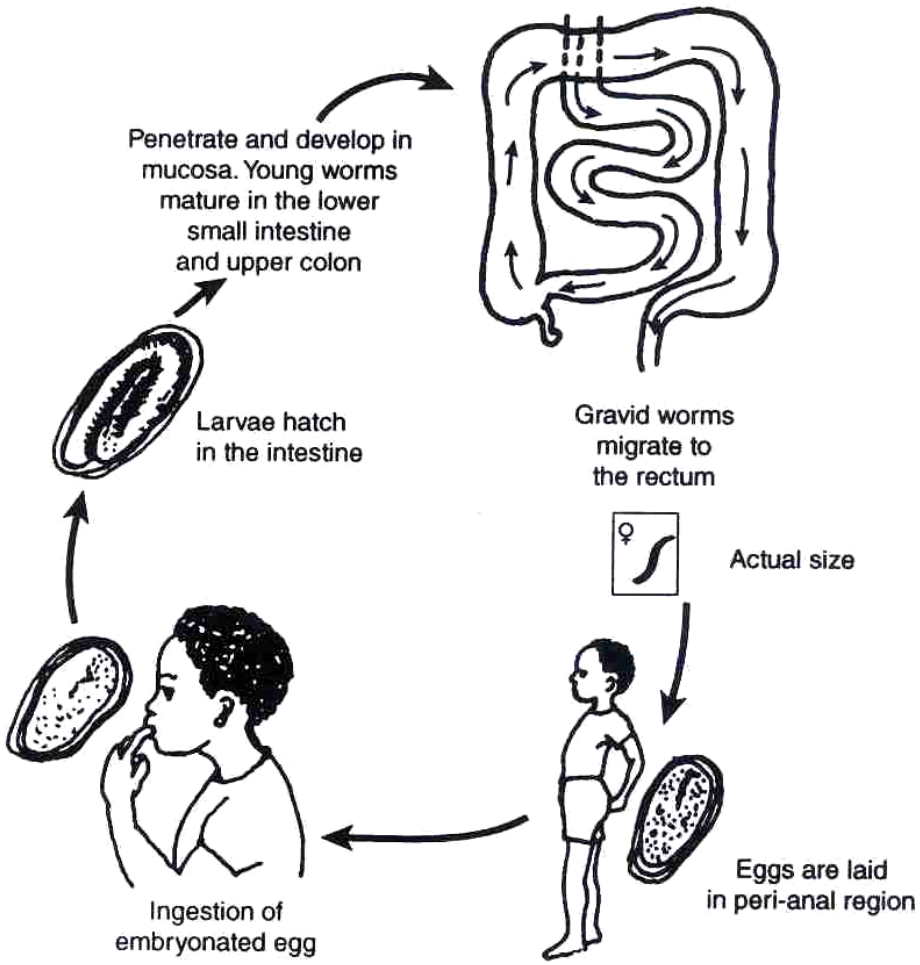
Larvae can be identified in sputum or gastric aspirate during the pulmonary migration phase (examine formalin-fixed organisms for morphology). Adult worms are occasionally passed in the stool or through the mouth or nose and are recognizable by their macroscopic characteristics.

Personal cleanliness and thoroughly washed and properly cooked foods are the main preventive mesures.

Enterobius vermicularis.

Morphology and life-cycle. Pinworm is a cosmopolitan parasite with particularly high prevalence in countries with a temperate climate. The parasites affect children. Prevalence in children in certain communities has been found to be as high as 61% in India, 50% in England, 39% in Thailand, 37% in Sweden, and 29% in Denmark.

Adults are white, thin worms. Males are 0,2 mm thick and 2-5 mm long whereas females are 0,5 mm thick and 8-13 mm long. Females also posses a long, pin-shaped posterior end. Life expectancy for males is 7 weeks whereas females live 5-13 weeks. The males usually die after the pinworms have mated in the last part of the small intestine, ileum. Females reach fertility within four weeks. They dwell primarily in the ***caecum*** of the large intestine, from where the gravid females migrate at night to lay up to 15.000 eggs on the perineum (perianal region). Pinworm eggs are flattened asymmetrically on one side, ovoid, approximately 55 mm× 25 mm in size and embryonate in six hours. The eggs get stuck on skin, underwear or bedding and become infective within a few hours. Eggs survive up to three weeks on clothing, sheets or other objects. After the female has laid eggs it dies. Pinworm infection usually occurs via ingestion of infections eggs by direct anus-to-mouth transfer by fingers. This is facilitated by the perianal itch induced by the presence of pinworm eggs in the perianal folds, and commonly occurs as a result of nail biting, poor hygiene, or inadequate hand-washing.



Retroinfection is also possible, where some of the pinworm larvae which hatch on the anus return to the gastrointestinal tract of the original host, leading to a very high parasitic load as well as ensuring continued infestation.

However, the transfer can also occur by touching contaminated surfaces, such as clothing, bed linen and bathroom fixtures followed by ingestion.

Pinworm infections are easily spread among young children with the habits of nail biting and poor hygiene. Infected children can easily spread the infection to other family members.

Enterobius vermicularis does not need an intermediate host to complete its life-cycle.

Pathogenecity. Pinworm infection is usually benign, and 1/3 of those infected are asymptomatic. The most common clinical sign of pinworm infection is perianal itching, and the itching is usually the most severe at night. Secondary bacterial infection is caused by penetration bacteria throght the scratching. Secondary symptoms, which are due to disturbed sleep caused by pruritis, include anorexia and irritability.

Diagnosis and prevention: Microscopic identification of eggs collected in the perianal area is the method of choice for diagnosing enterobiasis. This must be done in the morning, before defecation and washing, by pressing transparent adhesive tape ("Scotch test", cellulose-tape slide test) on the perianal skin and then examining the tape placed on a slide. Alternatively, anal scrubs (a paddle coated with adhesive material) can also be used. Eggs can also be found, but less frequently, in the stool, and occasionally are encountered in the urine or vaginal smears. Adult worms are also diagnostic, when found in the perianal area, or during and-rectal or vaginal examinations.

Enterobius vermicularis is a pathogen of ***enterobiasis***. To prevent new infections:

– Always keep fingers out of your mouth and nose. Keep fingernails short and do not bite your nails.

– Wash your hands after using the toilet and before eating or preparing food.

– Change clothing, towels, and sheets frequently and wash them in hot water, especially during and after treatment.

– If you have pets, keep them clean, to. The human pinworm does not infect other animals but pets can carry eggs in their fur.

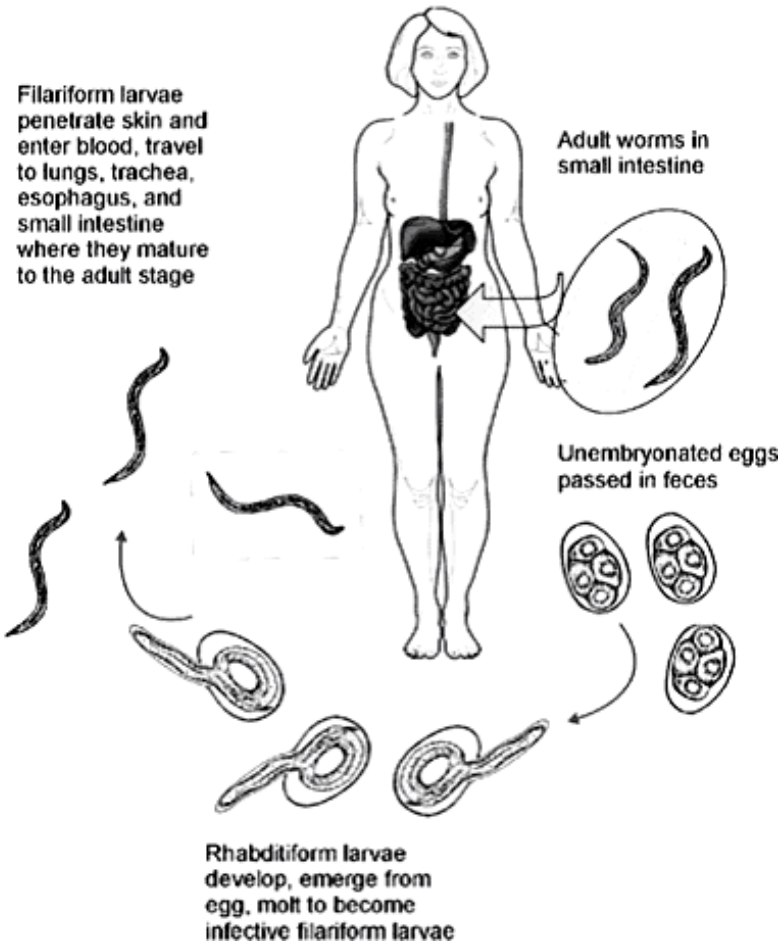
Ancylostoma duodenale

Ancylostoma duodenale is abundant throughout the world, including the following

countries: Southern Europe, North Africa, India, China, Southeast Asia, some areas in the US, Carribban, and South America.

Morphology. It has ***two ventral plates*** at the anterior margin of the buccal capsule. Each of them has ***two large teeth*** that are fused at their bases. A pair of small teeth can be found in the depths of the buccal capsule. Males are 8 mm to 11 mm long with a copulatory bursa at the posterior end. Females are 10 mm to 13 mm long. Females can lay 10.000 to 30.000 eggs per day. Their life span is one year.

It is a parasitic nematode worm, which together with ***Necator americanus*** are referred to as a"hookworms".



Development and life-cycle. It lives in the small intestine of host such as humans, cats and dogs. The infective stage is a ***filariform larva***. It penetrates the intact skin and enters the blood circulation. Then it is carried to the lungs, coughed up and swallowed back to the small intestine. The larva later matures into adult in the small intestine and female worms lay eggs. The eggs are released into the faeces and resided on soil. Enbryonated eggs on soil will hatch into juvenile I stage (rhabditiform or noninfective stage) and mature into filariform larvae. The filariform larvae can then penetrate another exposed skin and begin a new cycle of human infection.

Symptoms and diagnosis.Light infection causes abdominal pain, loss of appetite and geophagy. Heavy infection causes severe protein deficiency or iron deficiency anemia.

Diagnosis is made by identifying eggs of Ancylostoma in the faeces. The eggs of Ancylostoma duodenale and Necator americanus cannot be distinguished. Larvae cannot be found in the stool specimens unless it is left at ambient temperature for a day or more.

Prevention and Control

– Education, improved sanitation and controlled disposal of human faeces are important
– Wearing shoes in endemic areas can reduce the prevalence of infection.

Trichocephalus trichiurus is agent of trichocephalosis.

Morphology. Mature male has 3-4,5 cm long, female – 3-5 cm. The diameter of an cranial end of helminth is 0,16-0,18 mm. It makes 2/3 of the whole helminth length. It has no oesophagus. Caudal end of helminth's body is thick, contains intestine and sexual organs. The thin cranial part of this helminth deeply penetrates into the mucous coat of large intestine. The helminth is a facultative haemathophagus, consumes blood and tissue liquid.

Eggs of trichocephalus are of yellowish and brown colour, shaped as a lemon (or a barrel) with two colorless transparent corks on the poles. The egg's coat is thick, multilayered and smooth.

Life-cycle. The parasite locates in the caecum, appendix, upper parts of the colon, rarely in the lower part of small intestine.

Trichocephalus (or whip-worm) is a geogelminth. Its eggs pass out with the faeces into environment. In the soil eggs develop under the temperature 15-40^{0}C, humidity and oxygen. Lavae are formed within the eggs. Humans get infected by swallowing up the eggs of the parasite. Eggs hatch into larvae which penetrate into the villi of small intestine. 3-10 days later larvae leave villi and descend to the lumen of the large intestine. One week later whip-worms reach maturity. They live for 3-5 years.

Diagnosis, patogenesis and prevention. Diagnosis is made by identifying eggs of whip-worm Parasites cause the inflammation of large intestine, appendicitis, general intoxication. Secondary bacterial infections may be also occurring.

Clean fruits and vegetables, follow the hygienic rules.

Practice.

Assignment 1. Ascaris lumbricoides :

- Use charts, wet preparations and study the morphology of Ascaris. Draw male and female and label their morphological differences.
- Use charts, study and draw the life – cycle of Ascaris. Label its main parts.
- Use slides and microscope to examine eggs of Ascaris. Draw egg, label envelop of the egg and embryo inside it. Pay attention to the egg's size and color.

Assignment 2. Enterobius vermicularis .

Use charts, wet preparations and study the morphology of parasite. Draw and label: oesophagus with bulbus, intestine, womb with eggs, anterior and posterior parts of the body.

Assignment 3. Trichocephalus trichiurus

Use charts, wet preparations and study the morphology of parasite. Draw and label: oesophagus with bulbus, intestine, womb with eggs, anterior and posterior parts of the body.

Assignment 4. Ancylostoma duodenale and Necator americanus.

Use charts and study the morphology of helminthes. Draw these helminthes and label males and females.

TOPIC 27: PHYLUM NEMATHELMINTHES. THE LABORATORY DIAGNOSTIC OF HELMINTHES

Key concepts:

1. Morphology, life-cycle, pathogenecity of the parasites: Trichinella spiralis, Dracunculus medinensis, Strongyloides stercoralis, Wuchereria buncrofti, Loa- Loa, Onchocerca volvulus.
2. Diagnostics of diseases, caused by these parasites. Prevention.
3. The main methods of the laboratory diagnostics of helminthosis.

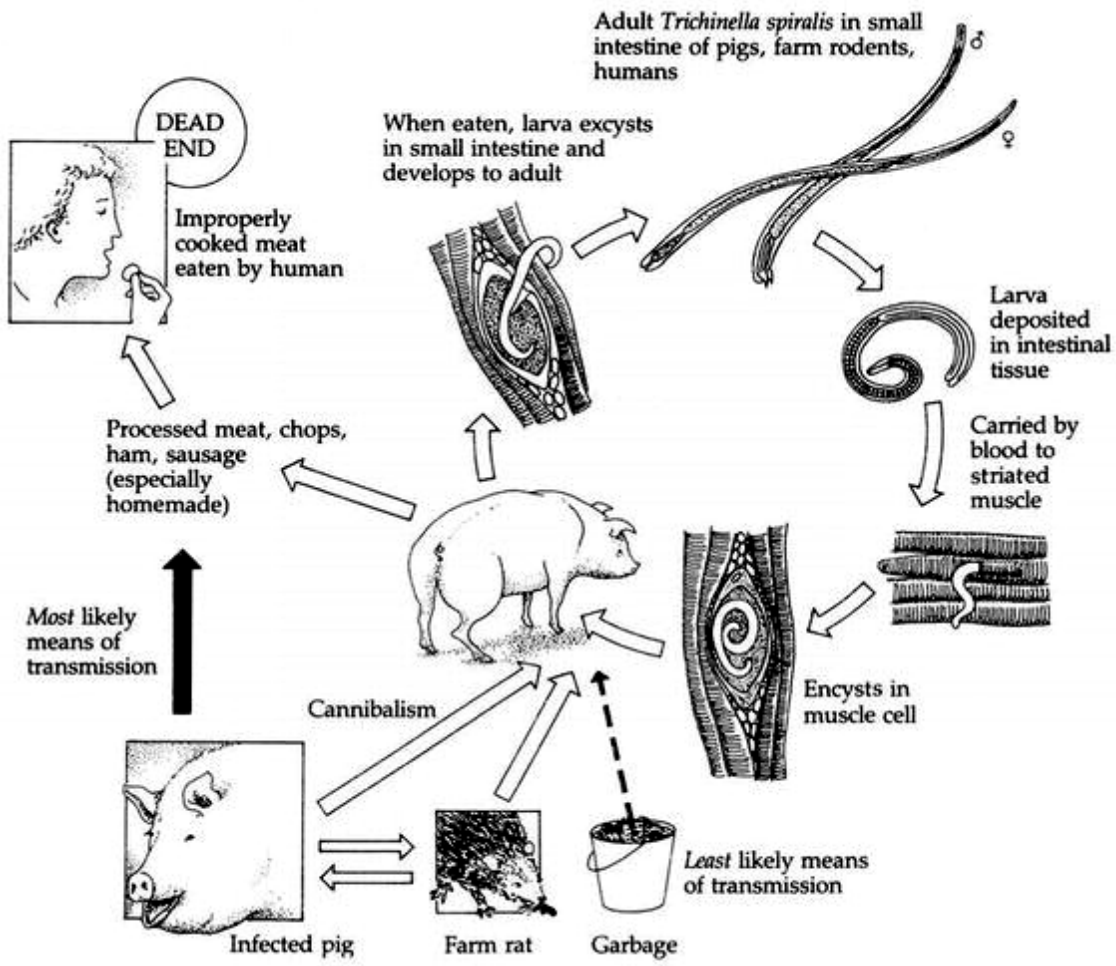
Trichinella spiralis – is an agent of trichinellosis.

Morphology and life-cycle. It is one of the smallest Nematodes. Females are about 2,2-3,3 mm long and males are 1,4-1,6 mm in length. Anterior part of the body is narrow, begins with oral cavity that contains lamina with hooks.

Mature forms are found in the small intestine and their juveniles in voluntary muscles, especially in diaphragm, tongue, eyes and limbs, where they roll themselves into a spiral, and a lemon-shaped cyst is formed around the embryo. A cyst may have 1 to 7 embryos. No further development occurs in the cyst.

Human beigns may be invaded by eating partly cooked infected pork. After digestion the capsules get destroyed, juveniles release and move to small intestine where they undergous metamorphosis and varios stages of development. Within 24 hours a larva becomes mature and undergoes copulation.

Trichinella sprilalis is a ***biohelminth.*** It found in humans, cats, dogs, pigs and rodents. The organism in which Trichinella parasitized is a single host in its life-cycle. Fertilization occurs in the small intestine of the host. The fertilized females give birth to juveniles by burrowing into the tissues, while the males die after fertilization and pass out. Further development takes place in the lymphatic system first and then in vascular system and muscles. The juveniles undergou spiralization after 17-20 days. The capsules of connective tissue develop around it within four weeks. It's incubational period of disease. For further development encysted larvae must be carried into the intestine of the host.



Pathogenecity, diagnosis and prevention. The invasion of human affects his immune system and causes different abnormalities in the body. The major symptoms of trichiniasis (the disease, caused by Trichinella) are: enteritis, muscular pain, pneumonia, kidney failure

and necrosis may prove fatal. Trichiniasis is characterized by specific symptoms like swelling of lips and face, rising of the eosinophile level and others.

Diagnosis is made by using:

- serological reactions
- biopsy of muscles
- allergical test

Preventions include:

- prohibition of invaded meat consuming
- proper sanitary and hygiene maintenance of standarts in markets and meat producing industries
- disposing invaded meat
- elemination rodents, invaded pigs.

An important significance of prevention and diagnosis is examination not only the patients but also the individuals who had consumed the infected meat and have no symptoms yet.

Dracunculus medinensis **(guinea worm)**

Morphology and life-cycle. The worms are a scourge in Western Asia from Arabia to India, and also in Africa and Indonesia. The female is 75 cm to 120cm long and 1-5 mm in diameter, the head is blunt and tail has sharp hooks. The male is 20-30mm long with a spirally coiled tail with 2 equal and large spicules.

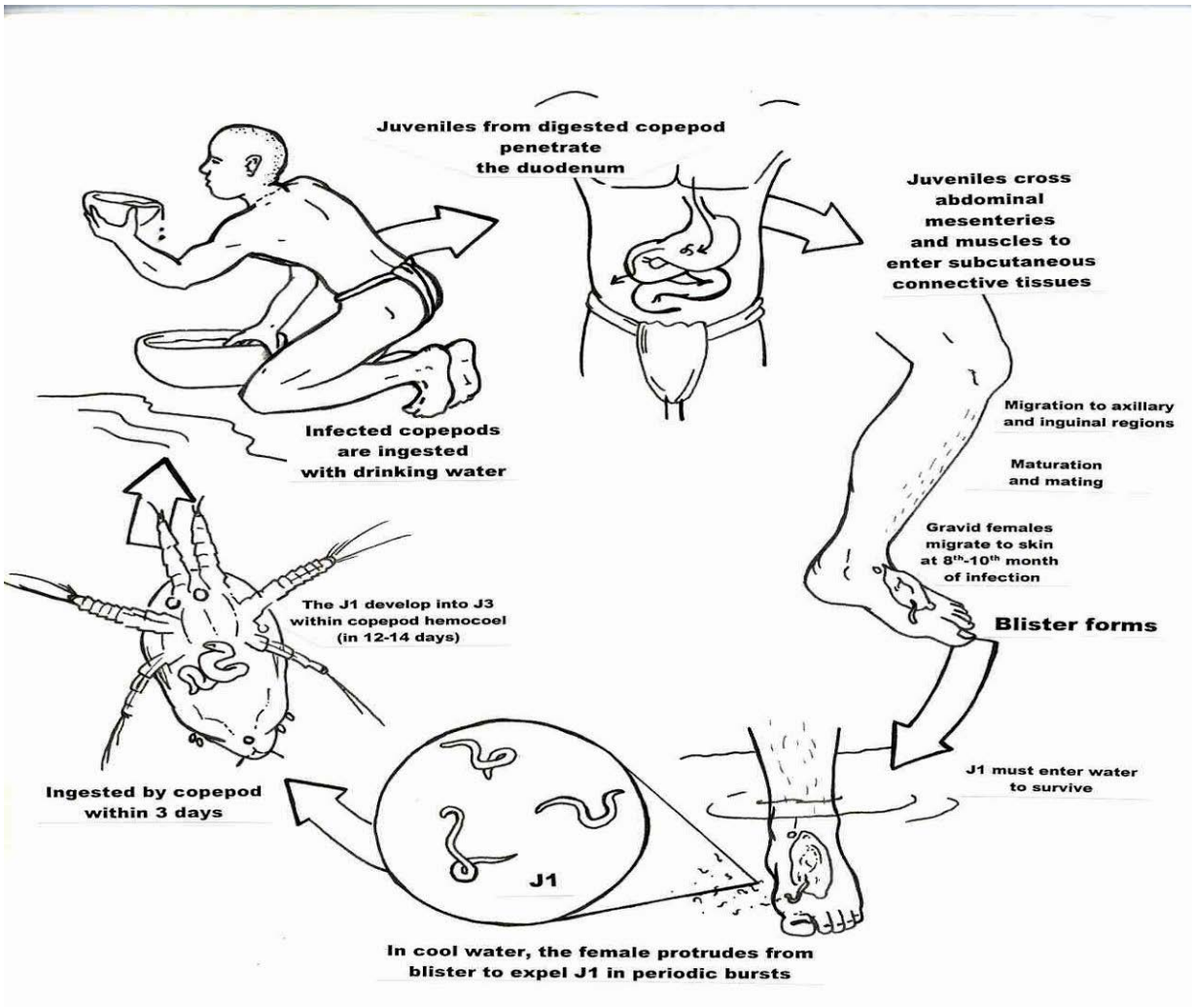
The guinea worm is parasitic in the deeper parts of subcutaneous tissue where the long female lies in a loose coil under the skin. Dracunculus is a biohelminth. Primary hosts are humans, dogs, monkeys, cattle. Intermediate hosts are cyclops and crabs. Humans are invaded by eating the invaded cyclops or crabs. In the stomach of the primary host the cyclope is digested and larvae of microfillarie type get released. The larvae reach the subcutaneous tissue from the intestine and mature in about a year.

Copulation takes place within 3 months after invation. The males die and females continue their maturation for 9-14 months. The mature females pierce the skin of the host and produce a toxin which causes a blister which enlarges into an ulcer. When the ulcer comes in contact with water, the uterus of the female pokes out of the ulcer and releases hordes of tiny

coiled juveniles. The juveniles are swallowed by Cyclops, (water Custacean), they moult twice and become infective in three weeks.

Diagnosis. The clinical presentation of dracunculiasis is so typical, and well known to the local population, that it does not need laboratory confirmation. In addition, the disease occurs in areas where such confirmation is unlikely to be available. Examination of the fluid discharged by the worm can show rhabditiform larvae. No serologic test is available.

Pathogenecity, diagnosis and prevention. After formation of an ulcer, the person may get urticaria, diarrhoea, asthma, giddiness. Bacteria infection of the ulcer then sets in. Diagnosis depends on clinical symptoms of disease: finding the ulcers in the rejons of the lower extremities.

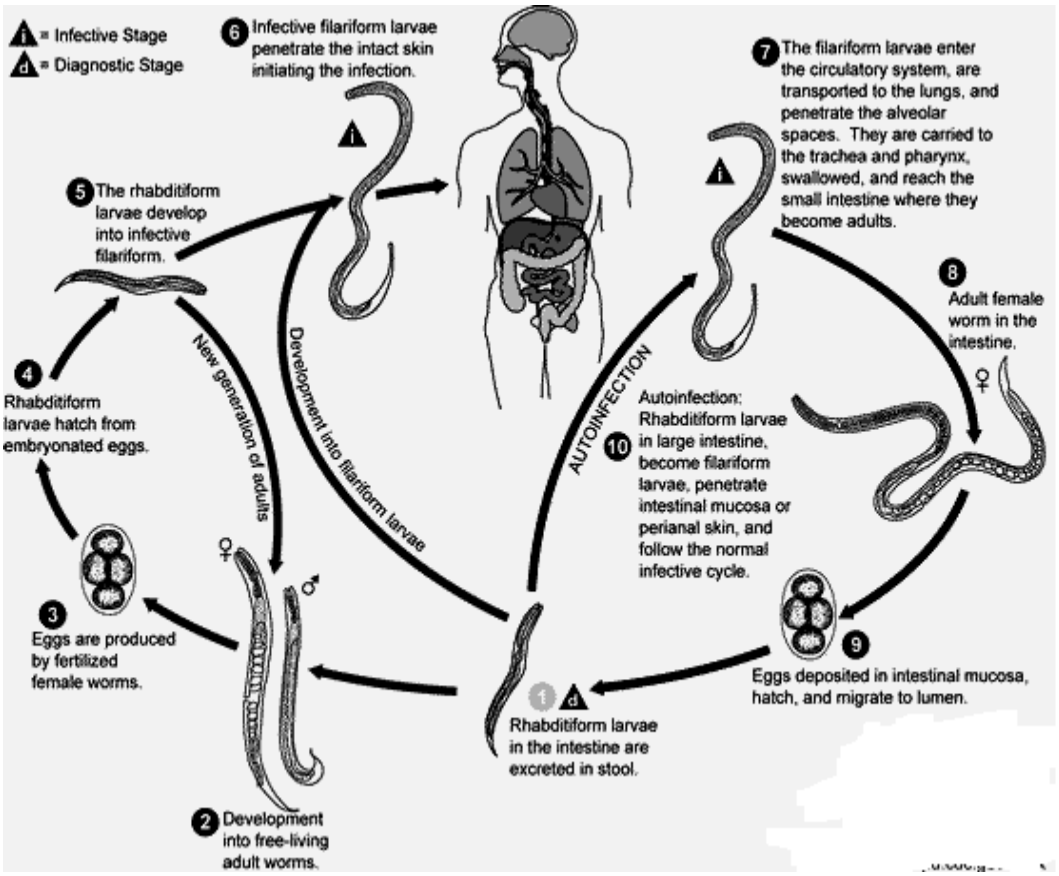


Prevention includes:

- isolation and treatment of the invaded persons
- elimination of Cyclops and Crabs
- treatment of the water
- not to drink polluted water, dirty fruits and vegetables.

***Strongyloides stercoralis* (*Dwarf Thread worm*)**

Morphology and life-cycle. It is a common parasite of man in warm countries. The free living stages are the present in the life cycle of these worms. These worms are very small. The females are about 1-2 mm long while the males are only 0,7 mm in length. The adults live in the small intesestine of man. ***Autoinfection*** also occurs if the rhabdite larvae change into filaria larvae in the lumen of the intestine before being expelled in faeces.



Free-living cycle: The rhabditiform larvae passed in the stool,can either molt twice and become infective filariform larvae (direct development) or molt four times and become free living adult males and females that mate and produce eggs from which rhabditiform larvae hatch. The latter in turn can either develop into a new generation of free-living adults (as represented in), or into infective filariform larvae. The filariform larvae penetrate the human host skin to initiate the parasitic cycle (see below).

Parasitic cycle: Filariform larvae in contaminated soil penetrate the human skin, and are transported to the lungs where they penetrate the alveolar spaces; they are carried through the bronchial tree to the pharynx, are swallowed and then reach the small intestine. In the small intestine they molt twice and become adult female worms. The females live threaded in the epithelium of the small intestine and by parthenogenesis produce eggs, which yield

rhabditiform larvae. The rhabditiform larvae can either be passed in the stool (see "Free-living cycle" above), or can cause autoinfection. In autoinfection, the rhabditiform larvae become infective filariform larvae, which can penetrate either the intestinal mucosa (internal autoinfection) or the skin of the perianal area (external autoinfection); in either case, the filariform larvae may follow the previously described route, being carried successively to the lungs, the bronchial tree, the pharynx, and the small intestine where they mature into adults; or they may disseminate widely in the body. To date, occurrence of autoinfection in humans with helminthic infections is recognized only in *Strongyloides stercoralis* and *Capillaria philippinensis* infections. In the case of *Strongyloides*, autoinfection may explain the possibility of persistent infections for many years in persons who have not been in an endemic area and of hyperinfections in immunodepressed individuals.

Diagnosis is made by finding the rhabdite larvae in the faeces.Desease (strongyloidiasis) is widespread throughout of tropics and subtropics. The clinical symptomps of infection with the dwarf thread-worm depend on the precise situation in which the parasites settle. Penetration of the larvae ***through the skin*** can cause dermatitis; signs of pneumonia often appear when larvae pass ***through the lungs*** of human. When the worms enter the ***mucosa of the small intestine,*** they cause abdominal symptoms, which can vary a great deal accoding to the heaviness of the infection: abdominal pain, diarrhea, weigh loss and oedema may develop.

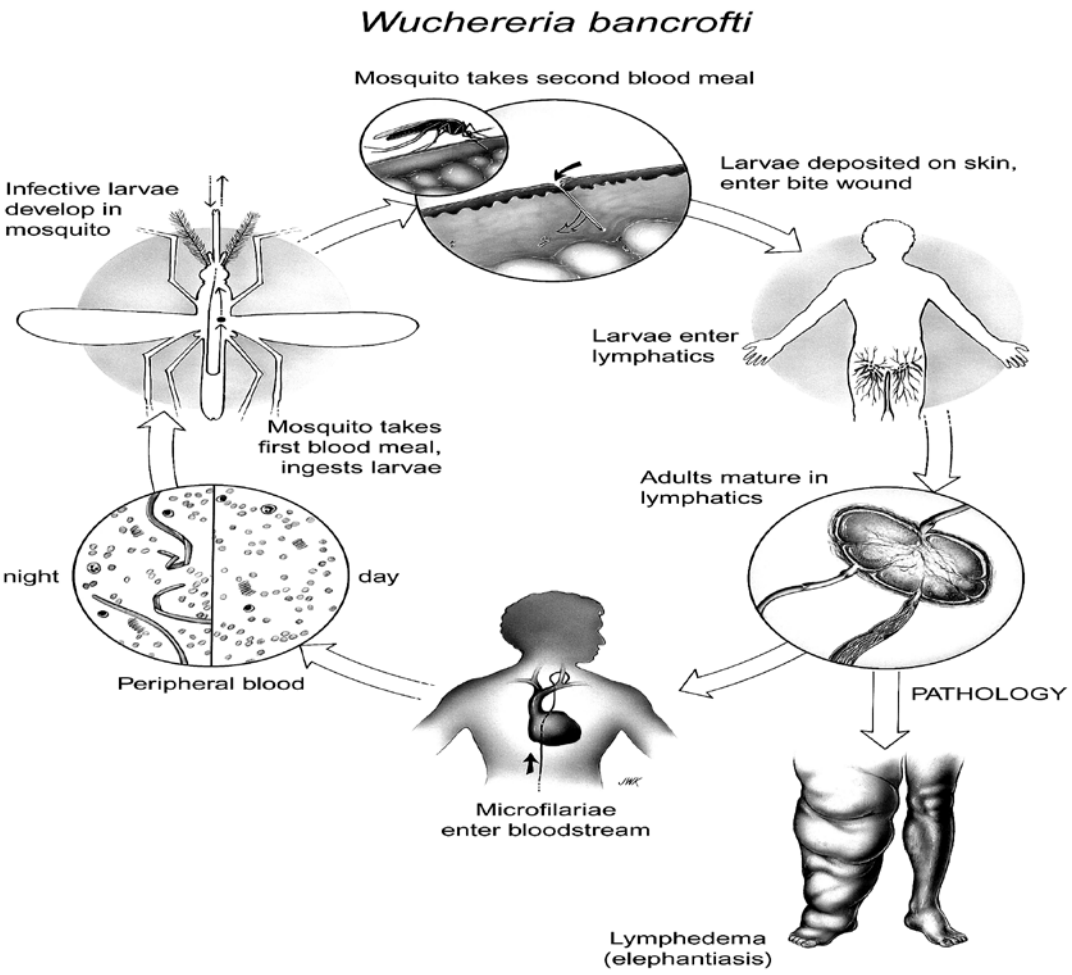
Prevention and Control

- Follow the higyenic rules, thoroughly wash foods
- Wear shoes in endemic areas
- Education, improved sanitation is important.

Wuchereria Bancrofti. It is the most important filarial parasite of man in tropical and sub-tropical regions of Africa, India, Malasia, Arabia, China and Japan. It causes ***lymphatic filariasis,*** an infection of the lymphatic system by filarial worms. If the infection is left untreated it can develop into chronic disease-called **elephantiasis.**

Morphology and Life-cycle. The adult worm is long, slender, and smooth with rounded ends. It has a short cephalic region. The male worm is 40 mm long and 100 mm wide, with a curved tail. The female is 6 cm to 10 cm long and 300 mm wide. They are ***ovoviviparous*** and can produce thousands of juveniles known as microfilariae. The microfilariae migrate between the deep and the peripheral circulation W.bancrofti is a periodic strain that exhibits nocturnal

periodicity: during the day they are present in the deep veins and during the night they migrate to the peripheral circulation.



Next, the microfilariae are transferred into a ***vector;*** the most common vectors are the mosquito species: ***Culex, Anopheles, Mansonia and Aedes.*** Inside the mosquito vector, also known as the ***intermediate host***, the microfilariae mature into motile ***larvae*** called juveniles. When the mosquito vector has its next blood meal, W. bancrofti is egested via the mosquito's proboscis into the blood stream of the new human host.

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 and reach sexual maturity in the afferent lymphatic vessels. After mating, the adult female worm can produce thousands of microfilariae that migrate into the bloodstream. A mosquito vector can bite the infected human host, ingest the microfilariae, and thus repeat the life cycle of W. bancrofti

Diagnosis. Identification of microfilariae by microscopic examination is the most practical diagnostic procedure. Examination of blood samples will allow identification of microfilariae of ***Wuchereria bancrofti, Brugia malayi, Brugia timori, Loa loa, Mansonella perstans***, and ***M. ozzardi***. It is important to time the blood collection with the known

periodicity of the microfilariae. The blood sample can be a thick smear, stained with Giemsa or hematoxylin and eosin. For increased sensitivity, concentration techniques can be used. These include centrifugation of the blood sample lyzed in 2% formalin (Knott's technique), or filtration through a Nucleopore membrane. Examination of skin snips will identify microfilariae of ***Onchocerca volvulus*** and ***Mansonella streptocerca***. Skin snips can be obtained using a corneal-scleral punch, or more simply a scalpel and needle. The sample must be allowed to incubate for 30 minutes to 2 hours in saline or culture medium, and then examined for microfilariae that would have migrated from the tissue to the liquid phase of the specimen.

Pathogenesity, diagnosis and prevention. The pathogenesis of W. bancrofti infection is dependent on the inmune system and inflammatory responses of the host. After infection, the worms will mature within 6-8 months; male and female worms will mate and then release the micrifilariae. These microfilariae worms can be released for up to ten years.

The worms prevent the flow of the lymph causing ***lymphedema.*** The individual will exhibit fever, chells, skin infections, painful lymph nodes, and tender skin of the lymphedematous extremity. These symptomes often lessen after 5-7 days. Other symptoms that may occur include:a) orchitis – inflammation of the testes, which is accompanied by painful immediate enlargment,b) epididymitis – inflammation of the spermatic cord.

Obstructiwe (Chronic) Phase – marked by and ***elephantiasis,*** which develops gradually with the attack of the lymphatic system. Elephantiasis affect men mainly in the legs, arms, and scrotum. In women, the legs and arms are affected.

A blood test must be performed to detect the juveniles in the periphead circulation (during the day-time). Sometimes infected people do not have microfilariae in the blood. As a result, tests aimed to detect antigens from adult worms can be used. Dead, calcified worms can be detected by X-ray examinations.

Protection is similar to that of other mosquito spread illnesses; one can use barriers physical (a mosquito net), chemical (insect repellent), or mass chemotherapy as a method to control the spread of the disease.

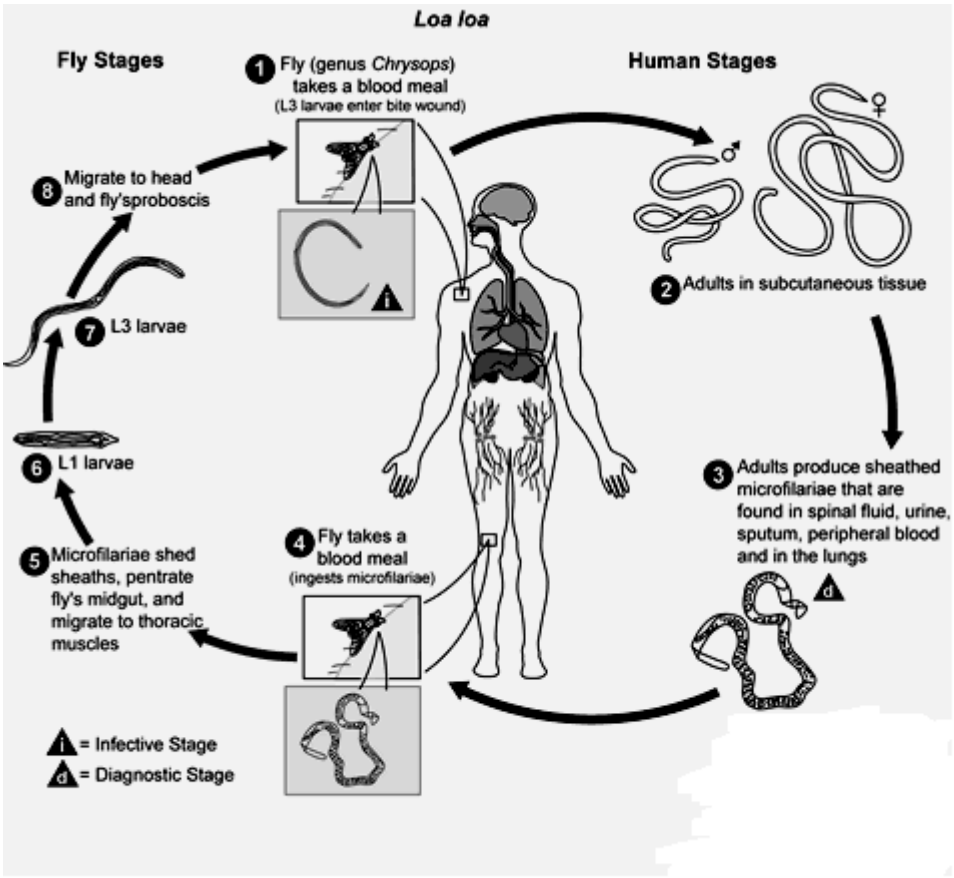
Loa Loa. It is a filarial nematode that causes ***loaisis.*** It is part of a group of parasitic filarial nematodes that cause lymphatic filiariasis (Wuchereria bancrofti and Brugia malayi), onchocerciasis (Onchocerca volvulus) and mansonelliasis (Mansonella). Loa loa is commonly known as the “eye worm”. Its geographic distribution includes Africa and Sudan.

Morphology and life-cycle. Loa Loa worms have a simple body including a head, body, and tail. Males range from 20 mm to 34 mm long and 350 mm to 430 mm wide. Females range from 20 mm to 70 mm long and are about 425 mm wide. Loaisis is transmitted to human by day-biting Chrysops flies (C.silacea, C. dimidiata). During a blood meal, an infected fly (Chrysops, day-biting flies) introduces third-stage filarial larvae into the skin of the human host, where they penetrate into the wound. Larvae develop into adults that commonly reside in subcutaneous tissue.

Microfilariae have been recovered from spinal fluids, urine, and sputum. During the day they are found in peripheral blood, but during the non-circulation phase, they are found in the lungs.

The fly ingests microfilariae during a blood meal. After ingestion, the microfilariae lose their sheats and migrate from the fly's midgut through the hemocoel to the thoracis muscles of the arthropod. There the microfilariae develop into first-stage larvae and subsequently into third-stage infective larvae. The third-stage infective larvae migrate to the fly's proboscis and can infect another human when the fly takes a blood meal.

Life Cycle of *Loa loa*



The vectors for Loa loa filariasis are flies from two species of the genus *Chrysops*, *C. silacea* and *C. dimidiata*. During a blood meal, an infected fly (genus *Chrysops*, day-biting

flies) introduces third-stage filarial larvae onto the skin of the human host, where they penetrate into the bite wound. The larvae develop into adults that commonly reside in subcutaneous tissue. The female worms measure 40 to 70 mm in length and 0.5 mm in diameter, while the males measure 30 to 34 mm in length and 0.35 to 0.43 mm in diameter. Adults produce microfilariae measuring 250 to 300 μm by 6 to 8 μm, which are sheathed and have diurnal periodicity. Microfilariae have been recovered from spinal fluids, urine, and sputum. During the day they are found in peripheral blood, but during the noncirculation phase, they are found in the lungs. The fly ingests microfilariae during a blood meal. After ingestion, the microfilariae lose their sheaths and migrate from the fly's midgut through the hemocoel to the thoracic muscles of the arthropod. There the microfilariae develop into first-stage larvae and subsequently into third-stage infective larvae. The third-stage infective larvae migrate to the fly's proboscis and can infect another human when the fly takes a blood meal.

Patogenesis. Loa Loa parasites infect human hosts by travelling through subcutaneous tissues such as the back chest, groin, scalp, and eye. These parasites cause inflammation in the skin wherever they travel. If a parasite stops in one place for a short period of time, the human host will suffer from local inflammation known as ***Calabar swellings.*** These often occur in the wrist and ankle joints but disappear as soon as the parasite begins to move again. Parasites can also travel through and infect the eye, causing the swelling of the eye. Common symptoms include itching, joint pain and fatigue.

Diagnosis. The main methods of diagnosis include the presence of microfilariae in the blood, the presence of worm in the eye, and the presence of skin dwelling. Surgical removal of the worm can be performed. The common treatment for the disease is a use of drugs.

Prevention:

- Isolation and treatment the sick persons
- Elimination of Chrysops
- Protection from the fly’s bites, using repellents and insecticides, anti-mosquito nets.
- Destroying the places of gad-flies and mosquitos development (puddles, ditches)

The main methods of the laboratory diagnostics of helminthosis.

Native smear

Using this method one can find out eggs and larvae. A small piece of feces (size is about matches head) place on a microscope slide into a couple drops of glycerine – water solution

(1:1) and stirred with a wooden stick, taking away the large fragments. Then carefully lower a cover slip over it and microscoped a slide.

Refining method based on flotation.

One should prepare suspense of feces in a saturated salt solution. The relative density of this solution is much greater than the one of helminth's eggs. That is why the eggs are floating on the surface. The film on the surface is to be microscoped. The saturated solution is prepared by solving of 400 gr of NaCl in the litre of water while boiling. The solution is to be filtered and chilled. Put 5 – 10 gr of feces in glass, add the saturated solution of salt and prepare the suspense. Large pieces that are floating must be removed. Remove the film of the surface by a wire hook after 30 – 40 minutes of sedimentation. Eggs of Trematodes, Taeniides and nonfertilized eggs of Ascaris do not float. That is why the sediment must be carefully microscoped.

- **Special method of enterobiosis and taeniarhinchosis diagnostics.**

These methods are based on studying of perianal and rectal mucous coat. Make a scrape from perianal zone with a cottonwool tampon, tightly reeled on a wooden stick and smeared with water solution of glycerine (50%). Wooden spatel can be also used.

Perform this procedure in the morning before defecation or in the evening 2 – 3 hours after the patient has gone to sleep. Children may undergo this procedure **after** their midday sleep. Received mucous is to be mixed with 1 – 2 drops of glycerine solution (50%) and microscopic.

- **Immunologic methods.**

These methods include:

- skin allergic tests and
- serologic reactions.

Skin allergic tests are used for diagnostics of echinococcosis and alveococcosis. Serologic reactions are based on finding antibodies of parasite in blood serum. Immunologic methods are used in the following cases:

- helminth located in organs and tissues.
- helminth larvae migrate in the host's body.
- the invasion is not intensive.
- the reproductive activity of helminth has not yet begun.

These methods are used for diagnostics of the ecinococcosis, alveococcosis, cysticercosis, and trichinelosis.

Parasitic diseases: helminthiases

Flatworms (Platyhelminthes)	Flukes (Trematodes)	Blood fluke	Shistosoma: ❖ mansoni ❖ haematobium ❖ japonicum	Schistosomiasis
		Live fluke	Clonorchis sinensis (Opisthorchis)	Clonorchiasis (Opisthorchiasis)
			Fasciola ❖ hepatica ❖ gigantic	Fascioliasis
		Lung fluke	Paragonimus ringeri	Paragonimiasis
		Intestinal fluke	Fasciolopsis buski	Fasciolopsiasis
	Cestoda (Tapeworms)		Taenia solium Taenia saginata	Taeniasis Cysticercosis Taeniasis
			Echinococcus granulosus	Echinococcosis
			Echinococcus multilocularis	
			Hymenolepis nana	Hymenolepiasis
			Diphyllobothrium latum	Diphyllobothriasis
Round worms (Nematodes)		Dracunculus medinensis		Dracunculiasis
		Onchocerca volvulus		Onchocerciasis
		Loa Loa		Loa Loa filariasis
		Dirofilaria repens		Dirofilariasis
		Wuchereria bancrofti		Wucheririasis
		Ancylostoma duodenale		Ancylostomiasis
		Necator americanus		Necatoriasis
		Ascais lumbricoides		Ascariasis
		Strongyloides stercoralis		Strongyloidiasis
		Enterobius vermicularis (Pinworm)		Enterobiasis
		Trichinella spiralis		Trichinosis
		Trichuris trichiura (Whipworm)		Trichuriasis

Practice:

Assignment 1. Trichinella spiralis:

Use charts, slides, microscopes and study morphology and eggs of Trichinella spiralis. Draw male, female and egg of the parasite.

Assignment 2. Strongyloides stercorales .

Use charts, slides, microscopes and study morphology and life - cycle of the parasite. Draw adult forms (male and female) and egg of Strongyloides stercorales.

Assignment 3. Dracunculus medinensis.

Use charts, slides, diagrams and study morphology and life - cycle of Dracunculus medinensis. Draw adult forms and make a diagram of the parasite's life – cycle. Label the main stages of the development.

Assignment 4. Family Filariidae.

Use charts, slides and study morphology and life - cycle of the following parasite:
Wuchereria bancrofti, Brugia malaji, Onchocerca volvulus, Loa – loa.Draw adult forms.

Assignment 5. Helminth's eggs.

Use slides, microscopes and study eggs of the following helminths:

- Fasciola hepatica (liver fluke).
- Opistorchis felineus (cat fluke).
- Shistosomes (blood flukes).
- Taenia solium or Taenia saginata.
- Ascaris lumbricoides.
- Enterobius vermicularis (pin worm).
- Trichocephalus trichiurus (whip worm).

Draw eggs and pay attention to the main features of their structure.

Features of helminth's eggs.

Fasciola hepatica:

- large eggs: 140 × 70 μm
- yellowish – brown color
- oval shaped with an aperculung on one pole
- rich with yolk cells and contain an embryo.

Opistorchis felineus:

- very small: 28 × 16 μm

- yellowish – brown color
- oval shaped with an apercular or without
- have a tuber – like knob at the apopercular end.

Schistosomes:

- large eggs: 140 × 60 μm
- have an oval shape, thin shelled with a sharp spine
- translucent with a miracidium larva.

Taenia solium or Taenia saginata:

- shaped ovally or roundly about 30 – 40 μm in diameter.
- colorless, with thin and transparent coat
- have an onchosphere with six hooks.

Ascaris lumbricoides:

Ascaris eggs can be fertilized and none fertilized.

Fertilized eggs:

- shaped ovally, size: 60 × 45 μm
- have a thick several layered coat, brownish

Non – fertilized eggs:

- have irregular shape, usually longer and narrower (90 × 40μm) than the fertilized ones brownish with a thin coat.

Entherobius vermicularis.

- shaped asymmetrically, one side is flat, another is thicker
- colorless and transparent, 15 × 20 μm
- contain a well - developed larva.

Trichocephalus Trichiurus

- barreled shaped with two transparent colorless corks on its poles
- size about 50 μm
- coat is thick, multilayered and smooth
- yellowish – brown color.

TOPIC 28: TEST OF SUBMODULE 5: MEDICAL HELMINTHOLOGY.

Teaching opjective: Checking the stdent's knowledge of Medical Helminthology.

Practice

Assignment 1. Revise morphological features of the parasites and their life-cycle by using drawings, pictures, diagrams and slides texts of books.

Assignment 2. Test.

Submodule 6

TOPIC 29: PHYLUM ARTHROPODA. CLASS ARACHNIDA

Key consepts:

1. General characteristics of Arthropods.
2. Class Arachnida: the main features, representatives.
3. Ticks and Mites.

Arthropoda constitute about 80% of the known animal species and have adapted themselves to diverse habitats, like water, land and air.They exhibit the greatest adaptive radiation. Arthropods include spides, scorpions, crabs, prawns, millipedes, insects etc.

General characteristics of Arthropods

1. The body of an arthropod is completely covered by the ***cuticle, an exoskeleton*** constructed from layers of protein and chitin. The cuticle can be a thick, hard armor over some parts of the body and paper-thin and flexible in other locations, such as the joints. The exoskeleton protects the animal and provides points of attachment for the muscles that move the appendages. The skeleton of arthropods is both strong and relatively impermeable to water. It helps in the maintenance of the shape of the body. In order to grow, an arthropod must occasionally shed its old exoskeleton and secrete a larger one. The process of casting off the skin or integument is known as ***ecdysis*** (molting).

2. Arthropods are characterised by true metamerism, a ***heteronomous type*** of ***segmentation.*** The components of all segments are different and the segments are grouped to form different functional regions of the body: ***head, thorax and abdomen*** in insecta or ***cephalothorax*** (head+thorax) and ***abdomen*** in crustacea and arachnida.

3. ***Jointed legs*** (appendages) show rapid movement with the help of bundles of striated muscles. These muscles appeared for the first time in the artthropods among the invertebrates.

4. Arthropods have ***open circulatory system*** in which fluid called ***haemolymph*** (blood) is propelled by a heart through short arteries and then into spaces called sinuses surrounding the tissues and organs. Haemolymph renters the arthropod heart through pores that are usually

equipped with valves. The body sinuses are collectively called the ***haemocoel***, which is not a part of the coelom. The true coelom is restricted to gonads.

5. Alimentary canal complete; mouth parts adapted for various modes of feeding. Arthropods have the following types of mouth parts:

- Biting and Chewing type: e.g. cockroach, grass hopper, etc
- Chewing and Lapping type: e.g. honey bee, wasp
- Piercing and Sucking type: e.g. bugs, mosquitoes, etc
- Sponging type: e.g. housefly
- Siphoning type: e.g. butterflies, moth, etc.

6. Respiration takes place through general ***body surface and gills*** in crustaceans; through ***trachea*** in insects: through book-lungs in Arachnida

7. Excretion is brought about by ***green glands*** in aquatic forms and ***malphigian tubules*** in terrestrial animal.

8. Nervous system consists of a ***nerve ring,*** which is present around the oesophagus, and a ***ganglionated*** double ***ventral nerve cord.*** The nerves arise from the different ganglia.

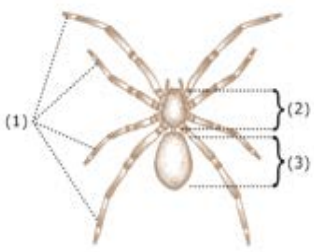
9. Sensory organs comprise simple eyes, compound eyes, antenae, chemoreceptors, statocysts, etc

10. Sexes usually separate. Fertilization internal; oviparous or ovoviviparous; development direct or indirect (with metamorphosis).

11. Classification of Arthropoda: Phylum Arthropoda is divided into six classes. Two classes: Arachnida and Insecta have great medical significance.

Class Arachnida

Arachnida is a large and well-known class of 8-legged arthropods related to crustaceans and insects.



Spider. External structure.

1. four pairs of legs
2. cephalothorax
3. opisthosoma (abdomen)

Body is divisible into an anterior ***cephalothorax*** (also called prosoma) and a posterior abdomen (also called opisthosoma). Antennae are absent. Prosomal appendages are six pairs. The first pair appendages are modified as mouth parts called ***chelicerae,*** the feeding appendages which masticate or chew the prey. The final sections of spider's ***chelicerae*** are

fangs, and the great majority of spiders can use them to inject ***venom*** into prey from ***venom glands*** in the roots of the chelicerae. The second pair of appendages ***pedipalps*** (used to touch or capture) and the last four pairs are in the form of ***walking legs.***

The cephalothorax is partiall or completely covered with a protective shield. The second segment is known as the abdomen or opistosoma, and contains the rest of the body. The abdomen may lack appendages entirely, or it may have spicialized appendages, such as the spinneret used to make spiderwebs. The abdomen is soft and egg-shaped. It shows no sign of segmentation. The cephalothorax and abdomen are joined by a small, cylindrical ***pedicel.***

Spiders are ***coelomates*** in which the coelom is reduced to small areas round the reproductive and excretory systems. They have ***open circulatory system***. The blood of many spiders contains the ***respiratory pigment haemocyanin*** to make oxygen transport more efficient.

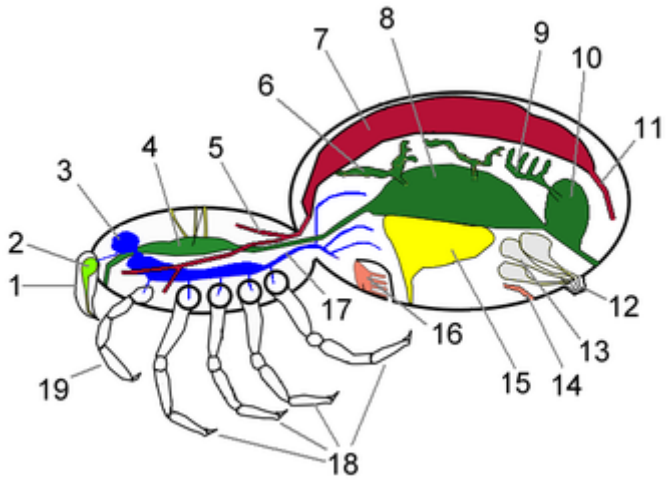
Digestive system. A narrow gut of spider scan only copes with liquid food. They pump digestive ***enzymes*** from the midgut into the prey and then suck the liquified tissues of the prey into the gut, eventually leaving behind the empty husk of the prey.

Respiration is by ***book-lungs*** or ***trachea.*** Some spiders have both book-lungs and trachea. Spiders have much more centralized nervous system: all the ganglia of all segments behind the oesophagus are fused, so that cephalothorax is largely filled with nervous tissues and there are no ganglia in the abdomen.

Excretory structures include ***Malpighian tubules*** and ***coxal glands.***

Development is direct. The major orders of Arachnida are:

1. Scorpiones (Scorpions)
2. Solpugidae (Sun spiders)
3. Araneae (spiders)
4. Acari (mites,ticks)



Spider’s main organs

1. Fang (chelicera), 2 Venom gland, 3 Brain, 4 Pumping stomach, 5 Forward aorta branch, 6 Digestive cecum , 7 Heart, 8 Midgut, 9 Malphigian tubules, 10 Cloacal chamber, 11 Rear aorta, 12 Spinneret , 13 Silk gland, 14 Trachea, 15 Ovary (female), 16 Book lung, 17 Nerve cord, 18 Legs,19 Pedipalp

The spiders are the largest order of arachnids that are generally carnivorous and feed only on living prey. The venomous species are Black widow (Latrodectus tredecimguttatus) and Tarantula (Iycosa sigoriensis).

Tarantula is a large spider of 35 mm in length. It is covered by thick hair of black or sometimes red colour. It inhabits vertical burrows in soil. Its poison is not deadly. On the place of a bite an expressed allergic reaction may occur (hyperemia, oedema), rapid pulse, sleepiness.

Black widow is a small spider. The male is of 1 cm length and female- 1,5-2 cm. The spider's abdomen is round, velvetly black, with 1-2 pink or yellow strippes. Male has elongated abdomen with dazzling white spots and red dots in the center. Black widow inhabits the holes of rodents, sheds, toilets, can be found among the stones in the beaches. The poison of spiders is neurotoxic. It causes full blocking of neuromuscular impulse transmission. The symptoms of poisoning are nervous pain, disturbance of the organizm, asthma, palpitations, spasm of bronchus, depression, swoons.

Ticks Ticks are blood-feeding external parasites of birds, mammals and humans. They are often found in tall grass and shrubs where they will wait to attach to a passing host.

Tick is the common name for the small arachnids that, along with mites, constitute the order ***Acarina.*** The body of ticks, in common with other arachnids (spiders, scorpions), is divided into two regions-a front part called the ***cephalothorax*** (or prosoma) and a hind part called the the ***abdomen*** (or opisthosoma). Although frequently there is no clear demarcation or obvious constriction between these parts and superficially the ***body appears undivided.***

Most ticks and mites possess the usual arachnid appendages-***chelicerae*** (jaws) and ***palps*** (a pair of sensory appendages) at the front-end, and four pairs of legs. In their life-cycle and development from an egg to the mature adult, mites and ticks pass through several stages, including a ***larval form*** with only ***tree pairs of legs,*** followed by a nymphal form with four pairs of legs like the adult

There are two well established families of ticks:

1. Hard Ticks: Family Ixodidae
2. Soft Ticks: Family Argasidae

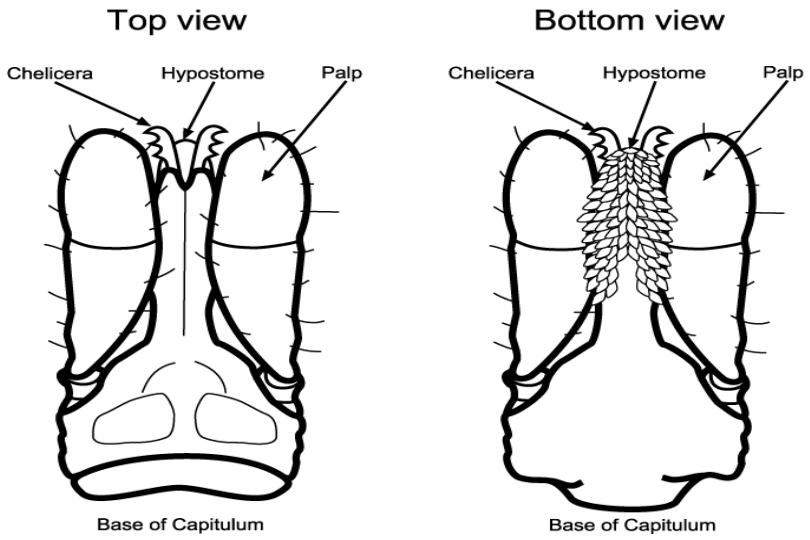
The hard ticks (Family Ixodidae) comprise the majority of our ticks and are distinguished by a ***hard dorsl plate*** in the shape of a fingernail and elongated mouthparts that

have rows of backward pointing teeth. Some species of tick's use these teeth in conjunction with a cement to remain attached to the host while blood feeding.

A ***hard scutum or shield*** lies over the front part of the body of the female, but covers the whole body of the male (atypical hard tick Dermacentor). Most hard ticks are moderately large, with the adults generally over 3 mm long and often much larger. They all live as external, blood-sucking parasites of reptiles, birds or mammals.

The mouthparts of hard ticks are readily visible from above. There are three visible components:

- the two outside jointed parts are highly mobile ***palps.***
- between these are paired ***chelicerae***
- the center rod-shape structure is hypostome protected by ***chelicerae.***



The palps move laterally while the tick is feeding and do not enter the skin of the host. The rough hypostome has many beak-like projections on it. This is the structure which plunges into the host's skin while feeding. The backward directed projections prevent easy removal of the attached tick.

Hard ticks seek hosts by a behavior called «questing». Questing ticks crawl up the stemps of grass or perch on the edges of leaves on the ground in a typical posture with the front legs extended, especially in response to a host passing by. Certain biochemicals such as CO_2 as well as heat and movement serve as stimuli for questing behavior subsequenly, these ticks climb on to a potential host which brushes against their extended front legs.

Hard ticks feed for extended periods of time on their hosts, varying from several days to weeks, depending on such factors as life stage, host type, and species of tick. The outside

surface, or cuticle, of hard ticks actually grows to accommodate the large volume of blood ingested, which, in adult ticks, may be anywhere from 200-600 times their unfed body weight.

Hard ticks have a varienty of life histories with respect to optimizing their chance of contact with an appropriate host to ensure survival. Some ticks feed on only one host throughout all three life stages. These ticks are called ***one host ticks***. This type of ticks remains on one host during the larval and nymphal stages, until they become adults, and females drop off the host after feeding to lay their batch of eggs. Other ticks feed on two hosts during their lives and are called ***two host ticks.*** This type of ticks feed and remain on the first host during the larval and nymphal life stages, and then drop off and attach to a different host as an aduls for its final blood-meal. The adult female then drops off after feeding to lay eggs. Finally, many ticks feed on three hosts, one during each life stage, and are appropriately named ***three host ticks.*** These ticks drop off and reattach to a new host during each life stage, until finally the adult females lay their batch of eggs. In each case, the fed adult stage is terminal, that is aftter laying one batch of eggs the female dies, and after the male has reproduced, he dies as well. They developed with ***incomplete metamorphosis***.

Hard ticks (Ixodidae ticks) are carries of ***ticking and spring-summer encephalitis,*** African tick fever, ticking (spotted fever) typhus. The agents of plaque, brucelosis, listeriosis, and leptospirosis are selected from Ixodidae ticks.

The females can transmit virus of spring-summer encephalitis through the egg to larvae, nymph, to the next generation ***transovarially*** (DNA of virus builds into DNA's of the tick's eggs cell).

Examples of Ixodidae ticks are:

- Ixodes ricinus or Caninus mite
- Ixodes persulcatus or Taiga mite
- Dermacentor pictus

Soft Ticks.Family Argasidae

Soft ticks differ from Hard Ticks by external structure, size, and mode of feeding. They are heat-loving and inhabit the caves of rodents, caves, and nests of birds; can be found in humans buildings.

Their bodies are gray and wrinkled. The size of female is about 8, 2mm, the size of male-5,8 mm. The mouthparts of soft ticks are not readily visible from above. They are hidden underneath the body.

The life stages of ticks are not readily distinguishable. The first life stage to come out of the egg, six legged larva, takes a blood meal from a host, and molts to the first nymphal stage. Unlike hard ticks, many soft ticks go through multiple nymphal stages, gradually increasing in size until the final molt to the adult stage. Soft ticks feed several times during each life stage, and females lay multiple small batches of eggs between blood meals during their lives. The time to completion of the entire life cycle is generally much longer than that of hard ticks, lasting over several years. Additionally, many soft ticks have an uncanny resistance to starvation, and can survive for many years without a blood meal.

Soft ticks feed for short periods of time on their hosts, varying from several minutes to days, depending on such factors as life stage, host type, and species of tick. They reside in the nest of the host, feeding rapidly when the host returns and disturbs the contents. The outside surface, or cuticle, of soft ticks expands, but does not grow to accommodate the large volume of blood ingested, which may be any where from 5-10 times their unfed body weight. Certain biochemicals such as carbon dioxide as well as heat and movement serve as stimuli for host seeking behavior.

The best method of avoiding ticks is to stay away from known tick infected areas. If visiting such an area, light colored clothing should be worn, as ticks will be much easier to detect. Trousers should be tucked into socks and shirts into pants.

All clothing should be removed on returning home and placed into a hot dryer for 20 minutes, which will kill any ticks that may still be on the clothing. The body should be searched well for ticks, especially behind the ears and on the back of the head. The repellent should be reapplied every few hours.

If a tick is detected that is attached, never attempt to touch or disturb it, as the tick will inject saliva into the skin, which could make the situation worse. The tick should be sprayed with a repellent and left. After 24 hours it should drop off naturally or be gently removed with fine-tipped forceps. It is normal for a tick bite to remain slighty itchy for several weeks, however if other symptoms develop, then a doctor should be consulted immediately.

Mites

Mites are found almost everywhere in nature, on land and in water. The vast majority

are tiny creatures less than 1 mm in length. The parasitic forms include a number of important pests of cultivated plants and several blood-sucking species that attack humans and other warm-blooded animals. Mites include 30.000 species of minute, usually oval-shaped body arachnids. They resemble ticks in morphology and life-cycle.

Mange Mites.Family Demodicidae.

Mange mites are elongate, microscopic mites, with four pairs of legs. They live in the hair-follicles of dogs and other mammals, including humans, and cause the disease called follicular or demodectic mange. The commonest of these mites is a species called ***Demodex folliculorum,*** of which there are several varieties, each specific to a different host. The variety that may be found in the hair-follicles and sebaceous glands of humans cause the disease called ***demodectic mange,*** which may take either the form called scaly or red mange, where infected areas of the skin become reddened, scaly and wrinkled accompanied by loss of hair and intense itching, or the so called pustular form, in which infection with bacteria occurs and absceses form.

Scabies Mites.Family Sarcoptidae

Adult scabies mites are spherical, eyeless mites with 4 pairs of legs. They are recognizable by their oval, ventrally flattend and dorsally convex tortoise-like body and multiple cuticular spines. Females are 0,3-0,45 mm long and 0,25-0,35 mm wide, and males are just over half that size.

Sarcoptes scabiei **is** a skin parasite. The action of the mites moving within the skin and on the skin itself produces an intense itch which may resemble an ***allergic reaction*** in appearance. The presence of the eggs produces a massive allergic response which, in turn, produces more itching. Upon infesting a human host, the adult female burrows into the skin, where she deposits 2-3 eggs per day. These oval eggs (0,1-0,15 mm) hatch as larvae in 3-4 days. Upon hatching, the 6-legged larvae migrate to the skin surface and then burrow into molting pouches (these are shorter and smaller than the adult burrows). After 3-4 days, the larvae molt, turning into 8-legged nymphs. This form molts a second time into adult mites. Adult mites then mate when the male penetrates the molting pouch of the female. Mating occurs only once, as that one event leaves the female fertile for the rest of her life (1-2 months). The impregnated female then leaves the molting pouch in search of a suitable location for a permanent burrow. Once a site is found, the female creates her characteristic S-shaped burrow, laying eggs in the process. The female will continue lengthening her burrow

and laying eggs for the duration of her life. Under the most favorable conditions, about 10% of her eggs eventually give rise to adult mites. Males are rarely seen: they make temporary shallow pits in the skin to feed until they locate a female's burrow and mate.

Transmission occurs primarily by the transfer of the impregnated females during person-to-person, skin-to-skin contact. Occasionally transmission may occur via fomites (e.g., bedding or clothing). Human scabies mites often are found between the fingers and on the wrists.

Dust Mites. Family Pyroglyphidae

Dust mites are tiny, translucent mites, generally less than 0.2 mm long, and more or less invisible to the naked eye. They live amongst dust, feeding on the shed skin and other organic debris which constitutes much of the «dust» that settles and accumulates in our houses and workplaces. The mites themselves are quite harmless, but their cast skins and the digestive secretions and enzymes they produce while feeding, and deposit in their droppings, can cause severe asthma and other allergic complaints in humans. These mites probably occur in most houses and workplaces. They sometimes reach huge numbers, although in many premises almost none are found. The degree of infestation depends on general cleanliness – thorough and frequent vacuum cleaning (which in household premises should include bedding and mattresses) can effectively reduce and contain mite infestations. In addition, it is equally important to maintain an indoor environment that is unfavourable for the mites, in particular a low level of moisture and humidity – dry, well aired buildings, with humidity levels below 60%, appear to support fewer mites than damp, musty premises.

Food Mites. Family Acaridae

Several species of mites infest stored foods and other organic debris such as grain, flour, cereals, dried fruits and vegetables, cheese, dried milk, ham, sugar, pet foods, paper, etc., and may also infest areas where moulds have formed, as well as bird and animal nests. They generally prefer a moist, damp location. Sometimes the surface of infested material may appear to move due to the enormous number of mites that are present. Also, a coating or small piles of brownish «mite dust», consisting of living and dead mites, cast skins and faeces, may appear on open shelving, around the base of food packages, on the surface of cheese or in other foods where infestations have developed.

The commonest food mites are:

– the grain mite (*Acarus siro*)

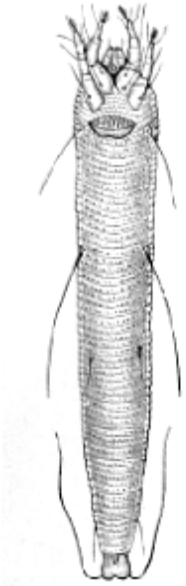
– the cheese mite (*Tyrolichus casei*)

– the mould mite (*Tyrophagus putrescentiae*).

All are barely visible, usually less than 0.5 mm long, and more or less translucent with darker mouthparts and appendages. Prolonged contact with mite infested foods may produce a mild dermatitis known as «baker's itch» or «grocer's itch», or cause asthma and dust allergies. Also, if mites are taken internally by eating infested food, they may cause stomach disorders.

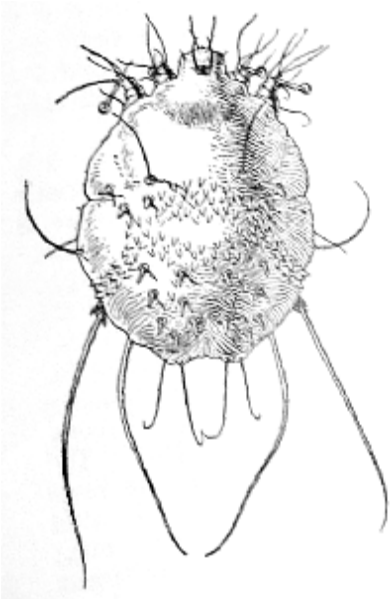
Domestic control measures against food mites should be made regulary.

Mite and Tick Gallery



Eriophyid Mite (*Eriophyes*)

Mange Mite (*Demodex*)

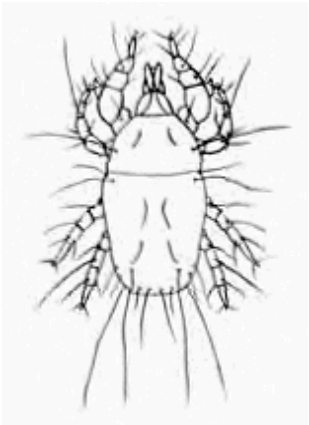


Scabies Mite (*Sarcoptes*)
Adapted from Mellanby (1972)

Soft Tick (*Ornithodorus*)

Hard Tick - Male (*Dermacentor*)

Body length: *Eriophyes*, *Demodex* and *Sarcoptes*, typically under 0.3 mm; *Ornithodorus* and *Dermacentor*, typically over 3 mm.



Dust Mite (*Dermatophagoides*)
length under 0.2 mm
Photo: J. Walsh - Micrographia ©

Practice:

Assignment 1.Morphology of ticks and mites :

Use charts, slides, microscopes and study morphology of:

1. Ixodes ricinus. Draw male and female (dorsal and ventral sides) and larva. Label: capitulum, chitinous integument hypostome, chelicerae and pedipalps legs. Draw attention, that larva has only three pairs of legs.

2. Ornithodorus and Gamazoidea ticks. Draw them.

3. Mites: Sarcoptes scabiei and Demodex folliculorum. Draw them.

Assignment 2. Biological characteristics and medical importance of some ticks and mites.

Copy and complete the table:

# #	Species	Inhabitance	Morphology	Life - cycle	Medical importance

TOPIC 30: CLASS INSECTA I

Key consepts:

1. General characteristics.

2. Morphology, life-cycle and medical significance of: lice (order Anoplura), fleas (order Aphaniptera), bugs (order Heteroptera), and cockroachers (order Blattoidea).

Insecta in general. The most advanced, structurally and functionally, the most numerous, the most successful and fascinating of all invertebrates are the insects. Insects may be found in every type of habitat, in every climate, in every country on the globe. All have the following characteristics which distinguish them from all other invertebrate animals:

1. Body divided into three segments: head, thorax (chest) and abdomen.
2. A pair of antennae at the top of the head.
3. A hard exoskeleton
4. Usually two pairs of wings.
5. Three pairs of segmented legs.
6. Breathing pores or openings on each side of body which led into tubes that branch throughout the entire body.
7. Compound, many-faceted eyes.

The insects differ from the rest of the arthropods in having only three pairs of jointed legs on the thorax and, typically, two pairs of wings. There are a great many different species of insects and some, during evolution, have lost one pair of wings, as in the houseflies and mosqutoes. Other parasitic species like the fleas have lost both pairs of wings. In beetles, grasshoppers and cockroaches, the first pair of wings has become modified to form a hard outer covering over the second pair.

The value of the external cuticle is to lie mainly in reducing the loss from the body, of water vapor through evaporation, but it also protects the animal from damage and bacterial invasion, maintains its shape and allows rapid locomotion. The cuticle imposes certain limitations in size. While they are growing, the arthropods periodically shed the outer layer of their cuticle when it has become too small. A new cuticle then forms over their expanded bodies. In insects, this moulting, or ecdysis, takes place only in the larval and pupal form and not in adults. Mature insects do not grow. The number of moults in any one species is usually constant, the forms existing between each moult being called ***instars.***

Internal structure. The ***digestive system*** of the grasshopper is a single tube running the length of the body. It consists of an ***oesophagus, a crop*** for storing food before it reaches the stomach; a ***gizzard*** that has tough walls for crushing food, a ***stomach*** where food is digested and a ***small intestine*** which widens into a ***large intestine.*** There are ***digestive glands*** in the mouth and stomach which supply digestive juices to the crop where some food is prepared for digestion.

The type of food an insect eats depends on the type of mouth parts it possesses. The mouth parts of beetles, grasshoppers are adapted for biting. Grasshoppers eat grass and other vegatation: beetles, which have sharp jaws for piercing and biting, live on other animals. Some insects have piercing and sucking mouth parts (mosqutoes and flies) and live on the fluids of plants or animals. Others have tubes for sucking the nectar of flowers (butterflies and moths).

Respiratory system. Running through the bodies of all insects is a branching system of tubes, ***tracheae,*** which contain air. They open to the outside by pores called ***spiracles*** and they conduct air from the atmosphere to all living regions of the body. The spiracles, typically, open on the flanks of each segment of the body.

The tracheal respiratory system is very different from that of the vertebrates, in which oxygen is absorbed by gills or lungs and conveyed in the blood stream to the tissues. In the

insects, the oxygen diffuses through the tracheae right up to the organ concerned, and the CO_2 escapes through the same path.

Blood system. The tracheal supply carrying oxygen to the organs makes the circulatory system rather less important to insects than it is in vertebrates, and it is generally little more than a single vessel running dorsally in the body cavity. External muscles propel the blood forward in this vessel and maintain a sluggish movement in the blood which surrounds the organs in the body cavity. Apart from this single, dorsal vessel the blood is not confined in blood vessel but occupies the free space between the cuticle and the organs in the body cavity. The blood, therefore, serves mainly to distribute digested food, collect excretory products and, in addition, has important hydraulic functions in expanding certain regions of the body to split the old cuticle and in pumping up the crumpled wings of the newly emerged insect.

Life-cycle. Insects lay eggs which hatch into ***larvae.*** These larvae are usually quite unlike the adult and are called grubs, maggots or caterpillars according to the species of insect. Generally the larva is the feeding and growing stage, eating voraciously, shedding its cuticle repeatedly and growing rapidly. When it has reached full size, the larva becomes inactive, neigher moving no feeding, and extensive breakdown and reorganization takes place within its body, giving rise eventually to the adult or ***imago*** form. The stage in the insect's life when these changes take place is called the ***pupa*** and the changes are called ***metamorphosis.*** The adults mate and lay eggs. The habitat, behavior, locomotion and feeding habits of the adult are quite different from the larva. In some insects, such as dragonflies, the nymphs live and grow in water for a year or so but live a few hours as adult: long enough to mate and lay eggs.

There are two forms of metamorphosis; one is referred to as ***incomplete*** metamorphosis and the other, ***complete*** metamorphosis. In complete metamorphosis, the egg hatches into a larva and larva changes into pupa which develops into adult organizm (imago). Moths and butterflies go through complete metamorphosis in their life cycles. They pass through several entirely different forms as they grow from egg to adult stage. The cockroach or locusts have another kind of life history. In these insects the egg does not hatch into a larva but a ***nymph*** which though still very different from the imago, more closely resembles it than does a larva. The nymph has three pairs of joined legs, compound eyes and rudimentary wings. At each moult, changes occur which bring it nearer to the adult form. The final ecdysis usually reveals drastic changes that have occurred in the final weeks of the nymph's development.

The most medical significance has got insects:

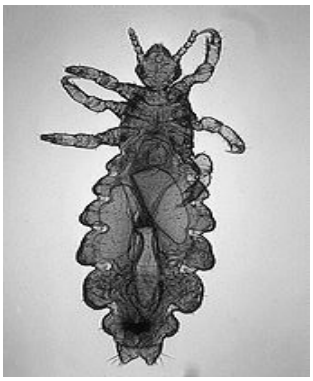
- mosquitoes, flies, midges (order Diptera)
- lice (order Anoplura)
- fleas(order Aphaniptera)
- bed-bugs (order Hemiptera)

Lice (Order Anoplura)

Lice are small insects which are wingless with mouthparts adapted for piercing skin and sucking blood. Lice are ***external parasites,*** living by hematophagy of the blood of mammals (including humans) and birds. Three species are parasites of man:

- Pediculus humans capitis (Head louse)
- Pediculis humanis humanis (Body louse)
- Phtirus pubis (Pubic louse)

Head Louse. The body is light-gray colored with dark pigmented spots on thorax and abdomen. Females are 3-4 mm long and males – 2-3 mm. Their bodies are dorso-ventrally compressed and divided into head, thorax and abdomen. Head is equipped with two short and thick antennas (an olfactorial organ), two sipmle eyes, and mouth apparatus.



Thorax is shaped as trapezium and consists of three segments, each of which has a pair of extremity ending with a mobile claw for attachement to the host. Abdomen consists of 9 segments, between them there are clearly visiblle incisures called festones.

The female louse glues her eggs to the hair of the head. Development goes with incomplete metamorphoses. Larvae and imago feed on blood and development lasts nearly 16 days.

Lice distribute relapsing fever and epidemic typhus .The agents of epidemic typhus are Prowache's Ricketisiae. They intrude lice's stomach with the blood of an infected person, penetrate into the epithelial cells of the intestine and reproduce 4-7 days; later Rickettsiae are passing out of the louse's body in its faeces on the skin of the host. A person gets infected while rubbing ***lice faeces,*** containing disease agents, into the scratches. Such way of the agent's transmission is called contamination.

The relapsing fever is caused by Obermayer's spirochete. Lice get infected while sucking blood a sick person. Spirochetes from lice's intestine move to the cavity and reproduce in the haemolymph.

A person gets infected while rubbing ***the dustructed lice*** into the scratches that itch.

Pediculus humanus humanus (body louse). They resemble head lices but are larger (female- 4-7,5 long, male –up to 3,75 mm), have longer and thinner antennas, less distinct pigmentation of abdomen, their incisures are not so deep.

Body lice locate in clothiers and underwear folds. They are ectoparasites, blood sucking insects. Life-cycle of the body lice is the same as of head lice.

Phtirus Pubis. They have short, wide pear-shaped bodies with four pairs of hairy protuberance on them. They are very small: females-1,5 mm, males-1 mm. Posterior extremities are longer than auterior ones. There are four pairs of hairy protuberances on their bodies.

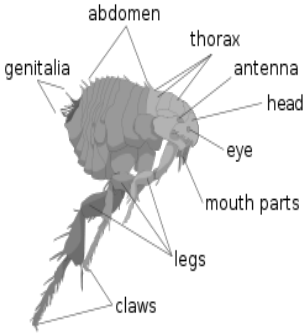
Localization and life cycle: on pubic hair, on eyelashes, eyebrows, moustash and beard. In the case of severe pediculosis they can be found in different parts of the body. Development goes with incomplete metamorphosis and takes 22-27 days. Female lays up to 3 eggs per day, imago and larva feed on blood.

Medical significance: lice are carries of diseases (relapsing fever and epidemic typhus) and all lice are agents of ***phtiriosis.*** The disease manifests itself by irritation and itching. Then bacteria may be rubbed or scratched into the tiny wound and start an infection.

A person gets invaded while contacting with a carrier or with his clothes, brush, hats, sheets. Phtiriosis can be transmitted during sexual intercouse.

Preventive measures can be gained by:

- preventing lice from breeding and reproduction
- following the hygienic rules: regularly washing the body with soap, processing of clothes in a special desinfection camera, hair cutting.



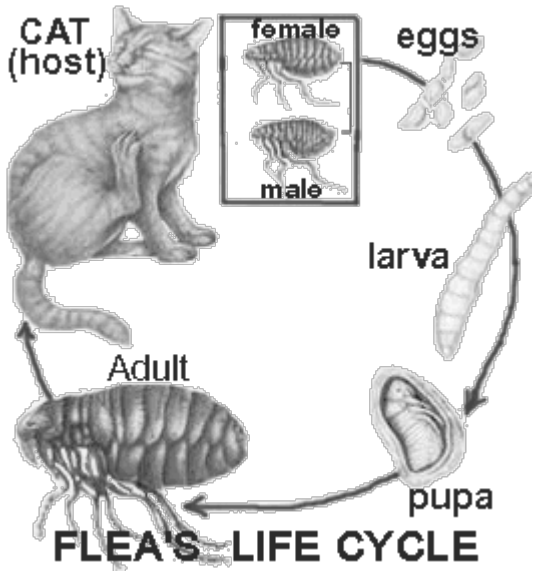
Fleas. (Order Aphaniptera)

Morphology and behavior

Fleas are small (1/16 to 1/8-inch (1.5 to 3.3mm long), agile, usually dark colored (for example, the reddish-brown of the cat flea), wingless insects with tube-like mouth-parts adapted to feeding on the blood of their hosts. Their legs are

long, the hind pair well adapted for jumping. Their bodies are laterally compressed, permitting easy movement through the hairs or feathers on the host's body (or in the case of humans, under clothing). The flea body is hard, polished, and covered with many hairs and short spines directed backward, which also assist its movements on the host.

Fleas lay tiny white oval shaped eggs. The larva is small, pale, has bristles covering its worm-like body, lacks eyes, and has mouthparts adapted to chewing. The larvae feed on various organic matters, especially the feces of mature fleas. The adult flea's diet consists solely of fresh blood. In the pupal phase the larva is enclosed in a silken, debris-covered cocoon.



Life-cycle, habitat. Fleas are ***holometabolous*** insects, going through the four ***life cycle*** stages of ***egg, larva, pupa, and imago*** (adult). The flea life cycle begins when the female lays eggs after feeding. Adult fleas must feed on blood before they can become capable of reproduction.http://en.wikipedia.org/wiki/Flea - cite_note-Florida-2#cite_note-Florida-2 Eggs are laid in batches of up to 20 or so, usually on the host itself, which easily roll onto the ground. As such, areas where the host rests and sleeps become one of the primary ***habitats*** of eggs and developing fleas. The eggs take around two days to two weeks to hatch.

Flea larvae emerge from the eggs to feed on any available organic material such as dead insects, feces, and vegetable matter. They are blind and avoid sunlight, keeping to dark places like sand, cracks and crevices, and bedding. Given an adequate supply of food, larvae should pupate and weave a ***silken*** cocoon within 1–2 weeks after 3 larval stages. After another week or two, the adult flea is fully developed and ready to emerge from the cocoon. They may however remain resting during this period until they receive a signal that a host is near –

vibrations (including sound), heat, and ***carbon dioxide*** are all stimuli indicating the probable presence of a host. Fleas are known to ***overwinter*** in the larval or pupal stages.

Once the flea reaches adulthood its primary goal is to find blood – adult fleas must feed on blood in order to reproduce. Female fleas can lay 500 or more eggs over their life, allowing for phenomenal growth rates.

Fleas attack a wide variety of ***warm-blooded vertebrates*** including dogs, cats, humans, chickens, rabbits, squirrels, rats, ferrets, and mice. Fleas are a nuisance to their hosts, causing an ***itching*** sensation which in turn may result in the host attempting to remove the pest by biting, pecking, scratching, etc. the vicinity of the parasite. Fleas are not simply a source of annoyance, however. Some people and animals suffer ***allergic reactions*** to flea ***saliva*** resulting in ***rashes.*** Fleas can also lead to hair loss as a result of frequent scratching and biting by the animal, and can cause ***anemia*** in extreme cases.

Besides the problems posed by the creature itself, fleas can also act as a ***vector for disease***. For example, fleas transmitted the ***bubonic plague*** between rodents and humans by carrying ***Yersinia pestis*** bacteria.

Bugs. Order Heteroptera

Bed bugs. They are small, elusive, and parasitic insects of the family Cimicidae. They live strictly by feeding on the blood of humans and other warm-blooded animals.

Adult bed bugs are reddish-brown, flattened, oval, and wingless. Adults grow to 4–5 mm in length and 1.5–3 mm wide. They do not move quickly enough to escape the notice of an observer. Newly hatched ***nymphs*** are translucent, lighter in color and become browner as they ***moult*** and reach ***maturity.***

Bed bugs are bloodsucking insects. They are normally out at night just before dawn, with a peak feeding period of about an hour before sunrise. Bedbugs may attempt to feed at other times if given the opportunity and have been observed feeding during all periods of the day. They reach their host by walking, or sometimes climb the walls to the ceiling and drop down on feeling a heat wave. Bedbugs are attracted to their hosts by warmth and the presence of ***carbon dioxide.*** The bug pierces the skin of its host with two hollow feeding tubes. With one tube it injects its saliva, which contains ***anticoagulants*** and ***anesthetics,*** while with the other it withdraws the ***blood*** of its host. After feeding for about five minutes, the bug returns to its hiding place. The bites cannot usually be felt until some

minutes or hours later, as a dermatological reaction to the injected agents, and the first indication of a bite usually comes from the desire to scratch the bite site. Because of their natural aversion for sunlight, bedbugs come out at night.http://en.wikipedia.org/wiki/Bedbug_-_cite_note-7#cite_note-7

Although bedbugs can live for a year or eighteen months without feeding, they normally try to feed every five to ten days. Bedbugs that goes dormant for lack of food often live longer than a year, while well-fed specimens typically live six to nine months. People commonly respond to bed bug infestations and their bites with anxiety, stress, and ***insomnia.*** Individuals may also develop skin infections and scars from scratching the bedbug bite locations.

Extensive testing in laboratory settings concludes that bed bugs are unlikely to pass disease from one person to another.http://en.wikipedia.org/wiki/Bedbug_-_cite_note-thebedbug-17#cite_note-thebedbug-17

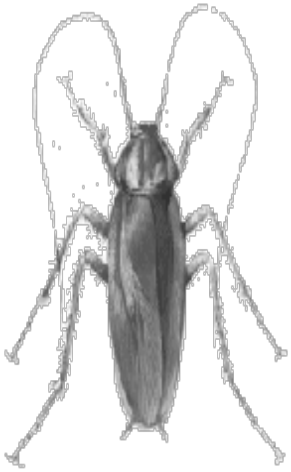
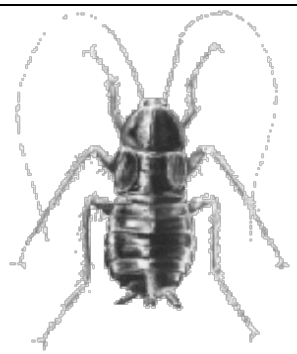
There is the possibility that the saliva of the bedbugs may cause ***anaphylactic shock*** in a small percentage of people. It is also possible that sustained feeding by bedbugs may lead to ***anemia***. It is also important to watch for and treat any secondary bacterial infection. Systemic poisoning may occur if the bites are numerous.

Cockroaches. Order Blattoidea

Cockroaches live in a wide range of environments around the world. The species of cockroaches adapt readily to a variety of environments, but prefer warm conditions found within buildings. Many tropical species prefer even warmer environments and do not fare well in the average household.

Cockroaches leave chemical trails in their feces as well as emitting airborne ***pheromones*** for swarming and mating. These chemical trails transmit bacteria on surfaces. Other cockroaches will follow these trails to discover sources of food and water, and also discover where other cockroaches are hiding. Cockroaches are mainly nocturnal and will run away when exposed to light. A female German cockroach carries an egg capsule containing around 40 eggs. She drops the capsule prior to hatching, though live births do occur in rare instances. Development from eggs to adults takes 3 to 4 months. Cockroaches live up to a year. The female may produce up to eight egg cases in a lifetime.The eggs are hatched from the combined pressure of the hatchlings gulping air. The hatchlings are initially bright white ***nymphs*** and continue inflating themselves with air, becoming harder and darker within about

four hours. Their transient white stage while hatching and later while ***molting*** has led many to claim the existence of albino cockroaches.

AMERICAN COCKROACH - PERIPLANETA AMERICANA.	
	Identification: The largest of the cockroach pest species, the body of an adult American cockroach or "water bug" is 1.5 to 2 inches in length. Color: reddish brown, with a yellowish band behind the head. Habitat: Preferred daytime habitat locations include the subfloor, basement, in sewers and other warm, dark, moist locations. They avoid cold areas but will thrive outdoors in temperatures above 80F. Indoors they often congregate around hot water pipes, fridge motors, boilers and other heating appliances.
ORIENTAL COCKROACH - BLATTA ORIENTALIS	
	Identification: The body of an adult oriental cockroach is about 1 inch in length. Dark brown to black in color. Habitat: Most often found in dark basements or cellars, but can also climb garbage shutes, sewer and water pipes to the upper floors in highrise buildings. Oriental cockroaches prefer to feed on starchy foods. Rapid breeding cycle: The female lives up to 2 years; deposits up to 18 egg-sacs in lifetime; each egg sac contains 16 eggs; incubation period is 1 to 2 months; development period is 12 months, undergoing 7 moults. An infestation will rapidly expand in ideal conditions, particularly during the warm summer months with temperatures regularly above 80F
AUSTRALIAN COCKROACH --- PERIPLANTA AUSTRALASIAE	
	Identification: the Australian cockroach is reddish brown and looks similar to American cockroach but is smaller at 1.25 inches (35mm) in body length. The Australian cockroach has`yellow strips on the outer edge of the front wings. A world-wide species that prefers a vegetarian diet. It is known to eat holes in clothing and even book covers. Habitat: Generally prevalent in areas where winters are relatively mild. They are opportunistic fliers and will infest anywhere adequate heat, humidity and food supply is available. Prime areas of interest are often pet food bowls and food waste storage areas. Rapid breeding cycle: The female lives up to 6 months; incubation period of eggs 40 days. An infestation can rapidly expand in ideal conditions, particularly during the warmer climates when temperatures are regularly above 80F.

Practice:

Assignment 1. Lice. External structure.

Use charts, slides, microscopes and study:

- morphology of the head louse, body louse and pubic louse. Draw them and label: head, thorax, abdomen, 3 pairs of legs with claws.
- eggs of lice. Draw an egg which is sticked to the hair.

Assignment 2. Morphology and life – cycle of flea.

Examine flea under the microscope. Draw it. Label: head, thorax, abdomen and legs. Draw the life – cycle of flea and label: egg, larva, pupa, and imago.

Assignment 3. *Comparative characteristic of some insects which have medical importance*

Copy and complete the table:

# #	Species	Presence (absence) of wings	Type of metamorphosis	Medical importance
1	Head louse			
2	Human flea			
3	Bed – bug			
4	Cockroach			

TOPIC 31: CLASS INSECTA II

Key concepts:

1. Morphology, life-cycle and medical significance order Diptera.

Order Diptera

These insects have only one pair of wings, which used in flight. The second pair being reduced to tiny stumps called ***halteres.*** In their life cycle they go through complete metamorphosis.

Culex One of the commonest kinds of mosquitoes found in dwelling-houses is the ***Culex pipiens.*** Culex includes many common species of mosquitoes which have a world-wide distribution, they are medium-sized and of grey colour. The adults hide in hollows of trees, caves, crevices, barns, etc. The life span of male mosquitoes is seldom more than three weeks; they die after impregnating the females. The females live from four weeks to several months, but they die after laying their full quota of eggs. Culex has several generations in a year.

Mophology. The body of mosquito is divided into ***head, thorax and abdomen***; it is covered with small scales. Head is globular and highly mobile on a slender neck. There are

two very large black ***compound eyes*** and two ***antennae with bristles.*** The bristles are longer and much more numerous on the antennae of males giving them a bushy appearance. In the female the antennae have whorls of a few short bristles: thus the sexes can be distinguished readily by the antennae. A female mosquito is attracted to a warm and moist surface of a warm-blooded animal such as man, pig and cattle. The mosquito is guided by smell. There are receptors on the antennae of the mosquito that have the power to identify the humen smell and also to feel the nature of the surface on which the mosquito alights.

Bisides the antennae, the head bears two maxillary palps and a proboscis. The proboscis is a straight long tube consists of tiny formed instruments for puncturing the skin and forming a channel through wich the blood is drawn into the alimentary canal. The natural food of both sexes is nectar of flowers and juices of plants modified for obtaining additional meals of blood of warm-blooded vertebrates.

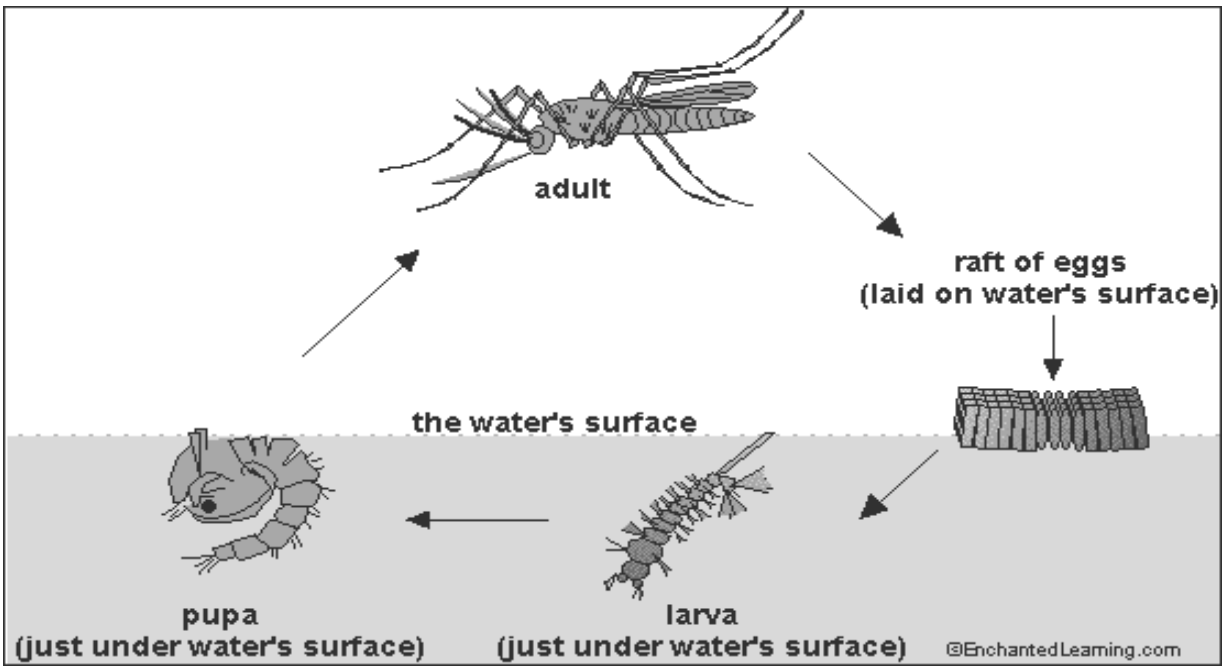
The thorax consists of three parts: ***prothorax, mesothorax*** and ***metathorax.*** On the thorax there are two pairs of ***spiracles.*** From the mesothorax arises the first pair of ***wings.*** The second pair of wings comes off from the metathorax but is reduced to form a pair of small ***halteres.*** They act as balances. From the thorax arise three pairs of ***legs*** which are very long and slender. The abdomen consists of 10 segments.

Life-cycle. After mating, the female lays eggs on still water; the eggs may be laid in ponds, pools, or rain-filled containers. The eggs are laid at night and one female my lay up to 300 eggs. The eggs are cigar-shaped and tapering at one end. The eggs are laid side by side standing erect, they are glued together to form boat-shaped ***rafts*** which float on water. The eggs hatch in 1 to 3 days, and the larva emerges from the lower end of the egg.

The larvae are called ‘wrigglers’ because of their wriggling movements, they are microscopic on hatching. The larva leads an active life, it swims about, feeds and grows, and the larval life lasts from 3 to 14 days according to temperature. During this period it moults and grows larger after each moulting. The larva feeds below the surface of water. The food consists of algae and small organic particles. The last segment of abdomen has a tubular ***respiratory siphon.*** The larva, though aquatic, breathes air through the ***siphon*** and comes to the surface to take in air. After the fourth moult, the larva changes into a pupa.

The pupa is comma-shaped. It has a large cephalothorax formed of the head and thorax. On the mid-dorsal side of the cephalothorax is a pair of tubular ***respiratory trumpets*** which are broader at the distal end. By means of the trumpets, the pupa hangs from the surface film

of water and takes in air through their distal ends which project slightly above water. Behind the cephalothorax is abdomen. On it are tufts of bristles, the ***hydrofuge hairs,*** which are separated at the water surface but fall flat when under water. The last segment bears a pair of chitinous paddles by which the pupa swims.



The pupa is a resting stage: during this period it does not feed, but the pupae of mosquitoes are active and can swim about. Unlike the larva, the pupa is lighter than water and requires a muscular effort to sink down. The pupal period lasts several days depending upon the temperature. During this time remarkable changes occur inside the pupa leading to the formation of an adult or ***imago*** mosquito. When the imago is completed, the skin of the pupa cracks and the imago emerges. The imago rests for some time on the pupal skin; it stretches and dries its wings, then flies off. It can start laying eggs in a week's time and thus repeat the life-history. This form of development is termed ***complete metamorphosis.*** The pupa undergoes very great internal changes in order to form the imago. Thus, in complete metamorphosis, the stages in the life-cycle are: egg→larva→pupa→ imago, and the adult wings develop inside from the imaginal buds.

Anopheles mosquitos. Several species of Anopheles are the carries or vector of a protozoan Plasmodium which causes malaria fever. Anopheles mosquitoes are generally active at twilight and early morning. Both sexes feed on honey and plant juices, but the females also suck the blood of vertebrates. Anopheline mosquitoes breed mostly in natural waters, such as ponds, swamps, rice-fields, and grassy ditches.

Anopheles resembles Culex in many details of structure and life-history, but it has certain characters by which it can be identified in all the stages of development.

***Imago*.** In male Anopheles the maxillary palps are longer than the proboscis, and are five-jointed, the last two joiints are flat and broad, so that the palps appear club-shaped. In the female the maxillary palps are usually as long as proboscis, but sometimes shorter than the proboscis. In Culex the maxillary palps of the male are usually as long as proboscis but are not club-shaped; in the female they are always short and tree-jointed.

The wings of Anopheles are marked with dark spots, while in Culex they are unspotted. Anopheles rests with its body at an angle to the surface, its proboscis being in line with the body; Culex rests with its body paralled to the surface and its proboscis is not in a straight line with its body.

Eggs. Female Anopheles lays 40 to 100 eggs at one time; the eggs are pointed at both ends and have a pair of lateral ***air floats.*** Eggs are laid singly and lie horizontally on water. In Culex the eggs are cigar-shaped, with no air-floats and they form floating rafts standing vertically.

Larva. There is no respiratory siphon in the larva of Anopheles. The larva hangs horizontally by means of the palmate bristles and the quadrilateral plate of the 8- th segment from the surface of water; this is a characteristic resting position. In this position it touches the water surface in several places and the spiracles project above the surface of water. The head of the larva is longer than broad and it feeds on the surface of water.

In Culex, the larva hangs by its respiratory tube with the head downwards; it touches the water surface only at one place by its siphon. The head is round and the larva feeds below the surface of water.

Pupa. In Anopheles the ***respiratory trumpets*** are short and broad and with a large terminal opening. In other mosquitoes, the respiratory trumpets are long and narrow, with a small terminal opening but with no split. The abdomen of the pupa of Anopheles is more strongly curved than in Culex.

Medical significance of mosquitoes. They are responsible for several diseases in humans, some of which are deadly. Many species of mosquitoes transmit disease in man and animals in two ways. They act as a host for disease-producing organisms which multiply in the mosquitos or mosquitoes are mechanical carries of such pathogens as bacteria, viruses and helminthes. In that case there is no multiplication of the disease-organism in the mosquitoes.

Flies

Musca domestica. The house-fly is very common in human dwellings; they are especially abundant and very active during summer. In winter most of them die. They rest at night on ceillings, walls.

The body of insect is grey-coloured and divided into head, thorax and abdomen. The head is large and freely mobile, it bears rwo large compound eyes laterally and three simple eyes on a triangular ocellar plate. The head also bears month parts which are modified for lapping up liquid food. The proboscis is extended and the labella are placed on the flued, the labella can smell and taste the food. By the suctorial action of the pharynx fluid food and very fine solied particles are sucked up into the mouth and then go to the alimentary canal. Hous-fly feeds on any organic fluid and also on solid substances, especially sugar and sweets; the fly regurgitates a drop of liquid from the alimentary canal and saliva from salivary glands on to the solid food. The alimentary canal fluid and saliva liquefy the solid particles of food which the fly sucks up.

The thorax is formed mostly by an enlarged mesothorax; the prothorax and metathorax are greatly reduced and almost hidden on the dorsal side. The large mesothorax bears a pair of wings. The wings are transparent. The metathoracic wings are much reduced and modifed to form ***halteres*** which are balancing organs, they vibrate rapidly during flight. Below the thorax arise three pairs of ***legs*** which have normal leg-segments. They ended in two claws, below which are two pad-like ***pulvilli;*** the pulvilli secrete a sticky fluid by means of which the fly can rest and walk on ceilings and smooth surfaces like glass panes without falling. The legs bear a large number of ***bristles.***

The abdomen is broad in the middle and narrow towards the apex. There are some segments in the abdomen and the attachment of abdomen to thorax is narrow.

Life-cycle. After mating, the female house-fly lays her eggs in human faeces, garbage, or decomposing animal and vegetable matter. The conditions required for laying eggs are moisture and a favourable temperature, hence stable manure or human faeces should not be dry. The house-fly lays eggs in stable manure by preference. The female lays about 120 to 160 eggs at one time. An egg is whitish, cylindrical and has two longitudinal rib-like thickenings on one side. The total larval period is from 6 to 8 days, during this time the larva moults twice, and it feeds and grows larger at each moulting. Actively feeding larva moves away

from light into moist and dark parts of the dung; it produces enzymes by which food is liquefied and it takes in liquids and small solid particles.

The larva changes into a pupa without moulting, the last larval skin hardens to form an outer covering or puparium which encloses the pupa. The pupa is immobile and the pupal stage lasts from 4 to 5 days. During this time ***histolysis*** occurs by the phagocytes feeding upon the tissues of larval organs. The ***imaginal buds*** of the larva begin to form organs of the adult. By these processes the adult fly or ***imago*** is formed from the pupa. The fly breaks the puparium which splits and the imago comes out. The wings of the imago dry and it flies off to become sexually mature in one week.

The flies are carries of pathogens. They pick up disease germs on their bristly legs and sticky pulvilli, and then they come and brush their legs on to human food. They also take in disease-organizms into their alimentary canal which they transfer to human food through their faeces, and through exuding saliva and fluids of alimentary canal on to human food. Thus house-flies are very dangerous and transmit organizms which cause human intestinal disorders, such as typhoid, paratyphoid, diarrhoea, both bacillary and amoebic dysentery, gastroenteritis and cholera.They also transmit tuberculosis and virus of poliomyelitis and cause food-poisoning. Often the eggs of helminth parasites of man have been found in the alimentary canal or faeces of house-flies and they transmit two much parasites; the eggs of a tapeworm are transferred from the faeces of one person to infect another.

Blood-sucking flies.

Some flies have mouth parts adapted for sucking the blood of man and animals; consiquently, they are vectors or carriers of diseases.

1. Glossina (tsetse-fly). They are slightly larger than house-flies. Tsetse fly is a vector of trypanosomes which are injected in the blood and lymph glands of humans, then trypanosomes enter the cerebrospinal fluid and cause sleeping sicknees which results in drowsiness, coma and finally death.

2. Stomoxys-fly (stable or biting house-fly). Stomoxys calcitrans is found all over the world. They are the vectors of Trypanosomes which cause surra in horses and cattle. They also transmit blood infections of cattle and serve as intermediate host of Nematodes.

3. Phlebotomus (sand-fly). They are small, slender hairy midges found all over the world. Mouth parts are for piercing and sucking; they suck the blood of mammals and reptiles.

Phlebotomus papatasi causes “sand-fly fever” in man.This disease resembles dengue and influenza. They are also vectors of various types of leishmanias.

4. Wohlfahrtia magnifica*.They is* large gray flies (9-13 mm) with dark stipes on thorax. Two thinner lines run alongside the medial one. There are dark spots on their bodies.

Females are viviparous and give birth to larvae that parasitized in human and animals tissues. Females are attracted by wound pus smell. Larvae are worm-liked about 1mm long. They feed on tissues and then devour bones distroying blood vesseles. Having spent 2,5-5 days in the wound, larvae travel into the soil, turn into chrysalis and become imago in 11-23 days.

Larvae of Wohlfahrtia magnifica are pathogens of disease named ***myiasis.***

To prevent myiasis in humans, there is a need for general improvement of sanitation, personal hygiene, and extermination of the flies by insecticides. Clothes should be washed thoroughly, dried away from flies, and ironed.

Practice:

Assignment 1. Life – cycle of mosquitoes: Anopheles, Culex.

Use charts, slides, microscopes and study the stages of life – cycle of Anopheles and Culex.

- Make a diagram: “Comparison the life – cycle stages of Anopheles and Culex.” Label the stages of the life - cycle.
- Copy and complete the table:

Comparison of Anopheles and Culex.”

Stage	Anopheles	Culex
Imago (adult)		
Eggs		
Larva		
Pupa		

Draw attention to the following:

1). Imago: - colour of the body;

1. mouth parts;
2. wing’s structure;
3. resting position.

2). Egg: - shape;

1. presence (absence) of air floats.

3). Larva: - resting position;

1. presence (absence) of respiratory siphon, palmate bristles;

2. mode of feeding.

4). Pupa: - structure of respiratory trumplets.

1. shape.

Assignment 2. Morphology of house – fly.

Use charts and wet preparations and study the morphology of house – fly. Draw and label the main parts of the body: head, thorax, abdomen, compound eyes, legs, wings.

Draw tip of tarsus and label: pulvillus and claw.

Submodule 7

TOPIC 32: MODERN EVOLUTIONARY SYSTHESES.

HOW HUMANS EVOLVED.

Key concepts:

1. What is evolution?
2. What are the essential features of Darwin's theory of Natural Selection?
3. What is a population, species, microevolutim?
4. What are the main processes of evolution?
5. Characteristics and role mutation, genetic flow, genetic drift and natural selection in the evolution.
6. What is the role of natural selection in the human's populations?
7. How Humans evolved.

Evolution is the process by which new species are formed from pre-existing ones over a period of time.

- Every organism tends to increase in geometrical proportions in its population. But it is not observed in nature. More number of individuals is eliminated, because available resources support only a limited number of organisms. Over population results in severe ***competition.*** Darwin called it ***struggle for existence.***
- During the struggle for existence, the organisms with beneficial variations alone will survive. These variations are sorted out by nature through competition - natural selection.

Modern Evolutionary Synthesis is based on:

1. Darwin's Theory of Natutal selection.
2. Population Genetics – study of genetic variation within a population. Population is a localized group of individuals of the same species.

   In «Origion of Species «Darwin regarded hereditery, variations and struggule for existence as the chief factors of evolution. Each species produces more offspring than will survive to maturity.Organisms complete with another for the limited resources available to them.There is variation among organisms.Individuals that posseses the most favorable combination of characteristics are most likely to survive and reproduce. That is, there is a "struggle for existence» (natural selection). The process of natural selection causes an increase of favorable genes and a decrease of unfavorable ones within a population. Over time these changes accumulate in populations and may be significant enough to cause a new species to arise.

Species – a group of populations whose individuals have the ability to breed and produce fertile offspring. To genetics, a population is an inter-breeding group of organisms. The genes of a population are freely interchangeable. The total of all the alleles of all the genes in a population is called **the gene pool.** Within the gene pool the number of times only one allele occurs is referred to as its frequency. On its basis the Hargy-Weinberg principle was formulated. Accoding to this principle evolution is the change of certain genes over time.

Evolution occurs within a species of population. It is ***microevolution.*** Microevolution refers to changes in allele frequencies in a gene pool from generation to generation. It represents a gradual change in a population.

Causes of microevolution:

- Genetic drift.
- Natural selection
- Gene flow
- Mutation.

Genetic drift is the alteration of the gene pool of small population due to chance. Two factors may cause genetic drift:

- ***Founder Effect.***

Theis occurs when a small amount of people have many descendants. In the Lake Maracaibo region of noth-west Venezuela, there is a high frequency of a severe genetically inherited degenerative nerve disorder known as Huntington's disease. There is no cure for this

disease, but there has been a test for its genetic marker available since 1993. All of the Lake Maracaibo region Huntingtow's disease victims trace their ancestry to a woman named Maria Concepciyn who moved into the area in the 19^{th} century. She had a large number of descendants and was the "founder" of what is now a population of having this trait.

- ***Bottleneck Effect.***

It is another form of genetic drift. In many species, there have been catastrophic periods caused by rapid dramatic changes in natural selection, during which most individual's died without passing on their genes. The few survivours of these "bottlenck" then were reproductively very succesul, resulting in large populations in subsequent generations.

Bottkennecking also occurs at times in human populations as a result of major epidemics and catastrophic storms, earthquakes, and volcanic eruptions.

Gene flow – is the movement of genetic information from one generation to another. Migration erases genetic differences between populations. Populations of the same species are usually not isolated from each other. Between them are constantly being exchanged genes. Animals migrate from one population to another. Pollen and seeds carried by the wind, currents. Isolation contrary, leads to an accumulation of difference. When differences between populations make it impossible crossing, formed a new species. Isolation - a necessary condition for speciation.

Mutation. Any change in genotype of an organism is called mutation. It provides and maintains genetic variation amongst individuals in a population. The frequency of mutation is not the same for different genes in different organisms. It increases in response to external factors, such as ionizing radiation, certain chemicals, viruses and changes the internal state of the body (aging, stress, etc.). The average frequency of mutations in bacteria is estimated as 10^{-9} per gene per cell per generation. In humans and other multicellular it's higher at 10^{-5} per gene per gamete per generation. In other words, only one of 100,000 gametes gene is altered. This would seem negligible, but the genes in each gamete very much. The human genome contains approximately 30000 structural genes. Therefore, in every generation about a third of human gametes are new mutations on some gene. Mutation process creats changes the frequencies of alleles in populations.

Natural selection. Organisms, which are physically, physiologically and behaviourally better adapter to the environment, are selected. They survive adapted; either fail to reproduce or die. Selection is an operative process that occurs in a population.There is a difference in

reproductive success of individuals. A measure of the reproductive success is the ***fitness*** or adaptive value of a genotype. Selections are three types.

Stabilizing selection:

- selection against the two extremes in a population (e.g., birth weight in humans)

Directional selection:

- selection for one extreme in a population, against the other extreme (e.g. antibiotic resistance in bacteria)

Disruptive selection:

- Selection for the two extremes in a population, against the average forms (e.g., flies on two hosts: apple and hawthorn).

In humans, natural selection has lost the function of speciation. Behind him is preserved stabilization function of the gene pool and maintain hereditary diversity. In favor of the stabilization of the form of natural selection indicates a high mortality among preterm and post-term infants. Found that about 15% of human fetuses die before birth, 3 % die before reaching sexual maturity, 20% of people do not marry, and 10 % of marriages are sterile.

Sources of ionizing radiation are widely used in human medicine, agriculture, industry and other mutagenic effects of ionizing radiation has long been known, but it is especially evident in the explosion of the atomic bombs in Hiroshima (1945) and the Chernobyl nuclear power station (1986). Chernobyl accident had an impact on the health of 3.4 million people. Major diseases that recognize the consequence of the accident, mainly considered oncological diseases of the circulatory system and nervous system. In addition, the overall level of chromosomal aberrations in children from the radiation monitoring is three times higher than for children outside this zone. Damage to the hereditary material of somatic and germ cells may lead to the gradual degeneration and death of individual human populations.

Human Origins. Darwin (1871) proved that man descended from a common ancestor with modern apes. Similarities with apes : the presence of nails, 12-13 pairs of ribs, 5-6 sacral vertebrae, the structure of the ear, eye, skin, four blood groups, common parasites of the same disease, emotions, etc.

Anthropogenes stages. The remains of Australopithecus were found in the 30s in South Africa. Australopithecus lived 5 million years ago - human ancestors (Homo habilis). He manufactured the cutting and chopping tools of pebbles. It belongs to, australopithecine or to very ancient people. In becoming man distinguish 3 stages: very ancient, ancient and early

modern humans. They are not replaced one another with complete disappearance of the previous and coexisted and not peaceful relations. Pithecanthropus - ape, found on Java in Europe, Asia and Africa, made tools, used fire, led gregarious lifestyle. Peking man (a Chinese man) found near Beijing. Pithecanthropus and Sinanthropus - 2 types of first subgenus - ape (type of people). Some refer here Homo habilis. Homo habilis were cannibals.

Ancient and modern mans. In 1856 in Europe discovered the remains of Neanderthal Homo erectrus. He lived 150,000 years ago in groups of 50-100 people. Used gestures, sounds, had the beginnings of speech. This species belongs to the subgenus ancient people (kind of people). He was under the influence biological (natural selection - survived hardy and strong) and social factors (work in a team, the joint struggle, the development of intelligence). Last Neanderthals (28 thousand years ago) lived among the first Cro-Magnon. Cro-Magnon found in France, lived 30-40 thousand years ago, had a speech, polished, drilled, potters, domesticates animals, engaged in farming, and had the rudiments of religion. Leading role in the evolution of the Cro-Magnon played social factors: education, training and knowledge transfer. They protected the offspring and the elderly - media experience. Laws of social life play a guiding role in the social progress of mankind. In this qualitative distinctiveness of human evolution compared to the evolution of animals.

Practice.

Assignment 1. Factors of Evolution.

Copy and complete the table.

Factors	Characteristics
Genetic drift	
Natural selection	
Gene flow	
Mutations	
Isolations	

Assignment 2. Characteristics of Hominids.

Copy and compele the table.

Hominids	Characteristics
Australopithecus	
Homo habilis	
Homo erectus	
Homo sapiens	

Topic 33 PHYLOGENESIS OF VERTEBRATE'S ORGANS.

Key concepts:

1. Analogous and Homologous organs.
2. Biogenetic Law.
3. Phylogeny the following systems of Vertebrates:
   - ✓ respiratory system
   - ✓ blood vascular system
   - ✓ excretory system
   - ✓ reproductive system
4. Congenital malformations of these systems that are prehistory of ontophylogenesis.

Historical development of organisms indicates the relationship between the major groups. Important kinship between organisms reveals comparative anatomy - the science that studies the same organ systems in different animals. In comparative anatomy distinguish two forms of similarity: homology and analogy.

Organs, having the same embryonic origin and plan, though different in functions, are called **homologous** organs. Homologies indicate relationship between their possessors. Homology is a question of percentage, the stamp of heredity. An arm of man, a leg of horse, a wing of bat, a wing of bird and the flipper of seal arc apparently different from one another in structure **and** function, yet all of them are built on one basic plan, hence they are homologous. The differences in them are to be explained on the basis of adaptation to special conditions.

Homologies are to be found in many systems of vertebrates; all of them from fish to man have a dorsal vertebral column formed of a number of jointed vertebrae. All mammals have seven cervical vertebrae, if may be a rabbit with average neck, a whale with no neck, or a giraffe with a long neck, this constancy is due to common ancestry.

The brain of vertebrates presents another good example of homology. The brains of vertebrates ranging from fishes to mammals are constructed of similar parts: olfactory lobes, cerebral hemispheres, optic lobes, cerebellum, medulla and so on. As one moves higher through the series some lobes become more prominent than other. This happens due to adaptations and evolutionary change. Thus, the optic lobes in fishes; in mammals they become more prominent, hiding the traces of optic lobes beneath them.

The only conclusion from these evidences is that animals having homologous structures must have arisen from common ancestors, and though successive generations extending over millions of years, groups of organisms have diverged more and more from the ancestral types, usually towards more perfect adaptations to their particular place in the world.

Analogous organs have different embryonic origin, but are similar in appearance and function. The wing of bat and a wing of pterodactyl or the wing of an insect, all serve the same function, though they have different origin and structure. The sills of fish and crustacean are analogous; the shape of bodies of fishes and whales are analogous. Analogy is a due to a similarity of environment, and sameness of functions, which result in **a** superficial resemblance of analogous structures.

Biogenetic law. As evolution suggested that more complex organisms would have achieved their state by elaborating on the existing development patterns of more primitive forms, so one would expect to find that certain relatively simple organisms and more complex ones have many initial developmental steps in common. In fact, the more developmental steps two species have in common, the more closely related they are to a common ancestral form.

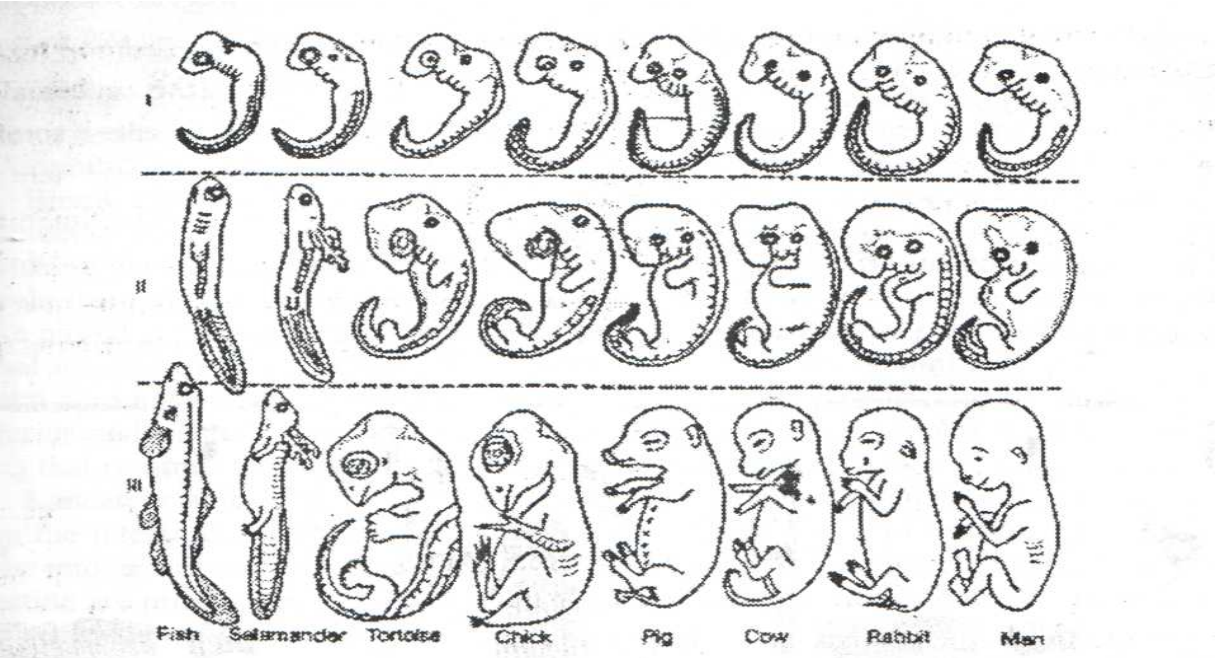
Comparative embryological studies have revealed that there was one developmental pattern that could be viewed as having undergone a series of branching. All multicellular animals start their development as a single zygote and through a series of mitotic divisions, increase in cell number until a blastula is formed. The developing embryo elaborates upon the blastula stage by forming two fundamental germ layers, ectoderm and endoderm, during the course of gastrulation. After the differentiation of the ectoderm and endoderm in the gastrula, the third germ layer, mesoderm, is formed.

Another feature of embryological development that serves to link all multicellular animals is the embryological source of organ systems. Regardless of the way in which the developing animal’s arc programmed for further differentiations of mesoderm they exhibit similar adult structures derived from the two primary germ layers. The outer covering of all multicellular animals, be it skin, scales, or gelatinous material, is derived from ectoderm. The universal features of ectodermallv and entodermally derived tissues also indicate the presence of a common ancestral type early in evolutionary history.

It is most commonly observed that the embryos of higher animals repeat many of the stages through which embryos of higher animals have passed. This has been referred to as

recapitulation. This concept, as originally used by von Baer (1792-1876) indicated that some of the developmental stages of an organism are similar to the developmental stages of its ancestors. Unfortunately, however, E.Haeckel in 1866, modified the concept into a "biogenetic law" which stated that *'ontogeny recapitulates phytogeny"*, i.e., in its development, the individual passes through stages like the adult stages of its ancestors.

There are numerous examples of recapitulation phenomenon during embryonic, development, but one of the best is afforded by a comparison of different vertebrate embryos at comparable stages in development. During the early embryonic stage in the series, all the embryos look very much alike. All have similar pharyngeal arches and pharyngeal clefts. At somewhat later stage in the series, the limb-bud primordia of fore-and hindlimbs are forming in all embryos in a similar way and all of them have embryonic tails. The embryos of the lizard, chick, opossum, monkey, and man have strong resemblances, yet those of the fish and salamander are beginning to assume recognizable forms. At this stage, gills have formed from the use lining the gill-clefts of both the fish and salamander. Later, each embryo has features that indicate fairly clearly its definitive nature.



Comparison of three embryonic stages from fish to man

Further, in the development of any mammalian embryo, the heart is a four-chambered in series structure, as it is in fish embryo; then it develops partitions of the auricle (atria) similar to those of amphibian embryos, followed by ventricular division that is incomplete for a period, as it is in the embryos of reptiles. A similar example, of recapitulation is found in mammalian embryos in the formation of pronephric, mesonephric and metanephric kidneys.

The development of individual forms has certain embryological principles. These are:

- during development, general characters appear before special characters;
- from, the general characters, first the less general and finally the special,characters are developed;
- during development, any animal departs progressively from the form of other animals;
- embryonic stages of some higher animals resemble the embryonic stages of lower animals, but not the adult form of these latter;

It must be assumed that changes occur, resulting in the origin of one type of animal from an ancestral form. This does not happen by the addition of new stages on the end of the ancestor's completed development, but by some modifications the early stages. Thus, for example, a mammal at no stage resembles an adult, but it does pass through a stage similar to that of the embryo of its reptilian. Once the embryo of a more advanced form has passed beyond the point of balance to the ancestral embryo, then the embryo itself may become magnificently adapted to successful development, quite apart from the superiority of the adult to which it gives rise.

It's possible to explain some anomalies of the development using a conception of of evolutionary development.

Phylogeny of the chordates respiratory system.

Function of the respiratory system:

1. The gas exchange between the organism and the environment (respiratory function).
2. Conducting air.
3. Osmoregulation.
4. Clearing the air from dust and small organisms.
5. Formation sound.
6. Isolation.

Respiratory system all chordates by location and structure associated with the intestine. In **aquatic chordates** respiratory function operate gill slits which penetrate the anterior part of the intestinal tube. Evolution of the gill apparatus in aquatic chordates accompanied by decrease in the number of gill slits and an increase in respiratory surface by the formation of the gill filaments . The fish has a 4-5 gill pouches.

The larvae of **amphibians** gill breathing, in adults appear lung bags. Pulmonary bags formed as doubles saccular outgrowth ventral side of the pharynx. Light primitive airways poorly differentiated. Therefore, respiratory function, other than the lungs, skin performs, filled with capillaries.

Reptiles complicated lungs develop numerous cellular crossbar, which increase the respiratory surface of the lungs.The bronchial airways appear.

Lungs of **birds** - is spongy body riddled branched bronchi, not bags, as in reptiles.

In mammals: the more complicated the bronchial tree; the bronchi appear second, third and fourth orders, bronchioles, on the ramifications of which are the alveoli. Due to this pulmonary respiratory surface increased.

In humans: lung area is 90 m2 branching, bonchi are 23 orders of magnitude. Thoracic cavity is separated from the abdominal cavity by the diaphragm, which plays an important role in the act of breathing.

Thus, the main direction of the evolution of the respiratory system is to increase the respiratory surface and the isolation of the airway.

Phylogeny of the chordates circulatory system.

The functions of the circulatory system:

1. Interaction with the environment (gas exchange).
2. Transportation and distribution of substances between blood and tissues.
3. Humoral regulation.
4. Protective function.
5. Osmonegulation.
6. Supports homeostasis.

In lower chordates there is no heart. Complication of the circulatory system in vertebrates is associated with the appearance of the heart, contraction of the gill arteries and their differentiation. In lower chordates (Amphioxus) it’s one circulation. Role of the heart performs the abdominal aorta, which extends from 100-150 pairs of gill (arterial) arcs. In lower chordates (Amphioxus) it’s one circulation.

In fish apeare two-chambered heart, the number of arterial arches reduced to 6-7 pairs. They have one circulation. In the heart only deoxygenated blood.

Amphibians heart 3- chamber and 2 circulations. The heart has two atria and ventricle. They are connected by a valve. In ventricle blood is pumped from the atria alternately -

venous and arterial. Ventricular walls are muscular growths (trabeculae), so the blood in the ventricle mixed unevenly on the right side – almost venous, in the middle - is mixed, and the left - almost arterial. Arterial arch originate from the remainder of the abdominal aorta, which starts from the right side of the ventricle. Amphibians remain VI, IV and III couple arterial arches with the reduction of ventricular blood to the abdominal aorta , and flows through the second pair of arterial arches (pulmonary artery, venous blood) to the lungs and skin, where oxygenated and returned to the left atrium (the pulmonary circulation) . They have a couple of IV mixed blood that goes to the body and on the third pair relative to arterial blood to the head (carotid arteries). From the head and body the blood returns to the right atrium (systemic circulation).

In reptiles, the heart of a 3- chamber and two circulations, but there is a rudimentary partition in the fourth ventricle chamber. Between the atria and ventricle appear two valves. Abdominal aorta disappears, and pair of arterial arches departs from the heart (the systemic circulation). Small circle separated from the big. From the right side of the ventricle begins 6th pair arterial arches (pulmonary artery, a small circle). From the left side of the ventricle, where it is relatively arterial blood originates third pair with the fourth right. The third pair corresponds to the carotid arteries, and the fourth right - own the aortic arch. Fourth left originates from the incomplete ventricular septum, mixed blood flowing (large circle). Fourth right and left, skirting the heart, joined together and sent to the body (accept the head).The crocodiles have 4 -chambered heart, but the blood is mixed in the systemic circulation.

In birds and mammals, four-chambered heart: two atria and two ventricles. Blood is not mixed; there are two circulations - big and small.

Systemic circulation starts from the left ventricle by aorta, arterial blood spreads through the body, and then passes through the capillaries and veins in venous transferred to the right atrium. Pulmonary circulation originates from the right ventricle. Venous blood through the pulmonary arteries flows to the lungs, and oxygenated (arterial).Onthe pulmonary veins the blood enters the left atrium.

Birds have an IV atrophied left arc and they have the right arc; **in mammals** is only IV left arc. The fifth pair of arcs in all vertebrates atrophies. The sixth pair of arcs loses contact with the dorsal aorta.

The vessel, which binds in embryonic development the pulmonary artery with the dorsal aorta, called arterial duct (residue V arc) .It operates in reptiles.

Thus, the evolution of the circulatory system is moving towards increasing the chambers of the heart, and reduces vascular differentiation extending from the heart. All that increases the oxygen contents of blood.

Congenital malformations of the circulatory system, which are results of abnormal ontophylogenesis.

1. Aortic ring instead of one (left) of the aortic arch develop two arcs that encircle the trachea and esophagus and connected to an unpaired dorsal aorta. Trachea and esophagus are in the aortic ring, which shrinks with age.
2. Cleft septum near the oval fossa, which is opening in the embryo.
3. Cleft arterial duct.
4. Cleft interventricular septum and then there is a three-chambered heart.
5. At a certain stage of development the embryo has one spiral arterial trunk, which is divided by a partition into the aorta and pulmonary trunk. If the partition does not develop, the arterial and venous blood, are mixed which leads to death.
6. Transposition of the aorta - if the partition is not formed spiral and straight shape; the aorta will depart from the right ventricle and the pulmonary trunk - from the left.

Phylogeny of the excretory system

Excretory system in chordates built on the lines of nephridia. Evolution of the excretory system was to transition from lower chordates nephridia to special organs, the kidneys. The kidneys are made up of a large number of nephrons and excretory channels are connected to a common excretory duct.

In vertebrates, there are 3 types of kidneys: pronephros, mesonephros, and metanephros.

In cyclostomes, fish and **amphibian**s in embryogenesis laid pronephros (pronephros or head kidney). It consists of 6-12 metamerically located funnels. Each funnel (nephrostome) has cilia on the edge and opens into the body cavity (coelom). The secretory tubule (pronephric) departs from the funnel and vascular glomerulus laid near funnels. Decomposition products come from blood vessels into the coelomic cavity and then through the funnel to the excretory canal. These metanephridial tubules resemble the excretory system of the worms. Pronephros functions only in some adults cyclostomes (hagfish).

In cyclostomes, fish and amphibians (anamnii) in embryogenesis formed primary kidney behined pronefros. Mesonephros consists of it metamerically arranged pairs of ciliated funnels. Their tubules grow toward pronephros ducts and open in them. Pronephric channel

becomes mesonephric. It is split into two channels: mezonefralny (Wolffian) and paramezonefralny (Muller) channels.In different classes and in different sex they perform different functions. In female fish and amphibians Wolffian duct is converted into the ureter and Mueller -in the oviduct.In the males of lower vertebrates Wolffian duct functions as the ureter and vas deferens, and Mueller channel atrophies. The funnel, which opens in coelom, is a common for pronephros and mesonephros. On the wall of mesonephros excretory canal protrusions appeared as a double-walled bowl (glomerular capsule). It invades the blood glomerulus. Waste products come not only through the funnel of the whole, but also from the blood.

It's a connection between the circulatory and excretory system. Excretory duct becomes longer and forms curves, which allows water reabsorption, glucose and other substances, whereby the concentration of the urine occurs.

In reptiles, birds, mammal's secondary kidney laid in the pelvic section, behind the mesonephros. In metanephros there is no funnel (nephrostome) and communication with the coelomic cavity is completely absent. Nephron begins with capsule, which lies in the middle of the vascular glomerulus – this is renal corpuscle. The convoluted excretory tubule starts from it. In reptiles, birds, and mammals the tubules of metanephros open into the ureter, which is separated from the last part of the Wolffian channel. Wolffian duct remains only in males and is converted into vas deferens. Mullerian duct remains only in females, and performs the function of the oviduct. Increasing of the surface of discharge and close connection with the circulatory system occurs in the evolution of excretory organs. Thus, in the human embryo have about 10 pronephros tubules, primary - 100, secondary - up to 1 million tubules.

Mesonephros functions in adults of lower vertebrates. Exception - hagfish (pronephros).Meta-nephros performs its functions in higher vertebrates (amniotes).In most vertebrates in the posterior part of the ureter is formed extension.It is the urinary bladder, which is absent in birds.

Anomalies of the excretory system. Sometimes one of the kidneys can not get up and remains at the site of the pelvis.

At the low position of both kidneys and their intergrowths of lower poles formed horseshoe kidney.

There are cases when both kidneys are located on one side of the midline of the spine and fused into a common renal mass. Sometimes the number of kidneys may be more or less than normal, rarer third kidney, which is located between the two.

Phylogeny of the reproductive system.

In the evolution the reproductive system in chordates varied from similar in structure to the specialized male and female glands. Reproductive ducts arise for each sex from different parts of the excretory system. Adaptations in both sexes vary depending on the type of fertilization (external or internal).

In fish ovary consists of folliculles, and in the testis seminiferous tubules appear. The fish gonaduct closely associated with renal excretory channels and fertilization in most fish is external. Amphibian's ducts of the testes are connected with the ureter (Wolffian duct), function as a vas deferens, and emter into cloaca. In females, the eggs from the ovary fall into the body cavity and through the oviduct (Mullerian channels) are brought out through the cloaca. In all higher vertebrates (amniotes) fertilization is internal.

In reptiles and birds paired gonads are formed, but then they develop unevenly and only one is functioning: left or right. They have a complication of the reproductive system, which is associated with the development of the uterus. The uterus is formed by extending of the posterior part of the oviduct and their fusion into one unpaired organ.

The complex system of glands appears in males - the seminal vesicles, prostate and copulatory organs. Sex glands of mammals developed initially in the trunk region, and then moved to the pelvic part. The ovaries remain in the posterior part of the abdominal cavity and testicles descend from the abdominal cavity into the scrotum.

Anomalies of the reproductive system. Sometimes there is a deviation from the normal development: one of the testes may not descend into the scrotum, but remains in the abdomen (cryptorchidism). This leads to the dysfunction of the testes.

During abnormal embryonic development glands of both sexes (true hermaphroditism)are formed. Sometimes there are differences in the structure of internal and external genitalia (false hermaphroditism).

Practice.

Assignment 1. Phylogenesis of the blood system of Vertebrates.

Study the morphological features of the heart and main blood vessels, which leave heart. Draws them and make conclusions about the main directions in the phylogeny of the blood

vascular systems.

Assignment 2. Ontophylogenetic reasons of some congenital malformations.

Copy and complete the table.

Congenital malformations	Onthophylogenetic reasons
1. Two chambered heart	
2. Three chambered heart.	
3. Defections in the depta.	
4. Presence both arch of aorta: right and left.	
5. Reduction the left arch of aorta.	
6. Presence of Botall's duct.	

Assignment 3. Evolution of the excretory system of Vertebrates.

Copy and complete the table.

Vertebrate's Classes	Number of kidneys, which are laid	Nephron structure	Functions of different kidney
Fish			
Amphibians			
Reptiles			
Mammals			

TOPIC 34: BIOSPHERE.

Key consepts:

1. Living matter and its characteristics.
2. Environmental factors.
3. Adaptive ecotypes people and their characteristics.
4. Anthropogenic ecosystems.

Biosphere is a shell of land inhabited by living organisms.The unit of the biosphere is biogeocoenosis. It is dynamically stable, historically developed community of living organisms in a particular territory habitat.This higher level of organization of livings provides the existence and maintenance of life on Earth.

The main feature of living organisms is a continuous relationship with the environment (living and nonliving). Science that studies the relationships of organisms or groups of

organisms with the environment is called **ecology.** The set of conditions in which dwells a particular organism is called a habitat. The basic general conditions for the existence of any organism is the presence of: the living environment (water), nutrients, energy in the range of +50 ° - 50 ° C. The living organisms can live in the in the folloving types of invironment:

1). Minimal environment – it gives conditions necessary for life (light, food, water), regardless of whether or not all of its properties are perceived by the organisms.

2). Physiological environment - it includes minimum and others effective factors which may be not necessary - the presence of enemies, competitors, parasites, population density.

3). Ecological environment- it includes minimum, and physiological factors that indirectly affect the organisms. For example, the yield of pasture for predators increases the number of its victims (fox - rodents).

Some nonhomogeneous components of the medium are called **environmental factors.**

In ecology, there are three main groups of factors:

• Abiotic - elements of nonliving nature (light, pressure, t °)

• Biotic - the relationship between living organisms and the products of their life,

• Anthropogenic - social activities of man.

Each organism reacts to the influence of environmental factors, respectively, with his genetic program and receives not only a factor, but the magnitude of its influence.

Ecological opportunity is defined hereditary norm of reaction with respect to each individual factor and called environmental opportunity. It is characterized by a certain breadth from min to max. The most favorable factor is **optimum.** Magnitude of the impact factor, beyond which the organism can not survive, is called **the limiting factor (limiting).**

Latitude environmental opportunities of factor are different for everyone and depend on gender, age, phase of development. The environmental opportunities (limits of tolerance) of the organisms may be wide and narrow.

All the factors interact when they influence on the organism. For the existence of the organisms must be the folloving:

1) The presence of all factors and their influence within the environmental capacities.

2) The presence of one optimum factor helps be tolerate to effects of other unfavorable factors.

3) The presence at least one limiting factor makes life impossible.

Human Ecology studies the relations between human and environment. Its task:

1. Study the laws of biological adaptation of people.

2. Regulation the populations.

3. Production process management (problems photosynthesis, biotechnology).

4. Developing environmental indication - to determine the extent of human influence and predict their impact on the environment. Environmental changes - to transform nature, mines, reservoirs, city, etc.

5. Environmental monitoring - for the rational use of the natural environment.

Monitoring is a system of environmental observations in the dynamics of service ("air hygiene", the analysis of drinking water, wastewater, and regulation catching of seafood in international fisheries places.

Human environment includes natural and social components. Natural component –it is a part of living and non living nature, which directly or indirectly affects humans and individuals. It defines - belonging to a race, adaptive type, a feature of the gene pool of the population, the genotype of the individual and its morphological and physiological characteristics.

Social component is an artificial, which consciously or unconsciously created by the people for the individual, social groups and humanity as a whole.It defines belonging to a particular economic - cultural type, nation, and ethnic group.

These two components and their factors are closely intertwined and affect the person directly or indirectly. In such conditions it is very difficult to establish quality criteria with regard to its suitability for a full human life. According to the WHO Constitution - this criterion is the state of health of the population as an indicator of complete physical and mental well-being and not only the absence of disease or infirmity.

According to this criterion it is distinguished the following environments:

1. Comfortable (healthy) environment- a set of factors that provide optimal living conditions and harmonious development. People fully provide their biosocial functions.

2. Discomfortable environmen - loss of individual life-support factors that disrupts the harmony of their effects on the organism. Negative factors are biological, radiological, chemical, and social. The human body tends to diseases.

3. Extreme environment - the specific conditions of existence. The conditions of life are distroied and do not comrortable for the bio-social nature of man. It is unusual factors, which provide development of disease.

Environment determines the possibility of existence for all living organisms. However, adaptive reactions, in response to the influence of the environment are mediated. They have subordinate character. A man does not change his biological nature as other organisms, and changes the environment, adapting it to him. Adaptation of people - it is an active, biosocial process of human adaptation to the environment, aimed at ensuring, preservation and continuation of normal life, including social.

All members of the species H.sapiens are capable of exhibiting reactions in response to changing environmental conditions.In the nature of the relationship of human populations with the environment there are some general patterns:

1. Regardless of race and ethnicity of the body to the same environmental influences appear in the same direction.
2. Reaction norm - change feature is within the inherent ecotype.
3. Compensatory reaction - the weakening signs of physical development (reduction of body weight, muscle mass, asthenic body type) there is an increase in blood γ - globulin producing antibodies in response to adverse effects.

Knowledge of these laws allows hygienists to give recommendations for the development of new habitats of people without compromising health.

During resettlement representatives of the species H. sapiens on earth land, the human body is feeling the effects of different climatic and geographical factors, adapted to them. It was formed people of different morphological and physiological features of climatic and geographical zones or specific ecological types.

Eco (adaptive) type - represents a norm of biological reactions to the prevailing living conditions, and manifests themselves in a complex of morphological, biochemical and immune traits that lead to a better adaptation to the biological environment. Adaptive type is not affected by race and social class.

It is distinguished general and specific elements in the ecotypes.

General elements are muscular mass of the body, the level of basal metabolism, the amount of proteins in the immune serum.

Specific elements are produced in response to the prevailing conditions of the habitats (hypoxia, heat, cold). Combination of general and specific elements reveals the following ecotypes:

• Tropical;

• Alpine;
• Continental;
• Moderate;
• Arid;
• Arctic.

The special characteristics of the ecotype form during embryogenesis and determine its environmental capacities.

Tropical ecotype is characterized by high humidity, the lack of protein in the diet and excess vitamins, carbohydrates, macro -and micronutrients, the presence of endemic diseases.Environ-mental conditions are very different. The members of major races live there.In the characteris-tic of the body there is a broad range of variability (giants and pygmies). General direction - the population of the tropics relatively long-legged, already pelvis and shoulders, somewhat flattened chest, body density decreases to the south. Population has basic metabolism 1300-1750 kcal, lower blood cholesterol. Specifically elongated body shape - the adaptation to high humidity and t^0 increased the number of sweat glands per 1 cm2 of skin, increased sweating intensity.

Zone of Mountain. 1.5 % of the world population lives above 2000m in extreme zone. It's characterized by reduced atmospheric pressure, lack of oxygen, cold, violation of the geochemical balance, lack of land. Protein nutrition, lack of carbohydrates, trace elements imbalance. Anthropologically meet all races. It's characterized by increased length and body weight, increase in the basic metabolism - 2000-2500 kcal, and adaptation to hypoxia (low O_2 content). Population has greater development of the long bones of the skeleton (increasing the medullary canal and red blood cell production).

Increase in hemoglobin and red blood cells increases the blood oxygen saturation.

Tolerant Zone. The population lives mostly in developed countries. The level of technogenic culture reinforces the independence of morphological features of their population from the effects of natural habitats. Food protein- carbohydrate or carbohydrate and protein content of macro-and micronutrients depends on the area. 2 races live in this zone: Caucasoid and Mongoloid (Kamchatka and the Commander Islands). The populations are characterized by the most massive body structure, which manifests itself not only in weight gain and weighty growth indicators, but also in the relative shortening of the lower extremities and an increase in body size. Basic metabolism occupies an intermediate position between the

tropics and the Arctic and is 1600-1850 kcal. Skeletal size and the level of mineralization depend on the content of macro-and microelements in water and soil. Changes of cholesterol twice lower than in the tropics.

Arid eco-type: Occupy 18 % of the land; there are lives 4% of the population. Extreme conditions are high t ◦, UV and thermal radiation, dry air, wind, dust. Overheating and dehydration are the main causes of stress in adaptations. However deserts are inhabited since ancient times. The population is concentrated near water sources. All races inhabit this area.

People of this ecotype are tall, with long extremities that increase the heat transfer. They have lower the level of the basal metabolism - 1200-1300 kcal, lowered cholesterol levels, blood gas exchange, reduced blood pressure, but increased heart rate, respiration, there is an effective vasomotor nervous control of heat loss during the day.

Arctic eco-type of People. Arctic ocupyed16% of the land, there lives 1 % of the population. Cold, long winter lasts 5-6 months. The population density is 0.01 people \ km2. Anthropologically - Mongolians, some combine the features of Mongoloid and Caucasoid.

Food contains a lot of proteins and fats, lack of carbohydrates, vitamins and minerals. The population has a survival coefficient= 2. In the age structure there is a high percentage of children under 10 years, a sharp decrease in the population occurs after 60 years. People are characterized by a small body length, relatively high growth, chest, relatively large development of a low-fat weight loss; they have a basal metabolism - 3000kKal, cylindrical thorax, large medullar canal of long bones increased red blood cells. Increased level of cholesterol in the blood indicates a high level of energy metabolism (energy is produced by the decomposition of fat).People have a very low range of variability of symptoms.

Practice.

Assignment 1. People's ecotypes.

Copy and complete the table.

Ecotype	Geographical and climate conditions	Races	Morpho-physiological features

TOPIC 35: Test of Module II.

Teaching objectives: Checking the knowledge of Module II.

Assignment. Students receive a set of test tasks to prepare for the Module.