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

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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**Bibliography**

recognition of the central role of phylogenetically conserved toll-like receptors in triggering innate immunity and the subsequent recruitment of adaptive response programmes].


Ambroise-Thomas, P. (2001): Parasitic diseases and immunodeficiencies. Parasitology 122(Suppl.):s65-s71. [the immunodepression associated with HIV and AIDS infections has resulted in the establishment of a number of new opportunistic parasitic infections].

Anthony RM, Rutitzky LI, Urban JF, Stadecker MJ Jr, Gause WC. (2007): Protective immune mechanisms in helminth infection. Nat Rev Immunol; 7(12): 975–87. [This study on the immune response against helminthes is of great interest in understanding interactions between the host immune system and parasites].

Anthony RM, Urban JF Jr, Alem F et al. (2006): Memory TH2 cells induce alternatively activated macrophages to mediate protection against nematode parasites. Nature Med; 12:955–60. [The authors studied the immune response that mediated through TH2 and the mechanisms that leading to host protection against helminthic parasites].

Arcari M., Baxendine A. and Bennett C. E (2000): Diagnosing Medical Parasites through Coprological Techniques [http://www.soton.ac.uk/~ceb/Diagnosis/Vol1.htm] [laboratory diagnosis of medical parasites by their detection in fecal specimens, body tissues or fluids using special techniques]

Ashford, R. W., and W. Crewe  (1998):  The Parasites of Homo Sapiens: An Annotated Checklist of the Protozoa, Helminths and Arthropods for Which We are Home, Liverpool School of Tropical Medicine, Liverpool, United Kingdom.[An indispensable guide for all parasitologists, it presents a comprehensive checklist of all animals naturally parasitic in or on the human body].

Ashokan KV and Pillai MM. (2008): In silico characterization of silk fibroin protein using computational tools and servers. Asian J.Exp.Sci, 22(3), 265-274.[In this paper, ten different silk fibroin proteins (SFs) retrieved from Swiss-Prot database are analyzed and characterized using in silico tools].


Azim S, Dojki F, Ahmad SS, Beg MA (2008): Role of Human Behaviour and Parasitic Diseases-Review Article. Infectious Diseases Journal of Pakistan, Volume 17 Issue 04, Page 128-134,[this review concluded that the prevalence of zoonosis is affected by human behavior. Interventions involving modifications of human behavior to reduce disease prevalence are neglected in many disease control programs].


Bray, R. S. (1996): Amoebiasis, The Wellcome Trust illustrated history of tropical diseases., Cox F. E. G. (ed.), The Wellcome Trust, London, United Kingdom, , p. 170-177. [Discovery of both the intestinal and liver forms of the disease was recognized from the earliest times as there were so many causes of both the bloody dysentery characteristic of amoebiasis and hepatic symptoms].

Burbelo, P. D., Goldman R. and Mattson T.L. (2005): A simplified immunoprecipitation method for quantitatively measuring antibody responses in clinical sera samples by using mammalian-produced Renilla luciferase-antigen fusion proteins, BMC Biotechnology, vol. 5, article 22.[The authors reported that a number of newer serology-based assays that are highly specific and sensitive have emerged].


Buzea C, Pacheco I, and Robbie K. (2007): Nanomaterials and Nanoparticles: Sources and Toxicity. *Biointerphases*; 2: MR17-MR71.[This presents the study of atoms and small molecules, using spectroscopy and mass spectroscopy, that were extended to other nanometer-sized structures].

Carter, W.J., Yan, Z., Cassai, N.D. and Sidhu, G.S. (2003): Detection of extracellular forms of *Babesia* in the blood by electron microscopy: a diagnostic method for differentiation from *Plasmodium falciparum*, *Ultrastructural Pathology*, vol. 27, no. 4, pp. 211–216.[ The authors used Electron Microscopy, a new tool, for differentiation between *Babesia* and *Plasmodium falciparum*.]


Cobo, F. Aliaga, L., Talavera, P. and Concha, A. (2007): The histological spectrum of non-granulomatosus localized mucosal leishmaniasis caused by Leishmania infantum,” *Annals of Tropical Medicine and Parasitology*, vol. 101, no. 8, pp. 689–694.[The authors evaluated that microscopy remains the only diagnostic tool for detection of parasites in tissue smears].


Dario A. Palmieri; Marcelo D. Bechara; Rogério A. Curi; Jomar P. Monteiro; Sérgio E.S. Valente; Marcos A. Gimenes; Catalina R. Lopes (2010): Genetic diversity analysis in the section Caulorrhizae (genus Arachis) using microsatellite markers, *Genet. Mol. Biol.* vol.33 no.1 São Paulo, Epub.[It presents the genetic differences between parasite strains and gene mutation in chromosomes that may occur].


©Encyclopedia of Life Support Systems (EOLSS)
Dobell, C. (1919): The amoebae living in man. John Bale Sons and Danielsson, London, United Kingdom.[this presents the discovery of protozoan parasites by Antonie van Leeuwenhoek toward the end of the 17th century].


Elliott, J. (1863): Report on epidemic and remittent fever occurring in parts of Burdwan and Neddea divisions. p. 1-23. Bengal Secretarial Office, Calcutta, India.[Kala azar was first noticed in Jessore in India in 1824, when patients was suffering from fevers].


Fong MY, Asha T, Azdayanti M, Yee LL, Sinnadurai S, Rohela M.(2008): Inferring the phylogenetic position of Brugia pahangi using 18S ribosomal RNA (18S rRNA) gene sequence, Trop Biomed. 25(1):87-92.[The researchers concluded that the amplified RNA sequences of parasites can establish how close or divergent they are]

Fotedar R, Stark D, Beebe N, et al. (2007): Laboratory diagnostic techniques for Entamoeba species. Clin Microbiol Rev; 20 (3):511-32,[The authors reported about the prevalence rate of amoebiasis that it is worldwide and the different identified species of Entameba].


Fumagalli M, Pozzoli U, Cagliani R, Comi GP, Riva S, Clerici M, Bresolin N, Sironi M (2009): Parasites represent a major selective force for interleukin genes and shape the genetic predisposition to autoimmune conditions. J Exp Med, 206:1395-1408.[The researchers verified that six risk alleles for inflammatory bowel (IBD) are significantly correlated with micropathogen richness which provide a large set of putative targets for susceptibility to helminth infections].

Ghaffar A. and Brower G. (2010): RASITOLOGY – Chapter Five –Cestodes (Tape Worms), h t t p : / / pathmicro . med . sc . edu / parasitology / cestodes . htm [It presents the PAIR technique and its uses in treatment of Hydatid disease].


©Encyclopedia of Life Support Systems (EOLSS)
Grassi, B (1981): Noto interno ad alcuni parassiti dell'uomo III. Interno all'Ascaris lumbricoides. Gaz. Osp. Milano, 2:432.[He did the experiment on himself by being exposed to infection with the eggs of *A. lumbricoides* and subsequently found eggs in his feces].

Gratz, N. (1998): Human lice, their prevalence and resistance to insecticides. Geneva: World Health Organization (WHO). [He studied the epidemiology of human louse infestations and noticed that its prevalence has increased worldwide since the mid-1960s, reaching hundreds of millions annually].


Healy, GR and Ruebush, TK. (1980): Morphology of *Babesia microti* in human blood smears, *American Journal of Clinical Pathology*, vol. 73, no. 1, pp. 107–109. [The authors reported that microscopy, for many years, has been the only tool available for the detection of parasites through inspection of different samples as blood smears].


Healy, GR and Ruebush, TK. (1980): Morphology of *Babesia microti* in human blood smears, *American Journal of Clinical Pathology*, vol. 73, no. 1, pp. 107–109. [The authors reported that microscopy, for many years, has been the only tool available for the detection of parasites through inspection of different samples as blood smears].


Hillyer, G. V., De Galanes, M. S., Rodriguez-Perez, J. et al. (1992): Use of the FalconTM assay screening test-enzyme-linked immunosorbent assay (FAST-ELISA) and the enzyme-linked immunoelectrotransfer blot (EITB) to determine the prevalence of human fascioliasis in the Bolivian Altiplano, *The American Journal of Tropical Medicine and Hygiene*, vol. 46, no. 5, pp. 603–609.[The authors found that FAST-ELISA and EITB tests have shown to be useful in the confirmation of chronic fascioliasis when egg production is low or sporadic].


Hoeppli, R. (1956): The knowledge of parasites and parasitic infections from ancient times to the 17th century. Exp. Parasitol., 5:398-419.[The author’s studies were on primitive tribes in Sarawak and North Borneo, where Hoeppli found that most people are aware of their intestinal roundworms and tapeworms].

Hotez P (2001): The Global Burden of Parasitic Disease in the New Millennium. Inter-science Conference on Antimicrobial Agents and Chemotherapy (41st Conference, Chicago, Ill.). [The authors reported that globalization has yet to benefit the enormous burden caused by parasitic infections among the poorest of the poor living in developing countries].


Jackson JA, Friberg IM, Bolch L, Lowe A, Ralli C, Harris PD, Behnke JM, Bradley JE (2009): Immunomodulatory parasites and toll-like receptor-mediated tumour necrosis factor alpha responsiveness in wild mammals. *BMC Biology*, 7:16.[The authors reported that some ectoparasites exert immune-modulatory effects similar to those associated with helminths gut infection, also the diminished cytokine responses following TLR stimulation].

James, WD.; Berger, TG.; et al. (2006): *Andrews' Diseases of the Skin: clinical Dermatology*. Saunders Elsevier, 446-8. [They differentiated the three types of pediculosis; *capitis*, *corporis* and *pubis*].


Khrana S, Dubey ML, Malla N. (2005): Association of Parasitic Infections and Cancers *Indian Journal of Medical Microbiology*, Volume 23(2) Page: 74-79.[They clarified the relationship between infectious agents and cancer, and have given valuable insights into the molecular basis of carcinogenesis].

Küchenmeister, F. (1857): Animal and vegetable parasites. Translated from the German by Edwin Lankaster. The Sydenham Society, London, United Kingdom.[He gave description of hydatid cysts in humans in the *Corpus Hippocratorum*].

Kuhn, K. (ed.). (1821-1833): *Galen (Galenum)*. Opera omnia, 22 vols. Leipzig, Germany.[In history of parasitic diseases, the reported about helminthic worms of fishes, domesticated animals, and humans].

Leung A.K.C.,and Robson LM (2008): "Pruritis in Children: What's Itching?". *Consultant for Pediatricians*. [The researchers described the Head-lice infestation is most frequent in children and their families. They also studied the epidemiology of head lice in United].

Macpherson C.N.L.(2005): Human behavior and the epidemiology of parasitic zoonoses. *Int. J. Parasitol.* 35: 1319-1331.[He wrote about the definitions of some epidemiological terms as Macroepidemiology].

Malaria, Fact sheet No. 94, 2010: h t t p : / / w w w . w h o . m i n / mediacentre / factsheets / fs094 / en / index . html [It presents epidemiology, transmission, symptoms, diagnosis and treatment of malaria].


Marcogliese D.J. (2008): The impact of climate change on the parasites and infectious diseases of aquatic animals, Rev Sci Tech,27(2):467-84.[The author described the effects of climate changes on parasitism and disease in freshwater and marine ecosystems, with consequences for human health and socio-economics].

Mata L. (1982): Sociocultural factors in the control and prevention of parasitic diseases. *Rev Infect Dis.*, 4 (4):861-9.[It presents the control and prevention of parasitic disease which depends on studying the interactions between factors such as human behavior, the environment, and the life cycles of parasites].
Mayumi A., Yamaji N., Eiji N., Kouichi N., Satoru K. and Masamichi A. (2001): Invasive forms of Toxoplasma gondii, Leishmania amazonensis and Trypanosoma cruzi have a positive charge at their contact site with host cells. Parasitology Research, Vol. 87(3), pp 193-197, Springer Berlin / Heidelberg.[The authors studied the cell surface charges of the invasive protozoan parasites using the Atomic Force Microscopy].


Mens P., Spiker N., Omar S. Heijnen M, Schallig H. and Kager P.A. (2007): Is molecular biology the best alternative for diagnosis of malaria to microscopy? A comparison between microscopy, antigen detection and molecular tests in rural Kenya and urban Tanzania, Tropical Medicine and International Health, vol. 12, no. 2, pp. 238–244.[The authors reported that molecular-based techniques offer greater sensitivity and specificity over the existing diagnostic tests].


Muldrew, KL. (2009): Molecular diagnostics of infectious diseases, Current Opinion in Pediatrics, vol. 21, no. 1, pp. 102–111.[This presents the value of real-time polymerase chain reaction that has shown a high potential for use in parasite diagnosis with increased specificity and sensitivity].


Nature Publishing Co. (2001): The human genome. Nature 409(Suppl.):813-958.[The paper presents the relation between human evolution and parasitic infections that was studied through the Human Genome Project].


Ortega Y.R (2006): Amoeba and Ciliates. In Food-borne Parasites, Ortega Y.R (ed), p: 1-14, Springer.[The author described the commensalism relation between 2 organisms in which one partner benefits from the association, but the host is neither helped nor harmed].


Parida M.M., Sannarangaiah, S., Dash, P.K., Rao, P.V.L. and Morita, K. (2008): Loop mediated isothermal amplification (LAMP): a new generation of innovative gene amplification technique; perspectives in clinical diagnosis of infectious diseases, Reviews in Medical Virolology, vol. 18, no. 6, pp. 407–421. [The authors described LAMP technique as it is a unique amplification method with extremely high specificity and sensitivity able to discriminate between a single nucleotide difference].


Rajan, T.V. (2003): The worm and the parasite, Natural History 112:32-35. [The author studied the relationship between filarial nematodes such Wuchereria bancrofti and Onchocerca volvulus which are mutually infected with Wolbachia bacteria].

Reinhard K, Confalonieri U, Ferreira LF, Herrmann B., Araújo A (1988): Recovery of parasite remains from coprolites and latrines: aspects of paleoparasitological technique. Homo 37: 217-239. [The authors reported about finding parasites in fecal material recovered from archaeological sites, they added that preservation seems to be best in moist anaerobic environments or desiccating environments].

Reinhard KJ (1992): The impact of diet, and parasitism on anemia in the prehistoric West. In P Stuart Mc Adam, S Kent (eds), Demography and Disease: Changing Perspectives of Anemia, Aldine de Gruyter, New York, p. 219-258. [This presents comparison of prevalence of intestinal parasites among Hunter-gatherer and agricultural groups of people in archaeological sites in United States].


Ross, R. (1899): Report on the nature of Kala Azar. Office of the Superintendent of Government Printing, Calcutta, India. [The author studied the parasite causing Kala Azar disease and he was convinced that kala azar was a virulent form of malaria].


whether the parasites overcomes the defense mechanism of the host or the parasite driven away and has no effect on the host].


Shokoples S. E., Ndao M., Kowalewska-Grochowska K. and Yanow S. K. (2009): Multiplexed real-time PCR assay for discrimination of Plasmodium species with improved sensitivity for mixed infections, Journal of Clinical Microbiology, vol. 47, no. 4, pp. 975–980.[The authors were able to identify the four human Plasmodium species (falciparum, vivax, malariae, and ovale)].

Smit L.A.M., Siroux V, Bouzigon E, Oryszczyn M-P, Lathrop M, Demenais F, Kauffmann F (2009): CD14 and toll-like receptor gene polymorphisms, country living, and asthma in adults. Am J Respir Crit Care Med , 179:363-368. [This presents that autoimmunity can occur in a variety of parasitic infections as filariasis, hookworms, schistosomiasis, also immunomodulation that may protect against autoimmune diseases in parasitic infections].


Sun J, Walsh M, Villarino AV, Cervi L, Hunter CA, Choi Y, Pearce EJ (2005): TLR ligands can activate dendritic cells to provide a MyD88-dependent negative signal for Th2 cell development. J Immunol , 174:742-751.[This paper described that host macrophages may be activated by parasites, via a contact-dependent mechanism, and via the production of INF-γ and NO in response to protozoa parasite glycoconjugates].


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].

UXL Encyclopedia of Science, (2002): h t t p : / / w w w . encyclopedia . com / topic / Parasites . aspx [This presents the definition of parasites and its classification to endoparasites and ectoparasites].

Van Riet E, Hartgers FC, Yazdanbakhsh M. (2007): Chronic helminth infections induce immunomodulation: Consequences and mechanisms. Immunobiology; 212:475-90.[The researchers reported that the chronic immune activation is associated with immune hyporesponsivness and anergy, with induction of the regulatory network]

Voehringer D, Shinkai K, and Locksley, RM. (2004): Type 2 immunity reflects orchestrated recruitment of cells committed to IL-4 production. Immunity; 20:267–77.[This presents the mechanism of how the innate and adaptive immune responses wok against the parasites].


Weisenhorn AL , Khorsandi M , Kasas M, Gotzos V and Butt H –J. (1993): Deformation and height anomaly of soft surfaces studied with an AFM. Nanotechnology, 4(2); p. 106-113.[This defined nanomedicine as a large subject area with applications for treatment, diagnosis, monitoring, and control of biological systems].

Weiss, J.B. (1995): DNA probes and PCR for diagnosis of parasitic infections. *Clinical Microbiology Reviews*, 01, Vol 8, No. 1, 113-130. [The author clarified that of PCR has high sensitivity, directly detect parasites independent of the immune-competence and can distinguish between organisms that are morphologically similar].

Wilson, M.E. (1995): Travel and the emergence of infectious diseases, *Emer Infect Dis*, 1, 39-46.[This describes the effect of population movement on transmission of parasitic diseases crossing the international borders].


Wynn TA, Thompson RW, Cheever AW, Mentink-Kane MM. (2004): Immunopathogenesis of schistosomiasis. *Immunol Rev*, 201:156–67.[This article clarifying the immune response to parasitic infection by increase secretion of some cytokines and diminished other cytokines which result in parasite-specific immune suppression].

Yang D., Yinchang Z., Donald A. ,Harn, X., Wang, J., Tang S., Zhao, F. L., and Xiaohong G. (2009): DNA Vaccination by Electroporation and Boosting with Recombinant Proteins Enhances the Efficacy of DNA Vaccines for Schistosomiasis *japonica*. Clinical and Vaccine Immunology, p. 1796-1803, Vol. 16, No. 12.[This article described the use of molecular biology in parasite vaccination through the identification of genes encoding secreted proteins and receptors that are novel targets for parasite vaccines].


Zarlenga D. S. and Higgins, J. (2001): PCR as a diagnostic and quantitative technique in veterinary parasitology, *Veterinary Parasitology*, vol. 101, no. 3-4, pp. 215–230.[The study reported that multiplexed PCR is proving useful in the diagnosis of several parasitic infections simultaneously].

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