INTRODUCTION TO MEDICAL PARASITOLOGY

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Summary

Medical Parasitology is the branch of medical sciences dealing with organisms (parasites) which live temporarily or permanently, on or within the human body (host). There are different types of parasites and hosts. The competition for supremacy that takes place between the host and the parasite is referred to as host-parasite relationship. Accordingly, the host may have the upper hand and remains healthy or loses the competition, and a disease develops. Human parasites are either unicellular (protozoa) or multicellular (helminthes and arthropods). The parasites may live inside the host (endoparasites) or on the host surface (ectoparasites).

Endoparasites are classified into intestinal, atrial or they may inhabit body tissues causing serious health problems. Ectoparasites are arthropods that either cause diseases, or act as vectors transmitting other parasites. Human evolution and parasitic infections have run hand in hand and most parasitic diseases and methods of their transmission have been discovered thousands of years ago. Environmental changes, human behavior and population movement have a great effect on transmission, distribution, prevalence, and incidence of parasitic diseases in a community. Parasites can invade the human body in different ways; through oral route, skin, arthropod vectors or sexual contact. Host defense mechanisms consist of innate immunity which mediates initial protection against infection and adaptive immunity which is more effective. Once parasites have evaded innate host defenses, adaptive cellular and humoral immune responses are promoted against a wide array of antigenic constituents.

Diagnosis of parasitic diseases depends on several laboratory methods, imaging techniques and endoscopy in addition to clinical picture and geographic location. Parasitic diseases may be presented by a wide variety of clinical manifestations according to the tissue invaded. Direct microscopy is based on detection of the parasite by examination of different specimens (stool, urine, blood, CSF and tissue biopsies). Immunodiagnostic techniques include antigen and antibody-detection assays. Molecular-based diagnostic approaches offer great sensitivity and specificity. Recently, nanotechnology can be applied as diagnostic procedures utilizing nanodevices. Control and prevention of parasitic diseases depend on the interactions among many factors such as the environment, the human behavior, and socio-cultural factors that determine transmission and persistence of parasites.

1. Introduction

Medical Parasitology is the science dealing with parasites that infect man, causing disease and misery in most countries of the tropics. They plague billions of people, kill millions annually, and inflict debilitating injuries such as blindness and disfiguration on additional millions. World Health Organization estimates that one person in every four harbors parasitic worms.

The present work aims to clarify several aspects concerning parasites of medical importance to man. Parasite classification, general characters, biology, ecological factors that affect their transmission, the immune response of the body to invading parasites, diagnosis and control of the disease developed are highlighted.

1.1. Medical Parasitology

Medical Parasitology is the branch of medical sciences dealing with organisms (parasites) which live temporarily or permanently, on or within the human body (host). Parasitology is a dynamic field because the relationships between parasites and their hosts are constantly changing. Parasitism comprises an ecological relationship between two individuals of different species where the parasite's environment is another living organism. Parasites often cause important diseases of humans and animals (Bogitsh *et al.*, 2005). For this reason, Parasitology is an active field of study in which advances in biotechnology have raised expectations for the development of new drugs, vaccines, and other control measures. However, these expectations are dampened by the inherent complexity of parasites and host-parasite relationships, the entrenchment of parasites and vectors in their environments, and the vast socioeconomic problems in the geographical areas where parasites are most prevalent (McGraw-Hill, 2005)**.** But what is the parasite?

The parasite is a living organism that lives in (endoparasite) or on (ectoparasite) another organism, termed its host. It obtains nourishment and protection while offering no benefit in return. Consequently, the host suffers from various diseases, infections, and discomforts. However, in some cases, the host may show no signs at all of infection by the parasite (UXL Encyclopedia of Science, 2002).

1.2. Types of Parasites

According to the nature of the host-parasite interactions and the environmental factors, the parasite may be one of the following types;

- An obligatory parasite that is completely dependent on its host and can't survive without it e.g. hookworms.
- A facultative parasite that can change its life style between free-living in the environment and parasitic according to the surrounding conditions. e.g. *Strongyloides stercoralis*.
- An accidental parasite that affects an unusual host e.g. *Toxocara canis* (a dog parasite) in man.
- A temporary parasite that visits the host only for feeding and then leaves it. e.g. Bed bug visiting man for a blood meal.

- A permanent parasite that lives in or on its host without leaving it e.g. Lice.
- An opportunistic parasite that is capable of producing disease in an immune-deficient host (like AIDS and cancer patients). In the immuno-competent host, it is either found in a latent form or causes a self limiting disease e.g. *Toxoplasma gondii.*
- A zoonotic parasite that primarily infects animals and is transmittable to humans. e.g. *Fasciola* species (Assaf *et al.,* 2004).

1.3. Types of Hosts

Hosts are classified according to their role in the life cycle of the parasite into:

- Definitive host (DH) that harbours the adult or sexually mature stages of the parasite (or in whom sexual reproduction occurs) e.g. man is DH for *Schistosoma haematobium*, while female *Anopheles* mosquito is DH for *Plasmodium* species (malaria parasites).
- Intermediate host (IH) that harbours larval or sexually immature stages of the parasite (or in whom asexual reproduction occurs) e.g. man is IH of malaria parasites. Two intermediate hosts termed 1st and 2nd IH may be needed for completion of a parasite's life cycle, e.g. *Pirenella conica* snail is the 1st IH, while *Tilapia* (Bolty) fish is the 2nd IH for *Heterophyes heterophyes*.
- Reservoir host (RH) harbours the same species and same stages of the parasite as man. It maintains the life cycle of the parasite in nature and is therefore, a reservoir source of infection for man. e.g. sheep are RH for *Fasciola hepatica.*
- Paratenic or transport host in whom the parasite does not undergo any development but remains alive and infective to another host. Paratenic hosts bridge gap between the intermediate and definitive hosts. For example, dogs and pigs may carry hookworm eggs from one place to another, but the eggs do not hatch or pass through any development in these animals.
- Vector is an arthropod that transmits parasites from one host to another, e.g. female sand fly transmits *Leishmania* parasites ((Bogitsh *et al.*, 2005).

1.4. Host-Parasite Relationship

The term refers to the relationship between the host and the parasite and the competition for supremacy that takes place between them.

Disease should not be confused with infection; a person may be infected without becoming diseased. If the host has upper hand, due to increased host resistance, it remains healthy and the parasite is either driven away or assumes a benign relationship with the host, but if the host loses the competition, a disease develops (Schmidt and Roberts, 2009).

In biology, the relationship between two organisms is mainly in the form of **symbiosis,** defined as "life together", i.e., the two organisms live in an association with one another. Thus, there are at least three types of relationships based on whether the symbiont has beneficial, harmful, or no effects on the other (Todar, 2011).

Types of Symbiotic Association:

- **Mutualism** is a relationship in which both partners benefit from the association. Mutualism is usually obligatory, since in most cases physiological dependence has evolved to such a degree that one mutual cannot survive without the other (Swift, 2009). Blood-sucking leeches cannot digest blood, and overcome that by harbouring certain intestinal bacterial species to do the digestion for their hosts. At least 20% of insect species, as well as many mites, spiders, crustaceans, and nematodes, are mutually infected with bacteria of genus *Wolbachia* (Warren, 2003). Also, filarial nematodes such *Wuchereria bancrofti* and *Onchocerca volvulus* which cause serious human diseases, are mutually infected with *Wolbachia*, and they can be cured of their bacterial infections by treating patients with antibiotics, but the worms die too (Rajan, 2003).
- **Commensalism:** in which one partner benefits from the association, but the host is neither helped nor harmed. Commensalism may be facultative, in the sense that the commensal may not be required to participate in an association to survive (Swift, 2009). Humans harbor several species of commensal protozoans, that colonize in the intestinal tract such as *Entamoeba dispar, Entamoeba hartmanni, Entamoeba moshkovskii***,** *Entamoeba polecki, Endolimax nana, Iodomoeba butschlii* (Ortega, 2006).
- **Parasitism:** in which one of the participants, the parasite, either harms or lives at the expense of the host. Parasites may cause mechanical injury, such as boring a hole into the host or digging into its skin or other tissues, stimulate a damaging inflammatory or immune response. Most parasites inflict a combination of these conditions on their hosts (Taliaferro, 2009).

Parasites are different from predators and parasitoids (which also derive benefits from certain interspecific interactions while harming the other participant) in that the host of a parasite is not necessarily killed. Instead, parasites derive benefits from their hosts, most often nutritional resources and shelter, over a longer period of time. It is in fact advantageous to parasites if they do not harm their hosts too badly, because that prolongs the period during which parasites can obtain benefits from hosts. However, in some cases, the impact of parasites on a host is great enough to cause disease, and in extreme cases, the death of the host may also occur (Yeh, 2002).

1.5. Classification and General Characters of Human Parasites.

The classification of parasites is controversial as there is no universally accepted system.

Parasites form part of the animal kingdom which comprises about 800,000 identified species categorized into 33 phyla.

The most acceptable taxonomic classification of human parasites includes Endoparasites and Ectoparasites. Endoparasites are sub-classified into Helminthic parasites (multicellular organisms) and Protozoan parasites (unicellular organisms). Helminthic parasites are either flat worms (Trematodes), segmented ribbon like worms (Cestodes) or cylindrical worms (Nematodes).

Figure 1. A Trematode worm, *Fasciola hepatica*

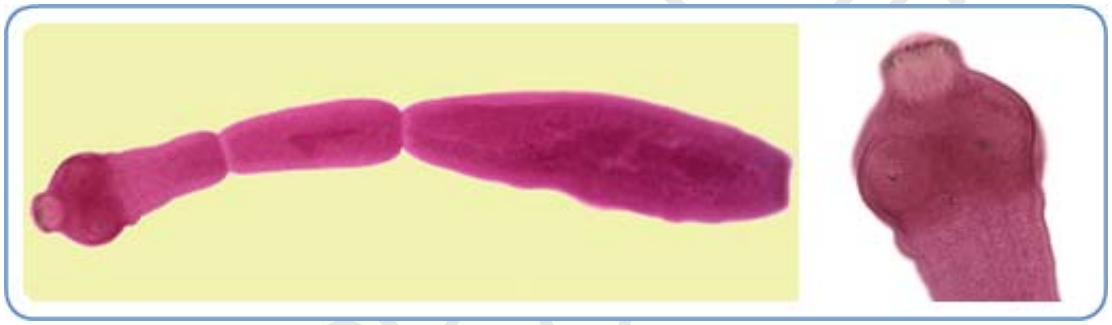

Figure 2. A Cestode worm, *Echinococcus granulosus*

Figure 3. A Nematode worm, *Ascaris lumbricoides*

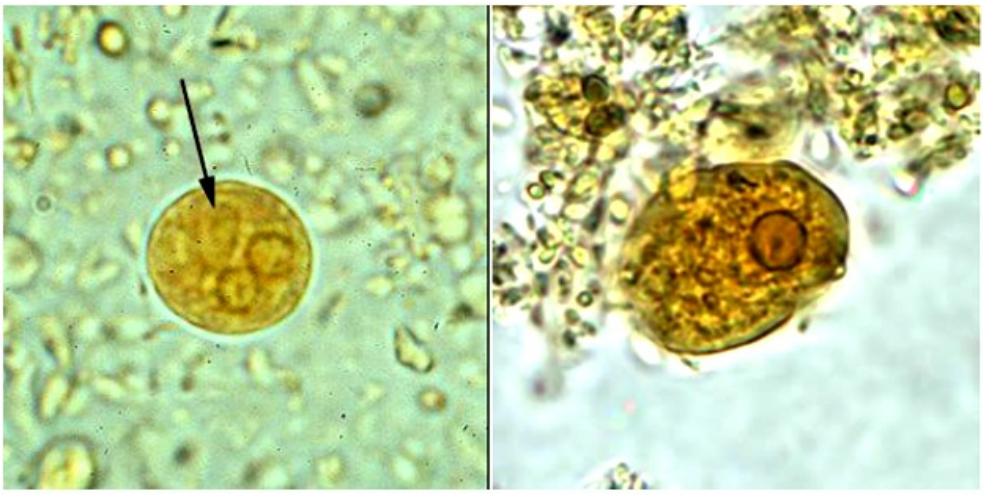

Figure 4. A Protozoan parasite, *Entamoeba histolytica* (cyst & trophozoite).

1.5.1. Endoparasites

Most parasites of humans live inside the host (*endo-* means internal). These are helminthes (worms of various types), protozoa, or sometimes larval stages of arthropods (insects, mites, etc.)

Both helminthic and protozoan parasites can infect different tissues and organs of the human body. A great number of endoparasites live in the intestines, or at least pass through the intestines, having been swallowed in food or water. Virtually any organ can be affected, however some parasites like *Trichinella spp*. and *Toxoplasma gondii* live in muscles, larvae of *Echinococcus spp*. and liver flukes occupy the liver, *Schistosoma hematobium* targets the urinary bladder and most of the protozoan parasites circulate in blood.

1.5.2. Ectoparasites

Human ectoparasites live on the host (*ecto-* means outside of). They include fleas, lice, mosquitoes, bugs, mites, ticks etc. In general, ectoparasites attach to the skin to feed and do not remain on the host for their entire lives.

Figure 5. *Pediculus humanus capitis* (male) as an example of ectoparasites.

Some of these organisms lie in a grey area between endoparasites and ectoparasites: scabies mites, for example, are generally considered ectoparasites though the female scabies mite does burrow into the skin. Fly larvae may feed on dead tissue in a wound, but some species never invade healthy tissue.

1.5.3. Parasites' Life Cycles

Life cycles of parasites may be simple or complex. Parasites that are characterized by a simple or direct life cycle have only one host and are described as **monoxenous (**e.g. life cycle of *Ascaris lumbricoides,* Fig. 6). The parasite generally spends most of its life in or on the host, and may reproduce within the host. Because offspring must be transmitted to other hosts, however, the parasite or its **progeny** must have some way of leaving the host, surviving in the external environment for some period, and locating and infecting a new host. Parasites with simple life cycles have both parasitic and free-living life stages. The proportion of the total life cycle spent in each stage varies according to the parasite.

Parasites with more complex life cycles involving multiple hosts are described as having indirect or **heteroxenous** life cycles (e.g. life cycle of *Fasciola* spp., Fig. 7). The primary or definitive host of a heteroxenous species is the one in which adult parasites live and reproduce sexually. The secondary or intermediate host (IH) is the host where immature life stages of the parasite live and reproduce asexually. In many cases, the parasite passes through critical developmental stages in the IH. The latter may also aid in transmitting parasites to their final host. Rat flea, for example, is the IH for mammalian parasites such as the tapeworm; *Hymenolepis diminuta*.

Some parasites are transmitted directly from one host to another, often by insects, described as vectors. One particularly effective vector for vertebrate parasites is the mosquito, which plays a role in transmission of numerous parasites including heartworm, the viruses that cause yellow fever and encephalitis, and *Plasmodium*, the protozoan that causes malaria (http://www.mosquito.org/mosquito-borne-diseases).

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Todar, K. (2011): The Nature of Bacterial Host-Parasite Relationships in Humans. In Todar's Online Textbook of Bacteriology P.1. [This presents the nature of the relationship between the parasite and its human host whether it is beneficial, harmful or no effects].

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Biographical Sketch

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- Member in the World Federation of Parasitologists.

- Reviewer in the Eastern Mediterranean Health Journal (EMHJ).
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- Co-founder for the Egyptian Parasitologists United (EPU) and Developer for the website: w w w . epu – eg . com
- Consultant of Medical laboratories at the Health Insurance Organization, Cairo-Egypt.
- Consultant of Molecular Biology and Genetics and Head of the Training Unit at the Medical Research Center, Ain-Shams University.
- Member in the Self-study Team of the Quality Assurance Unit, Faculty of Medicine, Ain Shams University
- Member of the Teaching and Examining Board of Parasitology for 3rd year students and for Post-graduates, Faculty of Medicine, Ain Shams University, Cairo, Egypt.
- Member of the Teaching and Examining Board of Parasitology and Biology at the Nursing School, and Faculty of Nursing and Faculty of Medicine, Ain Shams University, Cairo, Egypt.
- Head of the Scientific Research Committee, Faculty of Medicine, Ain Shams University.
- Organization and participation in many scientific training courses, workshops, national and international conferences in the field of Medical Parasitology, Molecular Biology, Telemedicine and Telehealth.
- Member in many scientific and medical societies.
- Supervision on many PhD and Master Theses.
- The Principle Investigator (PI) for a Research Project entitled "Relationship of chronic *Schistosoma mansoni* infection with Hepatocellular Carcinoma in Egypt", funded by Ain Shams University.
- Author for many scientific papers published in national and international journals
- Author and editor for many medical books; national and international.
- Translator for medical books (Arabic-English).