

Introduction to parasitology

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- Parasitology is the area of biology concerned with the phenomenon of dependence of one living organism on another.
- Medical parasitology deals with the parasites which infect man, the diseases they produce, the response generated by him against them and various methods of diagnosis and prevention.

Introduction

- **Parasite**-A living organism which receives nourishment and shelter from another organism where it lives.
- **Host**-An organism which harbours the parasite.
- **Symbiosis**-It is an association in which both are so dependent upon each other that one cannot live without the help of the other. None of the partner suffers any harm from the association.
- **Commensalism**-An association in which the parasite only is deriving benefit without causing injury to its host. A commensal is capable of leading an independent life.

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- **Parasitism**-An association in which the parasite derives benefit and the host gets nothing in return but always suffers some injury.
A parasite has lost its power of independent life.
- **Zoonosis**- It means a disease of animals. Leishmaniasis, trypanosomiasis, trichinelliasis and echinococcosis.
- **Classes of parasites-**
- **Ecto-parasite(Ectozoa)**:Lives outside on the surface of the body of the host.

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- **Endoparasite**-lives inside the body of the host, in the blood, tissues, body cavities, digestive tract and other organs.
- **Temporary parasite**-Visits its host for a short period.
- **Permanent parasite**-leads a parasitic life throughout the whole period of its life.
- **Facultative parasite**-Lives a parasitic life when opportunity arises.
- **Obligatory parasite**-Cannot exist without a parasitic life.

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- **Occasional or Accidental Parasite**-Attacks an unusual host.
- **Wandering or Aberrant parasite**-Happens to reach a place where it cannot live.
- **Free living**-The term free living describes the non parasitic stages of existence which are lived independently of a host. E.g. hookworm have active free living stages in the soil.
- **Classes of Hosts-**
- **Definitive Host**-Either harbours the adult stage of the parasite
Or
Where the parasite utilises the external method of reproduction.

In majority of human parasitic infections, man is the definitive host.

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- In malaria and hydatid disease, man acts as the intermediate host.
- **Intermediate host**-It harbours the larval stages of the parasite.
In some cases larval developments are completed in two different intermediate hosts .These are referred as first and second intermediate hosts respectively.
- **Paratenic Host**-(A carrier and transport host)-A host where the parasite remains viable without further development.
- **Reservoir host**-It is a host which harbour the parasite and serves as an important source of infection to other susceptible hosts.Epidemiologically, reservoir hosts are important in the control of parasitic disease.

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- **Vector**-A vector is an agent, usually an insect, that transmits an infection from one human host to another.
- **Mechanical vector**-This is a vector which assists in the transfer of parasitic forms between hosts but is not essential in the life cycle of the parasite.e.g. a housefly that transfers amoebic cysts from infected feaces to food that is eaten by humans.
- **Sources of infection-**
 1. Contaminated soil and water
 2. Freshwater fishes-Diphyllobothrium latum and Clonorchis sinensis.

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- Crab and crayfishes-*Paragonimus wertermani*.
- Raw or undercooked pork-*Trichinella spiralis*, *T.solium*.
- Raw or undercooked beef-*T.saginata*, *Toxoplasma gondii*.
- Watercress-*Fasciola hepatica*
- Blood sucking insects
- Housefly-Mechanical carrier-*E.histolytica*

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- Dog-Echinococcus granulosus and Toxocara canis.
- Cat-T.gondii.
- Man-E.histolytica, Enterobius vermicularis and H.nana.
- Autoinfection-May occur with E.vermicularis and S.stercoralis leading to hyperinfection.
- **Portal of entry into the body-**
- Mouth-Commonest portal of entry of the parasites is oral through contaminated food,water, soiled fingers or fomites.

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- Skin-Entry through skin is another important portal of entry of parasites. Infection with *A. duodenale*, *N. americanus* and *S. stercoralis* is acquired when filariform larvae of these nematodes penetrate the unbroken skin of an individual walking over faecally contaminated soil.
- Schistosomiasis caused by *S. haematobium*, *S. mansoni* and *S. japonicum* is acquired when the cercarial larvae, in water, penetrate the skin.
- Sexual contact-*Trichomonas vaginalis* is transmitted by sexual contact.
- Congenital-Infection with *T. gondii* and *Plasmodium* spp. May be transmitted from mother to fetus transplacentally.

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- Inhalation-
- Iatrogenic infection-Malaria parasites may be transmitted by transfusion of blood from the donor with malaria containing asexual forms of erythrocytic schizogony.This is known as trophozoite induced malaria or transfusion malaria. Malaria parasites may also be transmitted by the use of contaminated syringes and needles.This may occur in drug addicts.
- **Life cycle of human parasites**-On the basis of their life cycles human parasites can be divided into three major groups-
- **Pathogenicity**-A parasite may live in or on the tissues of its host without causing evident harm.

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- In majority of cases the parasite has the capacity to produce damage.
- With the advent of AIDS there is an increase in the incidence of newer parasitic infections caused by *Cryptosporidium parvum*, *Isospora belli*, *Cyclospora cayetanensis*.

Following are the ways in which the damage may be produced by the parasites:

Traumatic damage-

- Physical damage is produced by entry of filariform larvae of *S.stercoralis*, *A.duodenale* and *N.americanus* and cercarial larvae of *S.haematobium*, *S.mansoni* and *S.japonicum* into the skin.

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- Migration of several helminthic larvae through traumatic damage of pulmonary capillaries leading to extravasation of blood into the lung.
- Damage in cerebral, retinal or renal capillaries may lead to serious injury.
- Eggs of *S.haematobium* and *S.mansoni* cause extensive damage with haemorrhage as they escape from vesical and mesenteric venules, respectively, into the lumen of the urinary bladder and the intestinal canal.
- Attachment of hookworms to the intestinal wall results in traumatic damage of the villi and oozing of blood at the site of attachment.
- Large worms, such as *A.lumbricoides* and *T.saginata* may produce intestinal obstruction.

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- Ascaris may occlude lumen of the appendix or common bile duct, may cause perforation of the intestinal wall.
- They may penetrate into the parenchyma of the liver and the lungs.
- **Lytic necrosis**-*E.histolytica* secretes lytic enzyme which lyses tissues for its nutritional needs.
- It helps it to penetrate into the tissues of the colon and extraintestinal viscera.
- Obligate intracellular parasites e.g. *Plasmodium* spp., *Leishmania* Spp., *Trypanosoma cruzi* and *Toxoplasma gondii* cause necrosis of parasitized host cells during their growth and multiplication.

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- Competition for specific nutrients-Diphyllobothrium latum competes with the host for vitamin B₁₂ leading to parasite induced pernicious anaemia.
- Inflammatory reaction-Most of the parasites provoke cellular proliferation and infiltration at the site of their location.
- In metazoa and in some protozoan parasitoses, there is a moderate to significant eosinophilia.
- Iron deficiency, pernicious and hemolytic anaemia develop in patients with hookworm disease, diphyllobothriasis and malaria, particularly blackwater fever, respectively.

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- E.histolytica may produce inflammation of the large intestine leading to the formation of amoebic granuloma or amoeboma.
- Parasitization of fixed macrophages in the spleen, bone marrow, and lymph nodes by L.donovani causes proliferation of reticuloendothelial cells.
- **Allergic manifestations**-In certain helminthic infections, the normal secretions and excretions of the growing larvae and the products liberated from dead parasites may give rise to various allergic manifestations.
- Schistosomes cause cercarial dermatitis and eosinophilia.
- D.medinensis and T.spiralis infections cause urticaria and eosinophilia.
- Rupture of the hydatid cyst may precipitate anaphylaxis.

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- Neoplasia-The parasitic infection may contribute to the development of neoplastic growth.
- *C.sinensis* and *Opisthorchis viverrini* have been associated with cholangiocarcinoma and *S. haematobium* with vesical carcinoma.
- Secondary infection-In some helminthic infections(*Strongyloidiasis*, *trichinosis* and *ascariasis*), the migrating larvae may carry bacteria and viruses from the intestine to the blood and tissues leading to secondary infection.

Immunity in parasitic infections

- Protozoa are small and multiply within their vertebrate host, inside cells.
- Protozoa thus posing an immediate threat unless contained by an appropriate immune response.
- Helminths are large and do not multiply within their vertebrate host.
- So helminths do not present an immediate threat after initial infection.
- Parasite also elicit both humoral as well as cellular responses.
- But immunological protection against parasitic infections is much less efficient than it is against bacterial and viral infections.

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- Parasites are large and more complex structurally and antigenically so that immune system may not be able to mount response against the protective antigens.
- Many protozoa parasites (e.g. *Leishmania* spp. And *T.gondii*) are intracellular. This protects them from immunological attack.
- Many parasites, both protozoa and helminths, live inside the intestines. This location limits the efficiency of immunological attack.
- *T.brucei gambiense* and *T.b.rhodesiense* exhibit antigenic variations within the host.

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- Many nematodes have a cuticle which is antigenically inert and evokes little immune response.
- *L.donovani* causes extensive damage to the reticuloendothelial system thus leading to immunological tolerance.
- *E.vermicularis* does not breach the integrity of gut wall, thus immune system is not stimulated.
- In most of the parasitic infections, immunity lasts only till original infection remains active.This is known as concomitant immunity.(Premunition or infection immunity)

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- The protective immune response to parasitic infections has four arms-
 - Cytotoxic T(Tc) cells
 - Natural killer (NK) cells
 - Activated macrophages
 - Antibody(Produced by B-cells)
- The main classes of antibodies (Immunoglobulins) produced are IgM, IgG, and IgE.
- IgM appears first and denotes recent infection.
- IgG antibodies are usually the most abundant type in parasitic infections.
- Helminths and ectoparasites also provoke high titres of IgE antibodies.

Laboratory diagnosis

- Laboratory diagnosis of parasitic infections can be carried out by-
 - Demonstration of parasite
 - Immunodiagnosis
 - Molecular biological methods
- **Demonstration of parasites:**
 - **Blood**-In those parasitic infections, where the parasite itself, or in any stage of its development, circulates in the blood stream, the examination of blood film forms the main procedure for specific diagnosis e.g.

Demonstration of Plasmodium spp. and Babesia spp. inside the erythrocytes

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- *L.donovani* inside monocytes.
- Trypomastigotes of *T.b.gambiense*, *T.b.rhodesiense* and *T.cruzi*.
- *W.bancrofti* and *B.malayi* in the blood

Stool

- Examination of stool is important for the diagnosis of intestinal parasitic infections and helminthic infections of the biliary tract.
- Eggs are discharged in the intestine.

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- In the protozoal infections, trophozoites(during active phase) and cysts(during chronic phase) of *E.histolytica*, *G.lamblia* and *B.coli* can be demonstrated by wet mount of stool in normal saline and Lugol's iodine.
- In helminthic infections eggs, larvae and adult worms may be demonstrated.
- Concentration methods such as salt floatation or formalin ether concentration may be used when direct stool smears are repeatedly negative for ova and cysts.
- *Cryptosporidium parvum*, *Isospora belli* and other coccidia in stool specimens may be detected by modified Ziehl-Neelsen staining of the fixed smear.

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- Demonstration of parasites in the stools confirm the diagnosis.
- It is the gold standard in the diagnosis of intestinal parasitic infections.
- **Perianal and perineal skin scrapings**-May show the eggs or adult worms of *E.vermicularis*.
- **Urine**-Urine is useful in establishing the parasitological diagnosis when the parasite localises in the urinary tract.
- Eggs of *S.haematobium* and trophozoites of *T.vaginalis* may be demonstrated in the urine.

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- In case of chyluria caused by *W.bancrofti*, microfilariae are often demonstrated in chylous urine.
- **Genital specimens-**Trophozoites of *T.vaginalis* may be demonstrated in the vaginal and urethral discharge and in the prostatic secretions.
- **Cerebrospinal fluid (CSF)-**
- Trypomastigotes of *T.brucei* and trophozoites of *N.fowleri*, *Acanthamoeba* spp. and *B. mandrillaris* may be demonstrated in the CSF.

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- **Sputum**-eggs of *Paragonimus wertermani* may be demonstrated in the sputum specimen.
- Rarely, migrating larvae of *A. lumbricoides*, *S.stercoralis*, *A.duodenale* and *N.americanus*, and trophozoites of *E.histolytica* may be found in the sputum.
- **Tissue biopsy and aspiration-**
- Scolices and brood capsules may be demonstrated in the fluid aspirated from hydatid cyst.
- Amastigote forms of *L.donovani* may be demonstrated inside the reticuloendothelial cells in the aspirates of spleen, bone marrow, liver and lymph nodes.

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- Larvae of *T.spiralis*, *T.solium* and *T.multiceps* may be demonstrated in the muscle biopsy.
- Trophozoites of *G.lambliia* may be demonstrated in the bile aspirated from duodenum by intubation.
- Trophozoites of *E.histolytica* may be demonstrated in pus aspirated from amoebic liver abscess and in the necrotic tissue obtained from the base of the ulcers in the large intestine.

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- **Culture-**
- Some parasites like *E.histolytica* and *G.lamblia* in stool and *Leishmania* spp. and *Trypanosoma* spp. in blood can be cultured in the laboratory.
- Culture of parasites is particularly useful when the number of parasites in the specimens is too small.
- **Animal inoculation-**
- It is useful in the detection of *T.gondii* and *Babesia* spp. in the clinical specimens.

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- **Immunodiagnosis**-two type of tests are available-
 - Skin test
 - Serological tests
- **Skin test**-These tests are performed by intradermal injection of parasitic antigens.
 1. **Immediate hypersensitivity reaction**-It reveals erythema and induration after 30 minutes of injection. This reaction is seen in cases of hydatid disease, filariasis, schistosomiasis, ascariasis and strongyloidiasis.
 2. **Delayed hypersensitivity reaction**-It reveals erythema and induration after 48 hours of injection. This reaction is seen in cases of leishmaniasis, trypanosomiasis, toxoplasmosis and amoebiasis.

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- **Serological tests**-These tests detect antibodies or antigens in the patient serum and other clinical specimens.
- **Molecular biological methods**-These include DNA probes and polymerase chain reactions (PCR).
- **DNA probes**-
- DNA probe is a radiolabelled or chromogenically labelled piece of single stranded DNA complementary to a segment of parasitic genome.
- It is unique to a particular parasitic strain , species and genus.

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- Specific probe is added to the clinical specimen.
- If the specimen contains the parasitic DNA, probe will hybridize with it, which can be detected.
- DNA probes are available for the detection of the infection with *P.falciparum*, *W.bancrofti*, *T.b. gambiense*, *T.b. rhodesiense*, *T.cruzi* and *Onchocerca* spp.

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- **Polymerase chain reaction-PCR** is a DNA amplification system that allows molecular biologist to produce microgram quantities of DNA from picogram amounts of starting material.
- It has been employed to detect faecal antigens for the diagnosis of intestinal amoebiasis, giardiasis and other intestinal parasitic infections.

Classification of parasites

- Proposed by Whittaker in 1969, all living organisms belong to five kingdoms: Monera, Protista, Fungi, Plantae and Animalia.
- Protozoa which are eukaryotic unicellular organisms belong to the kingdom Protista.
- Helminths which are eukaryotic multicellular organisms varying in length from less than 1 millimeter to more than a meter belong to the kingdom Animalia.
- The study of protozoa and helminths is known as protozoology and helminthology respectively.