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.
<table>
<thead>
<tr>
<th>Medical parasitology has to investigate all aspects of the following:</th>
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<tbody>
<tr>
<td>Agent s of diseases</td>
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<tr>
<td>Epidemiology</td>
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<tr>
<td>Pathogenesis and basic clinical signs</td>
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<tr>
<td>Laboratory diagnosis</td>
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<tr>
<td>Antiparasitic drugs</td>
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<tr>
<td>Prevention</td>
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</table>

- 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

Lymphatic filariasis

Leprosy (replaced by HIV/AIDS)
### The burden of some major parasitic infections

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Disease</th>
<th>No. people infected</th>
<th>Deaths/yr</th>
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<tbody>
<tr>
<td><em>Plasmodium</em></td>
<td>malaria</td>
<td>273 million</td>
<td>1.12 million</td>
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<td>Soil transmitted helminths:</td>
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<td>2 billion</td>
<td>200,000</td>
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<tr>
<td>• Roundworm <em>(Ascaris)</em></td>
<td>Pnemonitis, intestinal obstruction</td>
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<td>• Whipworm <em>(Trichuris)</em></td>
<td>Bloody diarrhoea, rectal prolapse</td>
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<td>• Hookworm <em>(Ancylostoma and Necator)</em></td>
<td>Coughing, wheezing, abdominal pain and anaemia</td>
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<tr>
<td><em>Schistosoma</em></td>
<td>Renal tract and intestinal disease</td>
<td>200 million</td>
<td>15,000</td>
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<tr>
<td><em>Filariae</em></td>
<td>Lymphatic filariasis and elephantiasis</td>
<td>120 million</td>
<td>Not fatal but 40 million disfigured or incapacitated</td>
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<tr>
<td><em>Trypanasoma cruzi</em></td>
<td>Chagas disease (cardiovascular)</td>
<td>13 million</td>
<td>14,000</td>
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<tr>
<td><em>African</em></td>
<td>African sleeping sickness</td>
<td>0.3 – 0.5 million</td>
<td>48,000</td>
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<td><em>Leishamania</em></td>
<td>Cutaneous, mucocutaneous and visceral leishmaniasis</td>
<td>12 million; 2 million new cases/yr</td>
<td>50,000</td>
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</table>
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 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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      - Fourth level
        » Fifth level
The traditional classification scheme of protists, based largely on morphological characteristics and it is no longer valid.
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?
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.

- **Infected 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** - 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
• **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*

e.g. *Trichinella spiralis*

• **Sylvatic cycle**
• **Urban (domestic) cycle**
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.
Pathogenicity

• **Pathogenicity** - pathogenic parasites
  facultative pathogenic parasites
  nonpathogenic parasites
  (comensals)
  free-living parasites

• **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)

- **Toxin production**

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

Hookworm anemia
Immune effector mechanisms

- PARASITE
- ANTIBODIES
- B
- NK
- Tc
- Th 1
- Th 2
- Mφ
- Ag presentation
- COMPLEMENT
Preimunition

• 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 concominant 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 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
<table>
<thead>
<tr>
<th>Sporozoa</th>
<th>Flagellates</th>
<th>Amoebae</th>
<th>Ciliates</th>
</tr>
</thead>
<tbody>
<tr>
<td>all are intracellular parasites, e.g. <em>Plasmodium</em> in red blood cell</td>
<td>move by beating of one or more flagella, e.g. <em>Trypanosoma</em></td>
<td>move by extending pseudopodia, no fixed shape, e.g. <em>Entamoeba</em></td>
<td>move by beating of many cilia, e.g. <em>Balantidium</em></td>
</tr>
</tbody>
</table>

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## Taxonomic classification of protozoa

<table>
<thead>
<tr>
<th>Sub kingdom</th>
<th>Phylum</th>
<th>Sub-phylum</th>
<th>Genus-examples</th>
<th>Species-examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protozoa</td>
<td>Sarcomastig-ophora</td>
<td>Sarcodina-- move by pseudopodia</td>
<td>Entamoeba</td>
<td><em>E. histolytica</em></td>
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<td>Mastigophora</td>
<td>Explorer</td>
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<td><em>G. lamblia</em></td>
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<td>move by flagella</td>
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<td>Apicomplexa</td>
<td>Explorer</td>
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<td><em>P. falciparum,</em></td>
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<td>no organelle of locomotion</td>
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<td><em>P. vivax,</em></td>
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<td>Explorer</td>
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<td><em>P. malariae,</em></td>
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<td>Explorer</td>
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<td><em>P. ovale</em></td>
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<td></td>
<td>Ciliophora</td>
<td>Explorer</td>
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<td><em>B. coli</em></td>
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<td>move by cilia</td>
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</table>
Forms and reproduction of protozoa

**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.)
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)
- Platyhelminthes (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 helmints
## Taxonomic classification of helminths

<table>
<thead>
<tr>
<th>Sub kingdom</th>
<th>Phylum</th>
<th>Class</th>
<th>Genus – examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metazoa</td>
<td>Nematodes</td>
<td></td>
<td>Ascaris (roundworm)</td>
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<td></td>
<td>Round worms;</td>
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<td>Trichuris (whipworm)</td>
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<td>appear round in</td>
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<td>Ancylostoma (hookworm)</td>
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<td>cross section,</td>
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<td>Necator (hookworm)</td>
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<td>they have body</td>
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<td>Enterobius (pinworm or threadworm)</td>
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<td>cavities, a</td>
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<td>Strongyloides</td>
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<td></td>
<td>Platyhelminthes</td>
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<td>Taenia (tapeworm)</td>
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<td>Flat worms;</td>
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<td>Cestodes</td>
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<td>Fasciolopsis (liver fluke)</td>
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<td>Adult tapeworms</td>
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<td>Schistosoma (not leaf shaped!)</td>
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Helminths
Male and female reproductive organs are found in separate individuals. 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 the egg)
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.