

Introduction in medical parasitology and parasitic diseases

Medical (human) parasitology

- Human parasitology is the study of those organisms which parasitise humans
- According to the very broad definition of parasitology, parasites should include the **viruses, bacteria, fungi, protozoa and metazoa** (multi-celled organisms) which infect their host species
- However, for historical and other reasons the first three have been incorporated into the discipline of Microbiology

Medical parasitology has to investigate all aspects of the following:

Agents of diseases

Epidemiology

Pathogenesis and basic clinical signs

Laboratory diagnosis

Antiparasitic drugs

Prevention

- The biology of the parasite
- The variation in life-cycle of the parasites
- Methods of invasion of the host
- Migration and maturation within the host
- The effect of the parasite upon the host
- The host reaction and response to the parasite
- Methods of escape from the host
- Distribution of the parasite
- Diagnosis of parasitic diseases
- Treatment and prevention of the diseases

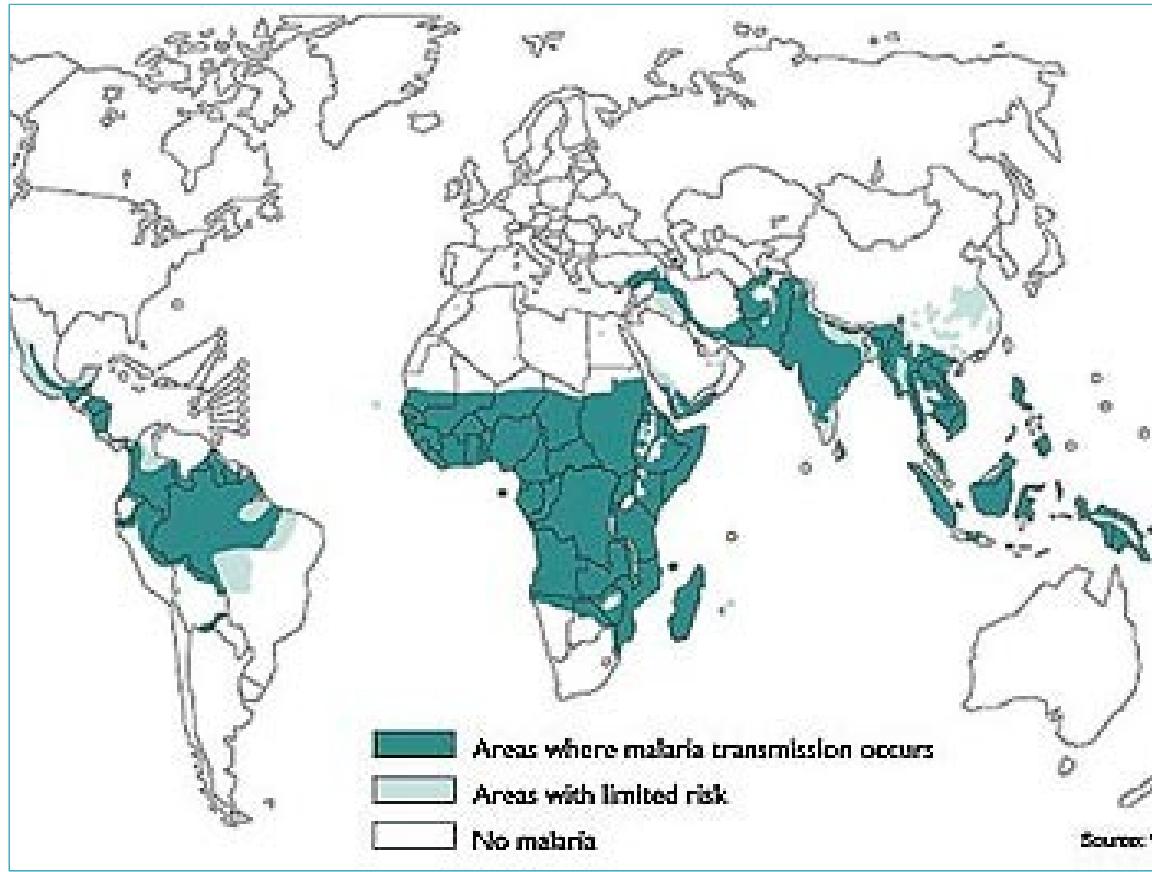
Parasitic diseases

→ factors that led to the increasing frequency of some parasitic diseases and their spread

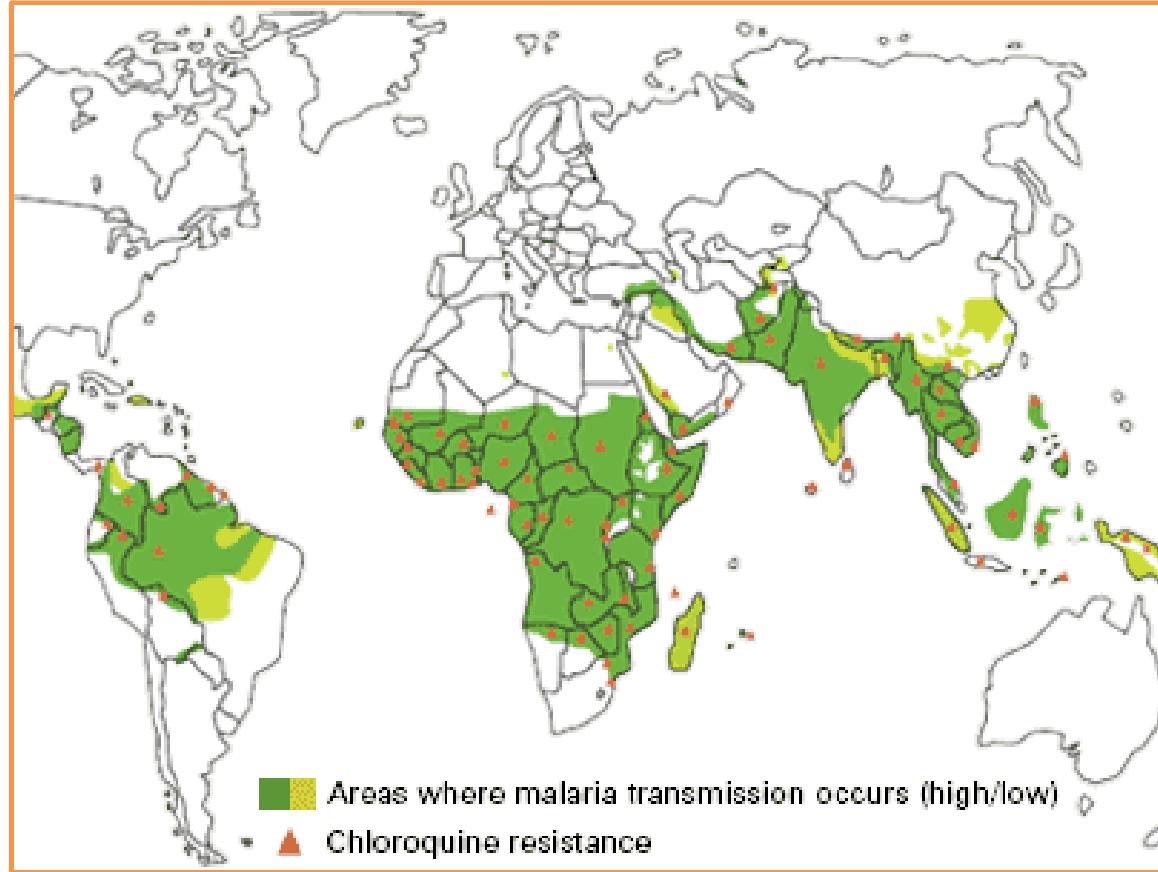
- Increased mobility of the population
- Popularity of the tropics and subtropics as vacation areas
- Speed of transportation
- Refugees from war-torn areas
- Modification of environment by humans
- “Global warming”
- Illegal trade of animals
- AIDS and patients under immunosuppression
- Development of resistance to drugs (antimalarials)

Geographic distribution factors (endemicity)

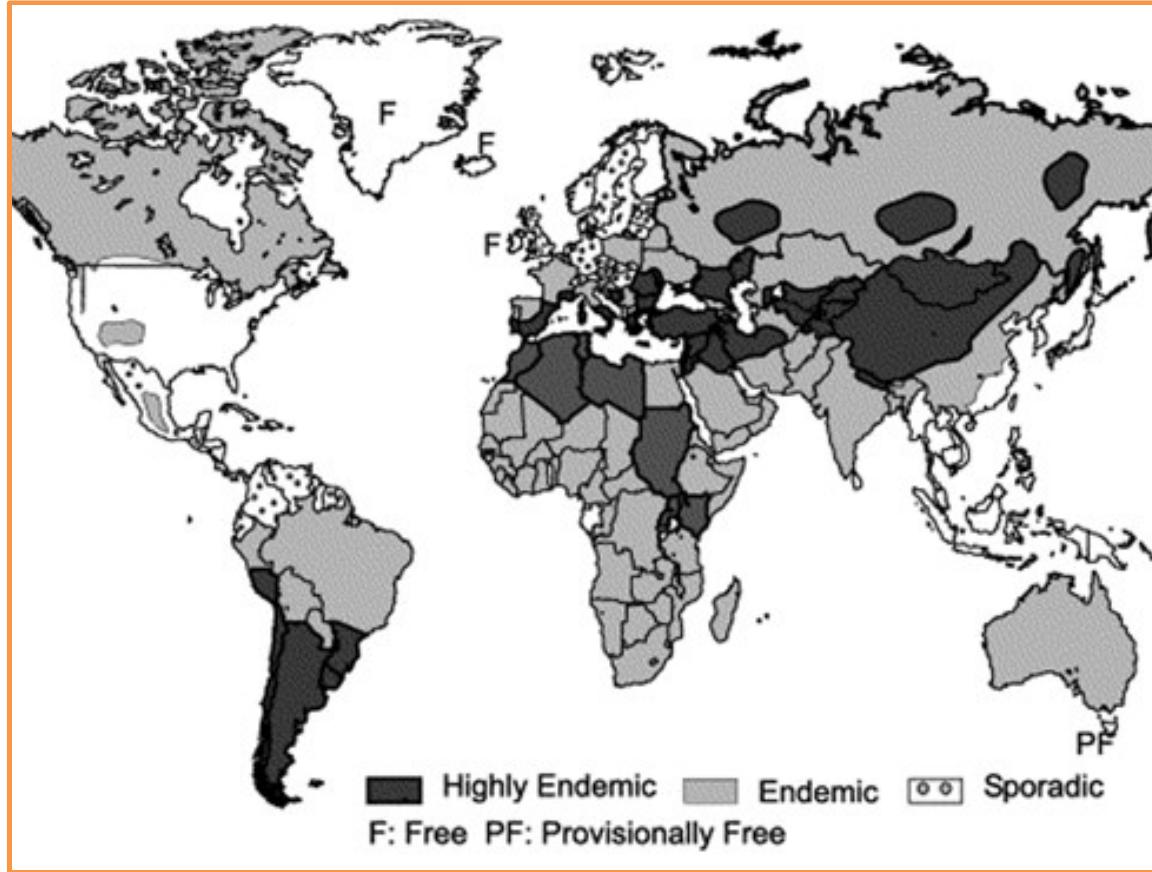
- Presence of a suitable host
- Habits of the host
- Escape from the host
- Favorable conditions outside of host
- Economic and social conditions



Geographic distribution of malaria



Chloroquine resistance in malaria



Geographic distribution of *Echinococcus granulosus*

WHO – Priority diseases

Schistosomiasis
Malaria
Filariasis
Trypanosomiasis
Leishmaniasis

Leprosy (replaced by
HIV/AIDS)

Lymphatic filariasis



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Second level
Third level
Fourth level
Fifth level

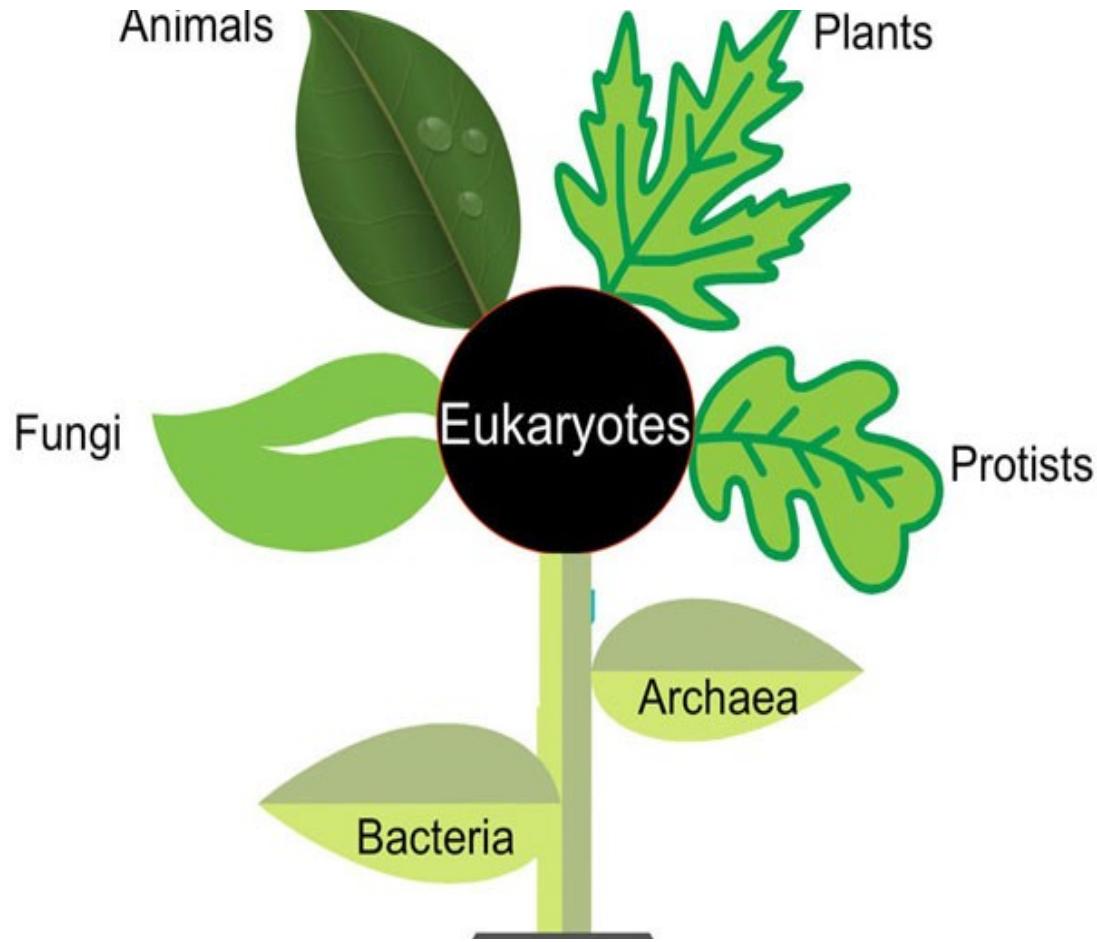
The burden of some major parasitic infections

<i>Plasmodium</i>	malaria	273 million	1.12 million
Soil transmitted helminths:		2 billion	200,000
• Roundworm (<i>Ascaris</i>)	Pnemonitis, intestinal obstruction		
• Whipworm (<i>Trichuris</i>)	Bloody diarrhoea, rectal prolapse		
• Hookworm (<i>Ancylostoma</i> and <i>Necator</i>)	Coughing, wheezing, abdominal pain and anaemia		
<i>Schistosoma</i>	Renal tract and intestinal disease	200 million	15,000
<i>Filariae</i>	Lymphatic filariasis and elephantiasis	120 million	Not fatal but 40 million disfigured or incapacitated
<i>Trypanasoma cruzi</i>	Chagas disease (cardiovascular)	13 million	14,000
African trypanosomes	African sleeping sickness	0.3 – 0.5 million	48,000
<i>Leishmania</i>	Cutaneous, mucocutaneous and visceral leishmaniasis	12 million; 2 million new cases/yr	50,000

Epidemiology

- Although parasitic infections occur globally, the majority occur in tropical regions, where there is poverty, poor sanitation and personal hygiene
- Often entire communities may be infected with multiple, different organisms which remain untreated because treatment is neither accessible nor affordable
- Effective prevention and control requires "mass intervention strategies" and intense community education. Examples include:
 - General improved sanitation: pit latrines, fresh water wells, piped water
 - Vector control: insecticide impregnated bed nets, spraying of houses with residual insecticides, drainage, landfill
 - Mass screening and drug administration programmes which may need to be repeated at regular intervals





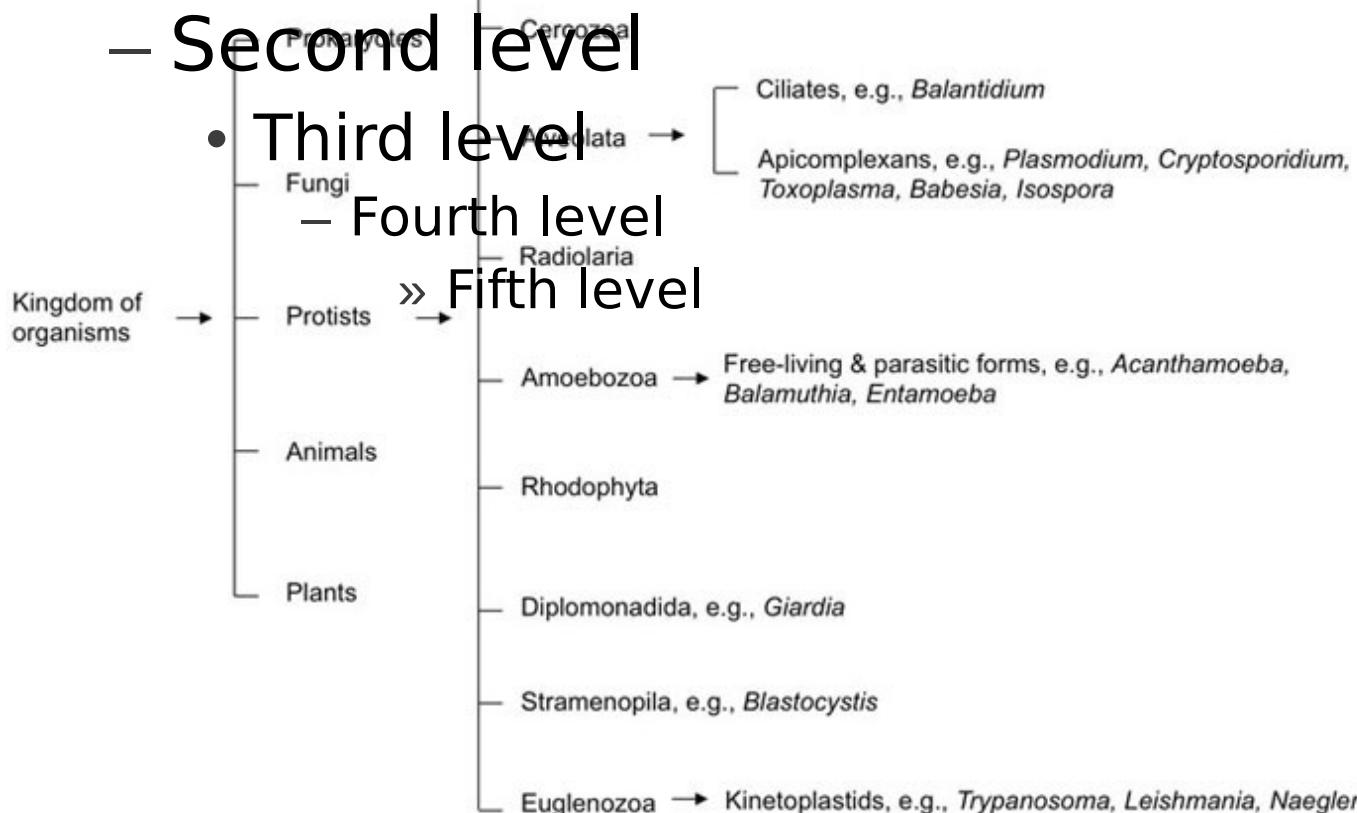
Three domains of life - Taxonomy

Key definitions

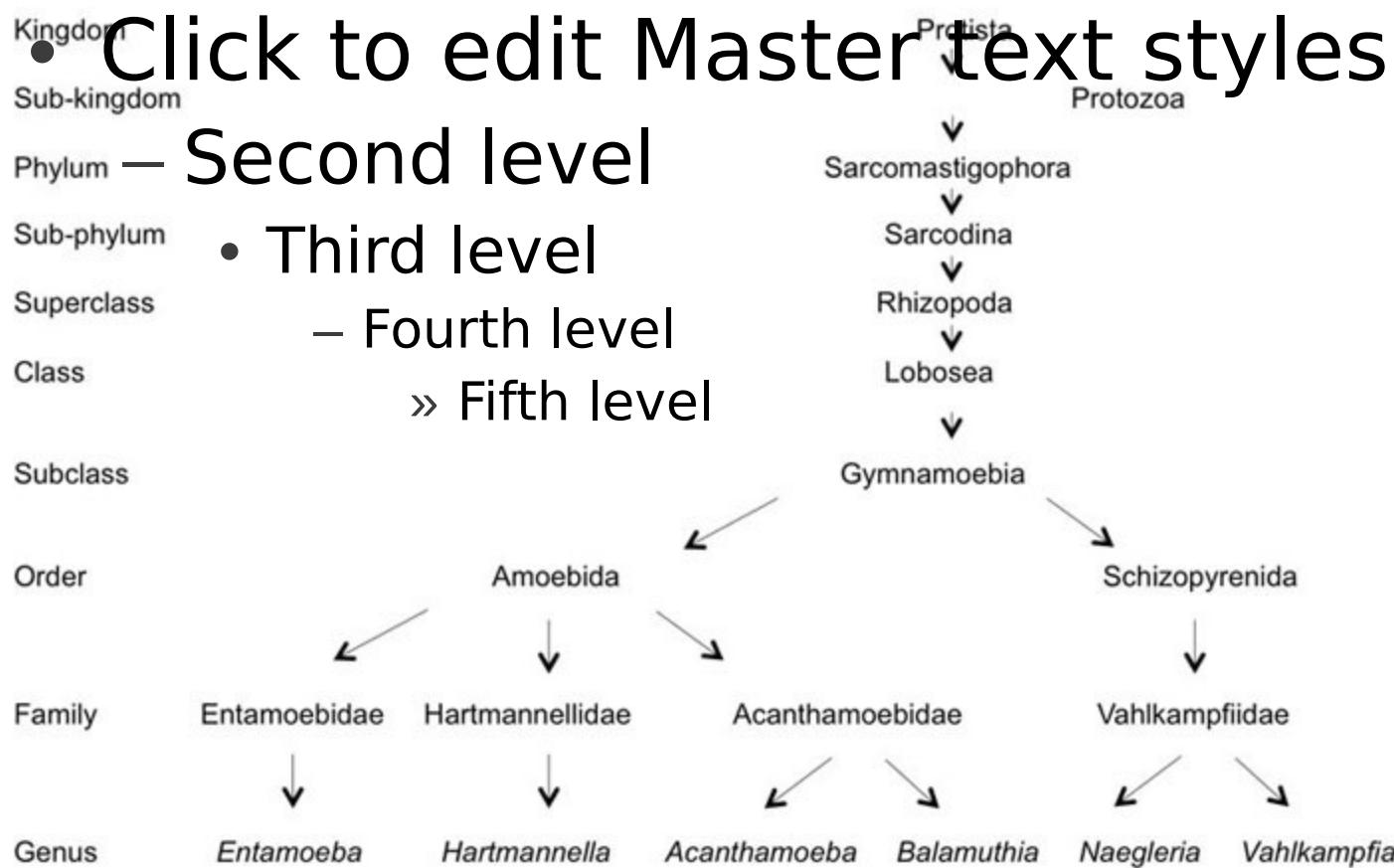
- **Eukaryote:** a cell with a well-defined chromosome in a membrane-bound nucleus; all parasitic organisms are eukaryotes
- **Protozoa:** unicellular organisms, e.g. *Plasmodium* (malaria)
- **Metazoa:** multicellular organisms, e.g. helminths (worms) and arthropods (ticks, lice)

Example: The present classification scheme of protists, based largely on their **genetic relatedness**

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Example: The traditional classification scheme of protists, based largely on **morphological characteristics** and it is no longer valid



Biological associations

Symbiosis

- Two different organisms live together and interact
- In this association one partner lives in or on another one's body
- Symbiosis include 3 types of associations:
mutualism, commensalism, parasitism

Mutualism

- Permanent association between two different organisms that life apart is impossible, two partners benefit each other, such as termites and flagellates
- The mutuals are metabolically dependent on one another; one can not survive in the absence of the other

Commensalism

The association of two different organisms, in which one partner is benefited while the other neither benefited nor injured, such as *Entamoeba coli* and man.

Parasites and parasitism

- **PARASITE** - live organism living in or on, and having some metabolic dependence on another organism known as a **host**
- **PARASITISM** - a relationship in which one of the participants, the parasite, either harms its host or in some sense lives at the expense of the host

Parasites

Protists (protozoa): *Sarcomastigophora, Ciliophora, Apicomplexa*

Worms: *Aschelminthes , Platyhelminthes*

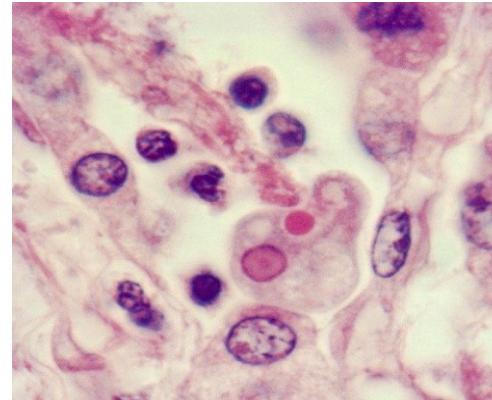
Nematoda (roundworms), *Cestoda* (tapeworms),
Trematoda (flukes)

Arthropods: *Arthropoda*

Microsporidia: *Microspora* /taxonomy unclear?

Human Parasitology

**Medical
Protozoology**



**Medical
Helminthology**

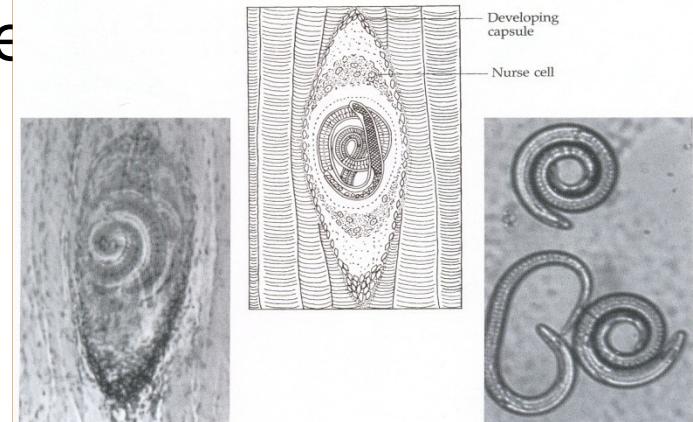


**Medical
Entomology**

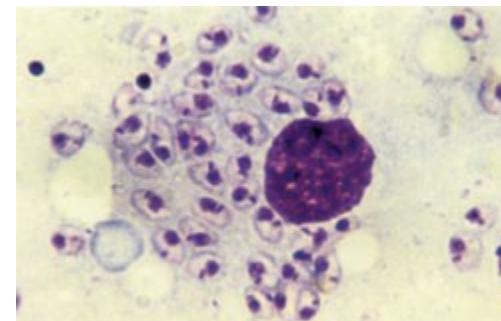
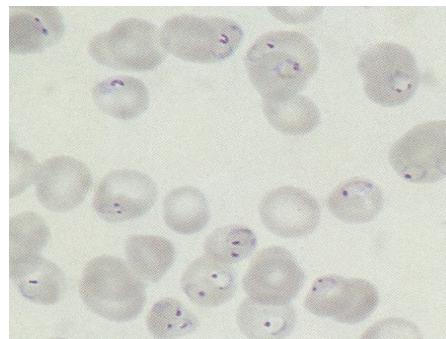


Parasites

- Microparasites / Macroparasites
- Endoparasites / Ectoparasites



- Intracellular parasites (mostly microscopic)
- Extracellular parasites (they range in size from micro- to macroscopic)



Parasites

- **Obligate (permanent) parasites** – organisms that for all or most of their life cycle are parasitic; they have at least one host during their life-history
- **Temporary (intermittent) parasites** – agents that are parasitic for limited periods for either feeding or reproduction
- **Facultative parasites** – organisms that are not normally parasitic but can survive for a limited period when they accidentally find themselves within another organism
- **Adaptive parasites** – those organisms that have capacity to live both as free-living or parasitic organisms

Life cycle

- Life cycle is the process of a parasite's growth, development and reproduction, which proceeds in **one or more different hosts** depending on the species of parasites
- **Infective stage** is a stage when a parasite can invade human body and live in it

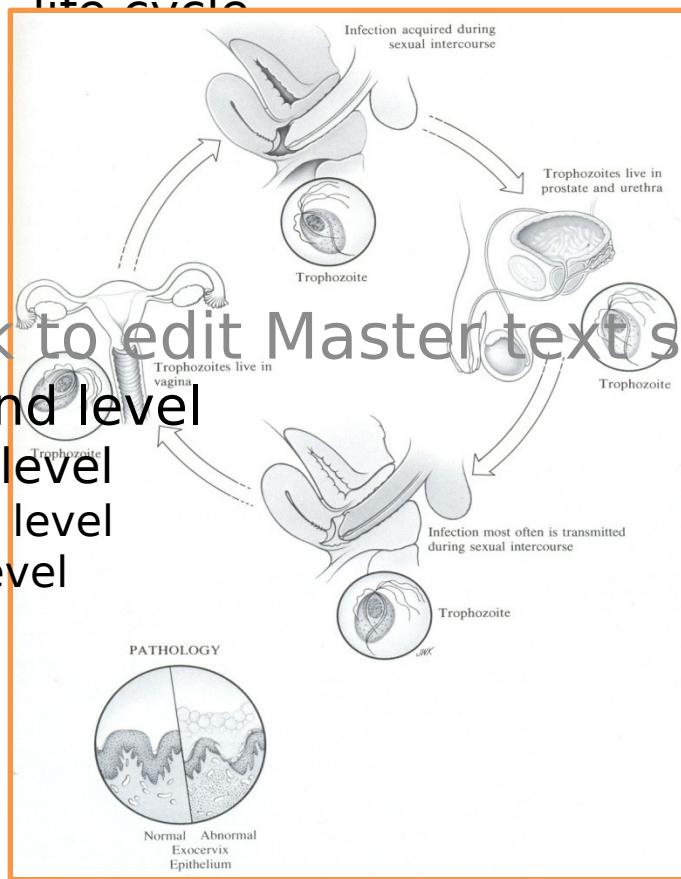
Life cycle

- **Infective route** is the specific entrance through which the parasite invades the human body
- **Infective mode** means how the parasite invades human body, such as:
 1. the cercariae of the blood fluke actively penetrate the skin of a swimming man
 2. the infective *Ascaris* eggs are swallowed by man

Life cycles

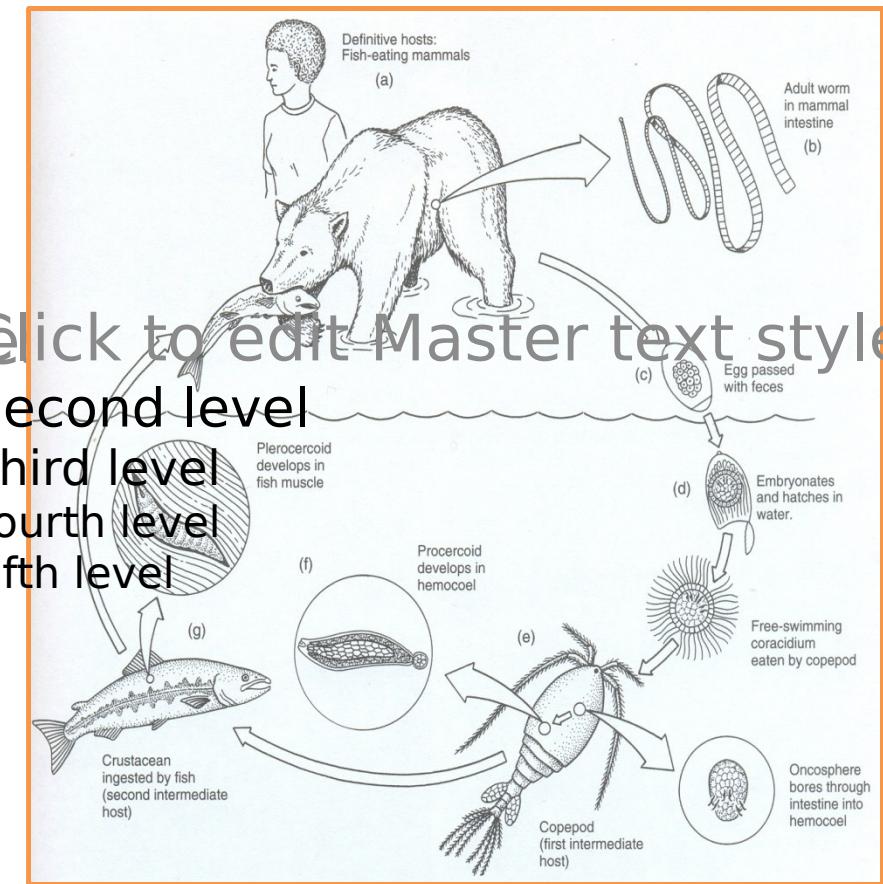
Direct life cycle

only a single host in the life cycle



Indirect life cycle

life cycle with more than one host



Host

- **Host** - in parasitism, it supplies the parasite with nourishment and shelter, it is the injured partner
- **Carrier** - a person who harbours parasite, has no clinical symptoms, is an important source of infection in epidemiology

Hosts

- **Definitive host** - one in which the parasite reaches sexual maturity and where the adult form of the parasite usually resides or in which sexual stages of reproduction occur
- **Intermediate host** - one in which the immature or larval form usually resides, or in which the parasite undergoes asexual reproduction
- **Transport (paratenic) host** - one in which the parasite does not undergo any development but in which it remains alive and infective to another host
- **Reservoir host** - any animal that harbors an infection that can be transmitted to humans, even if the animal is a normal host of the parasite

Host specificity

Which hosts can be infected by given parasite?

- Many parasites have **very specified host**
Ascaris lumbricoides
- Others have **wide range of hosts**
Toxoplasma gondii

Epidemiology

- **Zoonosis**

disease which is the result of the transmission of parasites normally found in wild and/or domestic animals to humans (these animals infected with parasites are called **reservoir hosts**)



Sheeps are reservoir host for liver fluke
Fasciola hepatica

- **Sylvatic cycle**
- **Urban (domestic) cycle**



e.g. *Trichinella spiralis*

Epidemiology

Methods of infection

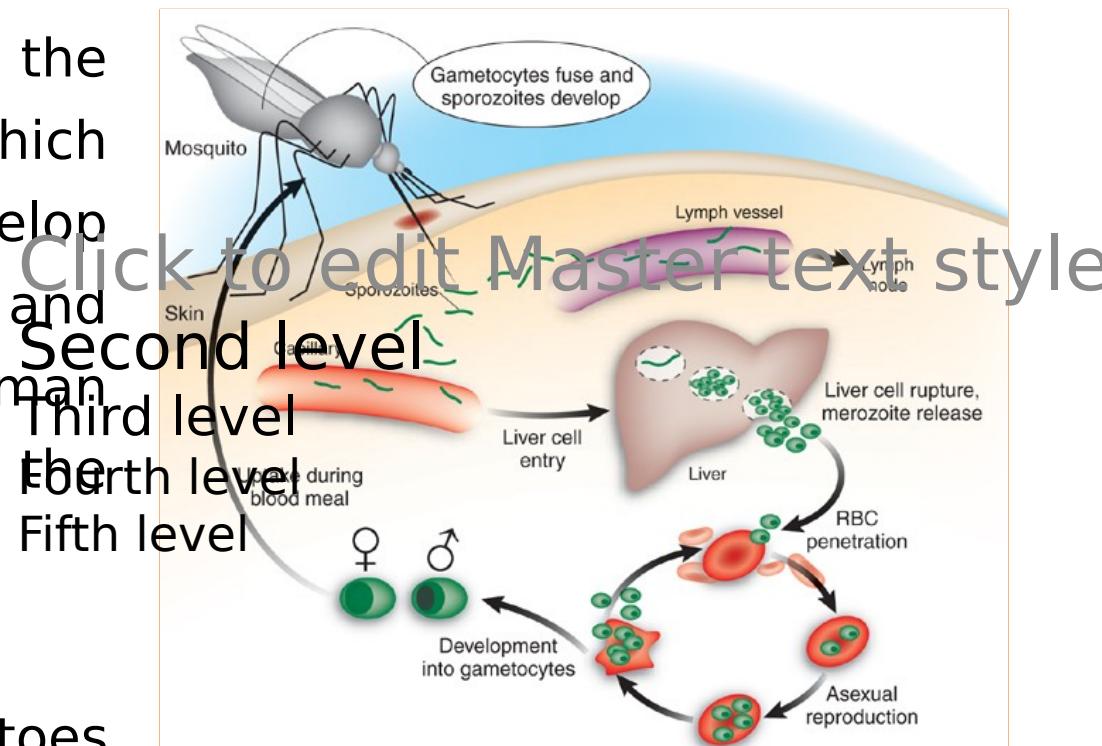
- faeco-oral (*Entamoeba histolytica*, *Ascaris lumbricoides*)
- undercooked food (*Trichinella spiralis*)
- via arthropod vector (malaria)
- direct penetration (*Strongyloides stercoralis*,
Ancylostoma duodenale)
- direct contact /person to person (*Trichomonas vaginalis*,
Sarcoptes scabiei)

Methods of escape

- faeces
- sputum
- via arthropods

Method of infection → arthropods: biological transmission

- Pathogens have to spend a part of their life cycle in the vector arthropods in which they multiply or develop into the infective stage and then invade the human body under the help of the arthropod



- E.g. *Anopheles* mosquitoes transmit malaria

Method of infection

→ arthropods: mechanical transmission

Arthropods play a role of the transportation of pathogens, which is not indispensable for the disease transmission

E.g. flies carry bacteria, viruses, worm's eggs, and amoebic cysts on their legs and body

Musca domestica



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Second level
Third level
Fourth level
Fifth level

Pathogenicity

- **Pathogenicity** - pathogenic parasites
 - parasites
 - (*comensals*)
- **Opportunistic parasites** - parasites that cause mild to moderately serious infections in healthy individuals, but particularly serious infections in the immunocompromised host

Pathogenic effects of parasites

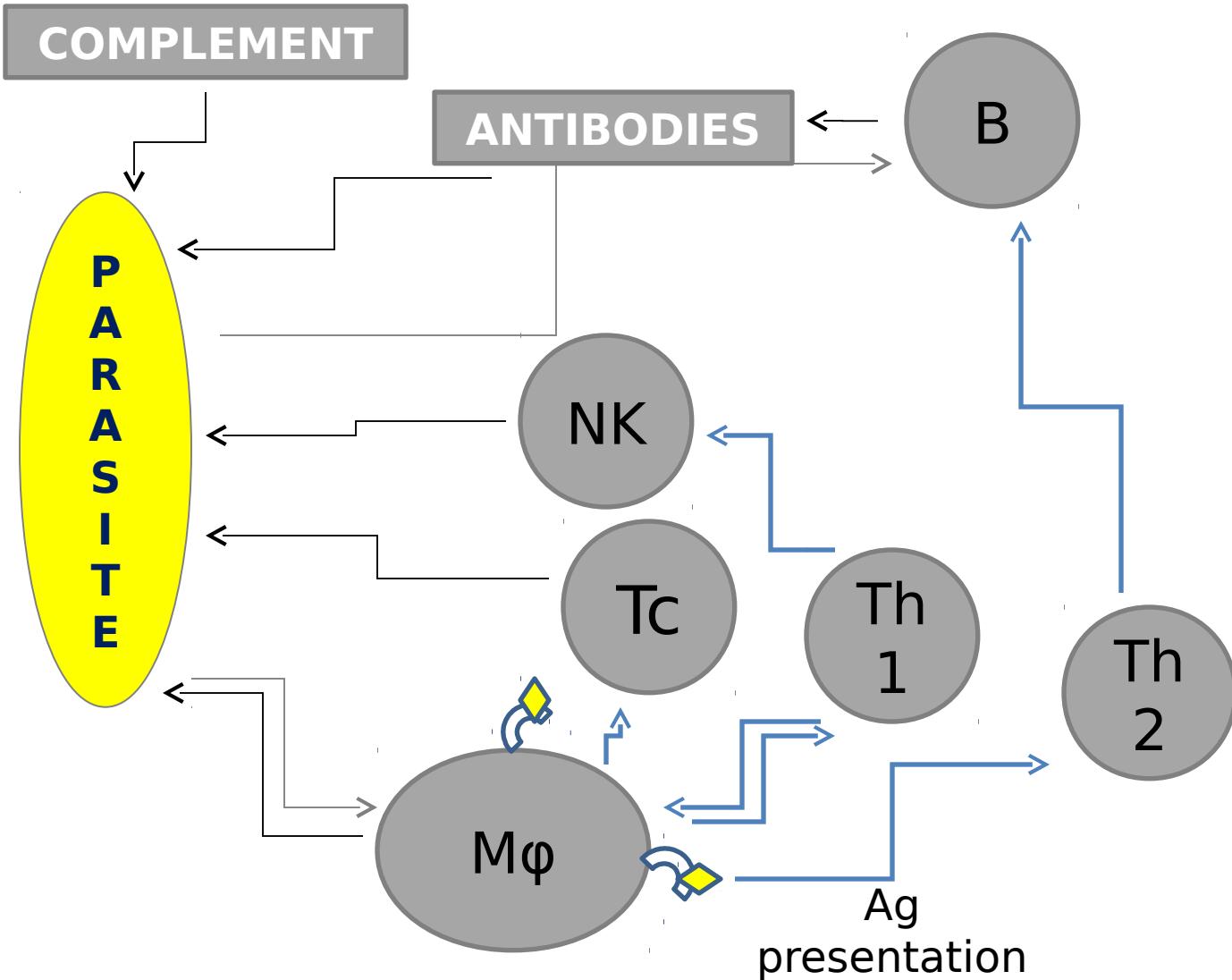
- **Trauma** - destruction of cells, tissues or organs by mechanical or chemical means
- **Nutrition robbing** - diversion of the host's nutritive substances (e.g. hookworms suck blood)

Hookworm
anemia



- **Toxin production**
- **Interactions of the host immune/inflammatory responses** (pathology due to host response - immunopathology)

Immune effector mechanisms



Preimmunition

- Its intensity and specificity are usually at a lower level than those produced by bacteria and viruses
- It refers to **non-sterilizing immunity**: the host may be protected from superinfection long as the parasites remain in the body
- This situation is known as **premunition or concomitant immunity**: this may be of great importance in endemic areas in limiting the severity of infection with, e.g. *Plasmodium*, *Schistosoma*, hookworms and other parasites

Disease

- Asymptomatic infection
- Symptomatic infection - acute /chronic
- Latent infection *Toxoplasma gondii*
- Malignant alteration *Clonorchis sinensis*,
Schistosoma haematobium

Parasites

→ according to which site they inhabit

- **Intestinal and urogenital parasites**
(protozoa and/or helminths)
- **Tissue and blood parasites**
(protozoa and/or helminths)

Diagnosis of parasitic infections

- Clinical diagnosis
- Laboratory diagnosis

Treatment of parasitic infections

- Medical and surgical
- Chemotherapy
- Adequate nutrition

Prevention and control

- Reduction in sources
- Education
- Destruction and/or control of reservoir hosts and vector

Protozoa

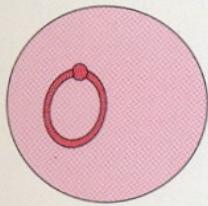
Protozoa are microscopic one-celled organisms that are categorized according to their method of movements.

- **Ciliates** – the only parasitic ciliate that causes disease in humans in *Balantidium coli*
- **Flagellates** – three of the most common and medically significant include: *Giardia lamblia*, *Trypanosome* sp. and *Trichomonas vaginalis*
- **Amoeba** –include the pathogenic amoeba *Entamoeba* and *Endolimax* which cause dysentery in humans

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Sporozoa

all are intracellular parasites
e.g. *Plasmodium* in red blood cell



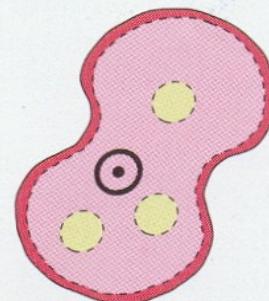
Flagellates

move by beating of one or more flagella
e.g. *Trypanosoma*



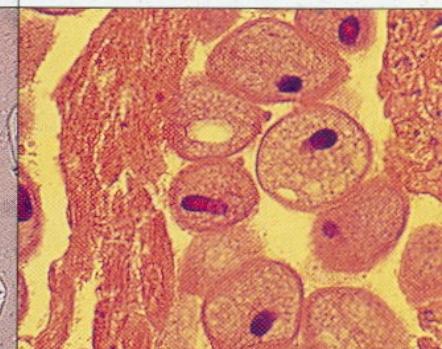
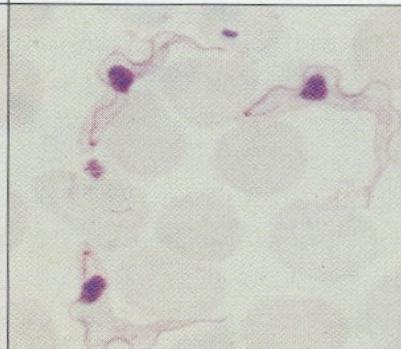
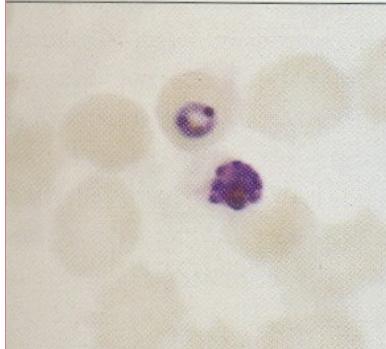
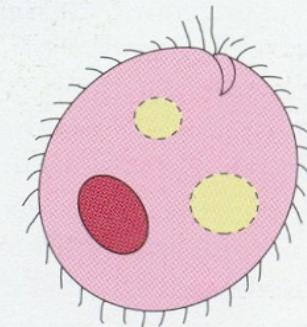
Amoebae

move by extending pseudopodia, no fixed shape, e.g. *Entamoeba*



Ciliates

move by beating of many cilia, e.g. *Balantidium*



THE MAJOR DIVISIONS OF PROTOZOA

- Second level

- Third level

- Fourth level

- » Fifth level

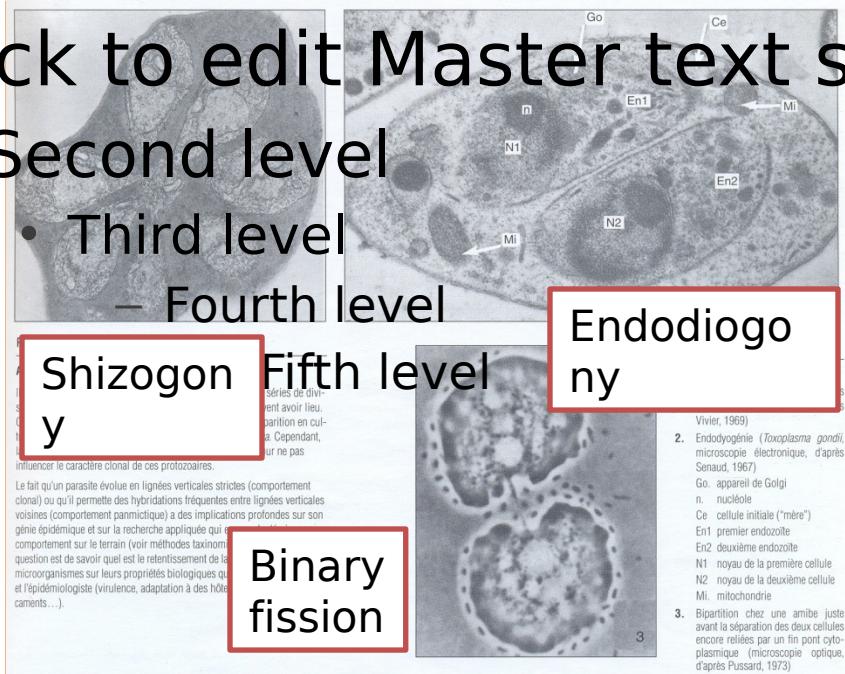
Taxonomic classification of protozoa

Sub kingdom	Phylum	Sub-phylum	Genus-examples	Species-examples
Protozoa	Sarcomastigophora further divided into	Sarcodina-- move by pseudopodia	Entamoeba	<i>E. histolytica</i>
		Mastigophora move by flagella	Giardia	<i>G. lamblia</i>
	Apicomplexa no organelle of locomotion		Plasmodium	<i>P. falciparum,</i> <i>P. vivax,</i> <i>P. malariae,</i> <i>P. ovale</i>
	Ciliophora move by cilia		Balantidium	<i>B. coli</i>

Forms and reproduction of protozoa

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 - Third level
 - Fourth level



Cysts - infective forms, survive in the environment

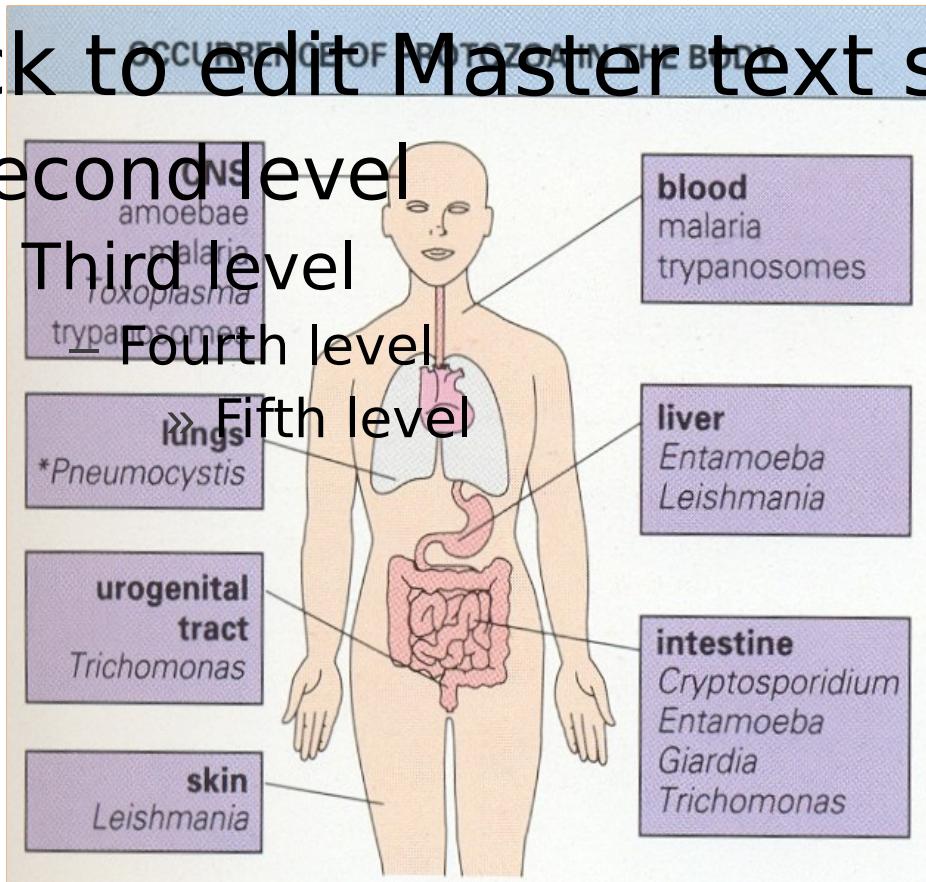
Trophozoites - vegetative forms, capable for reproduction:

- Shizogony (asexual)
- Binary fission (asexual)
- Endodiogony
- Sporogony (sexual)
- Conjugation

Protozoa

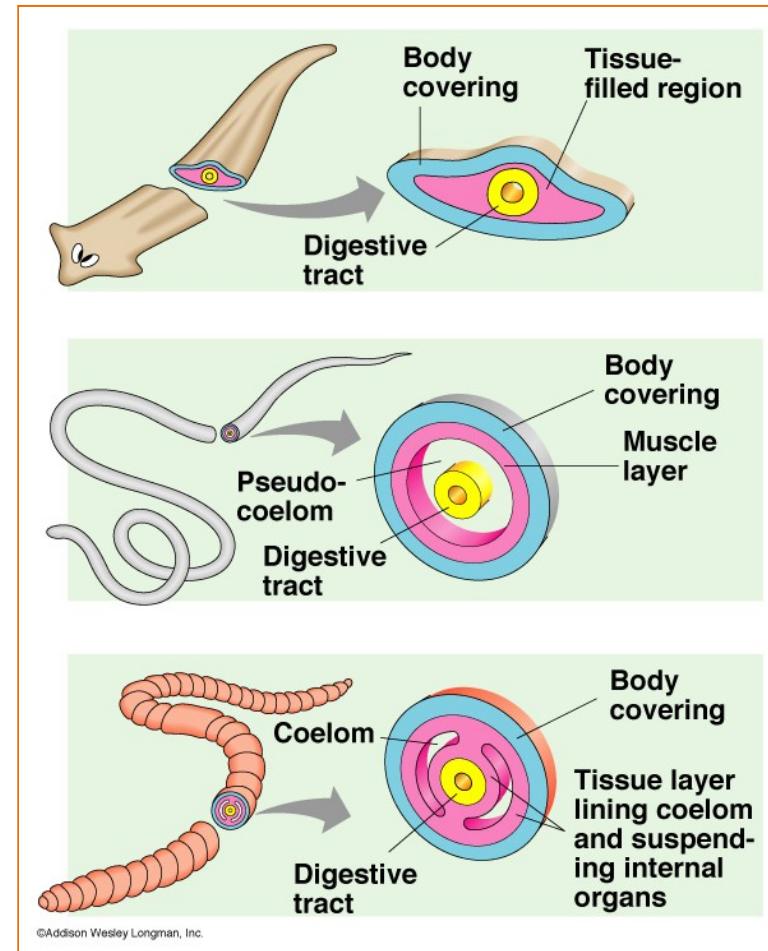
- **Blood and tissue protozoa**
(e.g.. *Plasmodium* spp.)
- **Intestinal and urogenital protozoa**
(e.g. *Entamoeba histolytica*,
Cryptosporidium spp.)

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Helminths (Worms)

- Eukaryotic, multicellular animals that usually have digestive, circulatory, nervous, excretory, and reproductive systems.
- Worms have bilateral symmetry, head and tail end of the body, and tissue differentiation (endoderm, mesoderm, and ectoderm).



Helminthes

Two main groups (phyla)

- Platyhelminths (Flatworms)
- Nematoda (Roundworms)

Life Cycle

- Extremely complex (egg → larva → adult)
- Intermediate hosts harbor larval (developmental) stage.
- Definitive host harbors adult stage

Localization

- Intestinal helminths
- Blood and tissue helminths

Taxonomic classification of helminths

Sub kingdom	Phylum	Class	Genus – examples
Metazoa	Nematodes Round worms; appear round in cross section, they have body cavities, a straight alimentary canal and an anus		Ascaris (roundworm) Trichuris (whipworm) Ancylostoma (hookworm) Necator (hookworm) Enterobius (pinworm or threadworm) Strongyloides
	Platyhelminthes Flat worms; dorsoventrally flattened, no body cavity and, if present, the alimentary canal is blind ending	Cestodes Adult tapeworms are found in the intestine of their host They have a head (scolex) with sucking organs, a segmented body but no alimentary canal Each body segment is hermaphrodite	Taenia (tapeworm)
		Trematodes Non-segmented, usually leaf-shaped, with two suckers but no distinct head They have an alimentary canal and are usually hermaphrodite and leaf shaped Schistosomes are the exception. They are the only trematodes that have a distinct head.	Fasciolopsis (liver fluke) Schistosoma (not leaf shaped!)

Helminths

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Sexual reproduction strategies

1 Male and female reproductive organs are found in separate individuals.

2 One animal has both male and female sex organs (most hermaphrodites copulate with other animals, a few copulate with themselves).

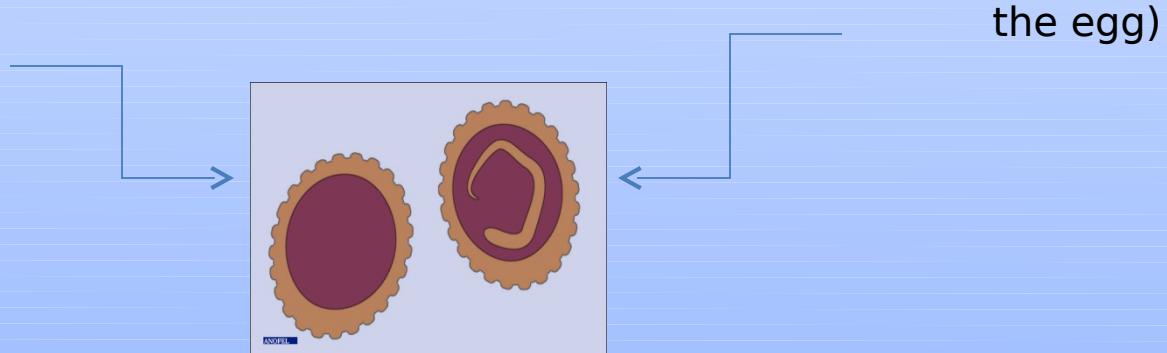
Female helminths:

Oviparous - lay eggs without embryonic development.

Ovoviviparous - embryos develop inside eggs.

Viviparous - the larva develops inside the body of the mother.

Eggs: unsegmented (no larva inside the egg) & segmented (larva inside



Parasite prevalence

- We have a parasite problem right here in the Serbia (and other countries).
It is just **not being addressed**.
- Many doctors **haven't been trained** to look for parasites, so **they don't find them**.
- **Not like to talk about these things.**
- **Neglected diseases.**