**LESSON 13.  
Microbiology diagnosis of protozoan infections**

**LESSON PLAN:**

• Classification and general characteristics of primitives.

• Classification of protozoa:

o Sarcomastigophora type:

• Sarcodina subtype:

• Entamoeba hystolitica, morpho-biological characteristics, pathogenesis, microbiological diagnosis of amebiasis (microscopic, histological, parasitological, serological methods)

• Subtype Mastigophora:

• Giardia lamblia, morpho-biological characteristics, pathogenesis, microbiological diagnosis

• Morpho-biological characteristics, pathogenesis, microbiological diagnosis of Trichomonas genus (T.vaginalis).

• Genus Leischmania (L.donovani, L.tropica), morpho-biological features, pathogenesis, microbiological diagnosis (microscopic, parasitological, serological methods)

• Causes of trypanosomosis (T. brucei, T. cruzi), morpho-biological characteristics, pathogenesis, microbiological diagnosis

• Type Apicomplexa:

• Plasmodium genus (P.malariae, P.vivax, P.ovale, P.falciparum), morpho-biological characteristics and life cycle. Pathogenesis of the disease. Microbiological diagnostics (microscopic, serological, express method)

• Toxoplasma gondii, morpho-biological characteristics, pathogenesis, microbiological diagnosis (microscopic, parasitological, serological (IFA, IFR, KBR, PHAR), skin-allergic methods)

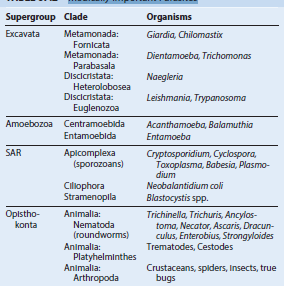
• Ciliophora type:

• Balantidium coli, morpho-biological characteristics, pathogenesis, microbiological diagnosis

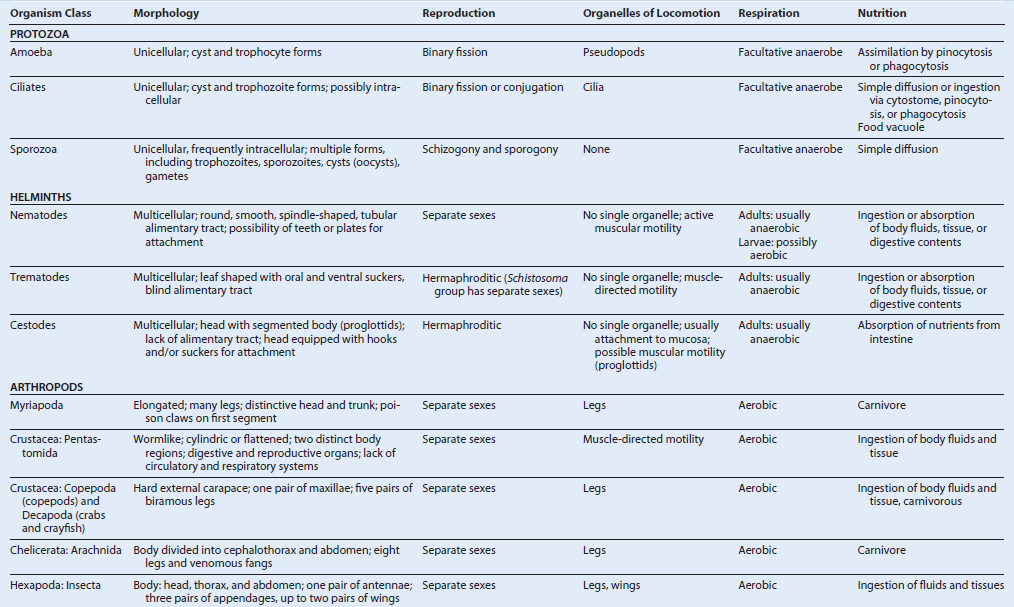
• Microspora type, Microsporidium genus – as an obligate intracellular parasite

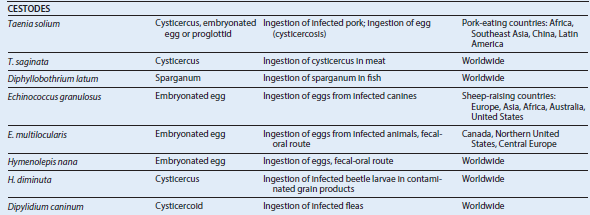
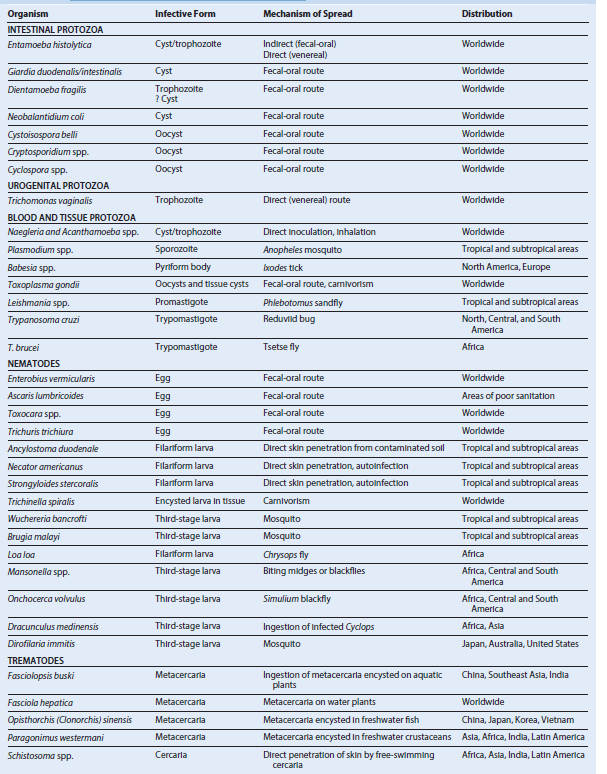
**ESTIMATED WORLDWIDE DISEASE BURDEN OF PARASITIC INFECTIONS**

Medically Important Parasites

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**Biologic, Morphologic, and Physiologic Characteristics of Pathogenic Parasites**

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**Transmission and Distribution of Pathogenic Parasites **

**Factors Associated with Parasite Pathogenicity**

Infective dose and exposure

Penetration of anatomic barriers

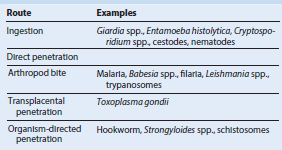
Attachment

Replication

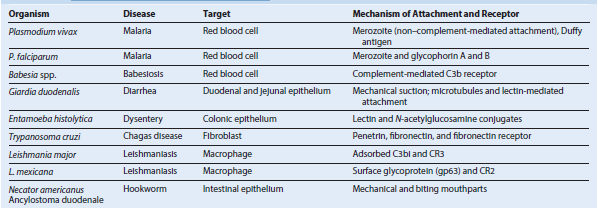
Cell and tissue damage

Disruption, evasion, and inactivation of host defenses

**Parasite Ports of Entry**

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**Examples of Parasitic Adherence Mechanisms**

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**Some Pathologic Mechanisms in Parasitic Diseases**

**TOXIC PARASITE PRODUCTS**

Hydrolytic enzymes, proteinases, collagenase, elastase - Schistosomes (cercariae), *Strongyloides* spp., hookworm, *Entamoeba histolytica*,

African trypanosomes, *Plasmodium falciparum*

Amebic ionophore - *E. histolytica*

Endotoxins - African trypanosomes, *P. falciparum*

Indole catabolites - Trypanosomes

**MECHANICAL TISSUE DAMAGE**

Blockage of internal organs - *Ascaris* spp., tapeworms, schistosomes, filaria

Pressure atrophy - *Echinococcus* spp., *Cysticercus* spp.

Migration through tissue - Helminthic larvae

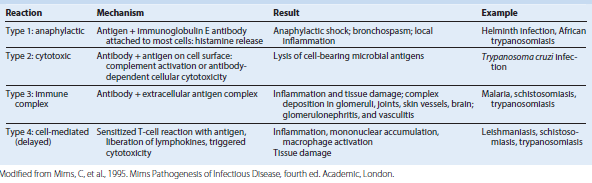
**IMMUNOPATHOLOGY**

Hypersensitivity

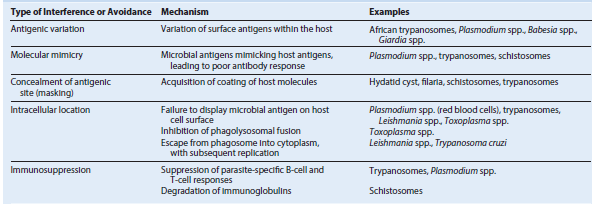
Autoimmunity

Protein-losing enteropathies - Hookworm, tapeworm, *Giardia* spp., *Strongyloides* spp.

Metaplastic changes - *Opisthorchis* spp. (liver flukes), schistosomes

**Immunopathologic Reactions to Parasitic Disease** ****

**Microbial Interference with or Avoidance of Immune Defenses**

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**SUMMARY OF PARASITES ASSOCIATED WITH HUMAN DISEASE**

**BLOOD**

Malaria - *Plasmodium falciparum, P. knowlesi, P. malariae, P. ovale, P. vivax*

Babesiosis - *Babesia* spp.

Filariasis - *Wuchereria bancrofti, Brugia malayi, Mansonella* spp., *Loa loa*

**BONE MARROW**

Leishmaniasis - *Leishmania donovani, L. tropica*

**CENTRAL NERVOUS SYSTEM**

Meningoencephalitis - *Naegleria fowleri, Trypanosoma brucei gambiense, T. b. rhodesiense, T. cruzi, Toxoplasma gondii*

Granulomatous encephalitis - *Acanthamoeba* spp., *Balamuthia mandrillaris*

Mass lesion, Brain abscess - *T. gondii, Taenia solium, Schistosoma japonicum, Acanthamoeba* spp*., B. mandrillaris*

Eosinophilic meningitis, Cerebral malaria - *Angiostrongylus cantonensis, Toxocara* spp., *Baylisascaris* (neural larva migrans), *P. falciparum*

Cerebral paragonimiasis - *Paragonimus westermani*

**EYE**

Keratitis - *Acanthamoeba spp., Onchocerca volvulus*

Chorioretinitis, Conjunctivitis - *T. gondii, O. volvulus, L. loa*

Ocular cysticercosis (mass lesion) - *T. solium*

Toxocariasis - *Toxocara* spp. (ocular larva migrans; mimics retinoblastoma)

**TRACT**

Anal pruritus - *Enterobius vermicularis*

Colitis - *Entamoeba histolytica, Neobalantidium coli*

Diarrhea/dysentery - *E. histolytica, Giardia duodenalis (intestinalis), Cryptosporidium parvum, Cyclospora cayetanensis, Cystoisospora belli, Schistosoma mansoni, Strongyloides stercoralis, Trichuris trichiura*

Toxic megacolon - *T. cruzi*

Obstruction, Perforation - *Ascaris lumbricoides, Fasciolopsis buski*

Rectal prolapse - *T. trichiura*

**LIVER, SPLEEN**

Abscess - *E. histolytica, Fasciola hepatica*

Hepatitis - *T. gondii*

Biliary obstruction - *A. lumbricoides, F. hepatica, Opisthorchis (Clonorchis) sinensis*

Cirrhosis/hepatosplenomegaly - *L. donovani, L. tropica, Toxocara canis and T. cati* (visceral larva migrans), *S. mansoni, S. japonicum*

Mass lesions - *T. solium, Echinococcus granulosus, E. multilocularis*

**GENITOURINARY**

Vaginitis/urethritis - *Trichomonas vaginalis, E. vermicularis*

Renal failure - *Plasmodium* spp., *L. donovani*

Cystitis/hematuria - *S. haematobium, P. falciparum* (blackwater fever)

**HEART**

Myocarditis - *T. gondii, T. cruzi*

Megacardia/complete heart block - *T. cruzi*

**LUNG**

Abscess - *E. histolytica, P. westermani*

Nodule/mass - *Dirofilaria immitis, E. granulosus, E. multilocularis*

Pneumonitis - *A. lumbricoides, S. stercoralis, Toxocara* spp., *P. westermani, T. gondii, Ancylostoma brasiliense*

**LYMPHATICS**

Lymphedema - *W. bancrofti, B. malayi,* other filaria

Lymphadenopathy *T. gondii,* trypanosomes

**MUSCLE**

Generalized myositis *Trichinella spiralis, Sarcocystis lindemanni, Toxocara* spp.

Myocarditis *T. spiralis, T. cruzi, Toxocara* spp.

**SKIN AND SUBCUTANEOUS TISSUE**

Ulcerative lesion - *Leishmania* spp., *Dracunculus medinensis*

Nodule/swellings - *O. volvulus, L. loa, T. cruzi, Acanthamoeba* spp., *Toxocara* spp.

Rash/vesicles - T*. gondii, A. brasiliense,* other migrating worms, schistosomes (cercarial dermatitis)

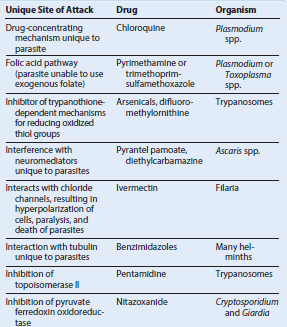
**SYSTEMIC**

General dissemination and multiple organ dysfunction - *P. falciparum, T. gondii, L. donovani, T. cruzi, Toxocara* spp., *S. stercoralis, T. spiralis*

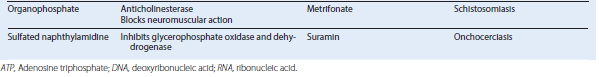
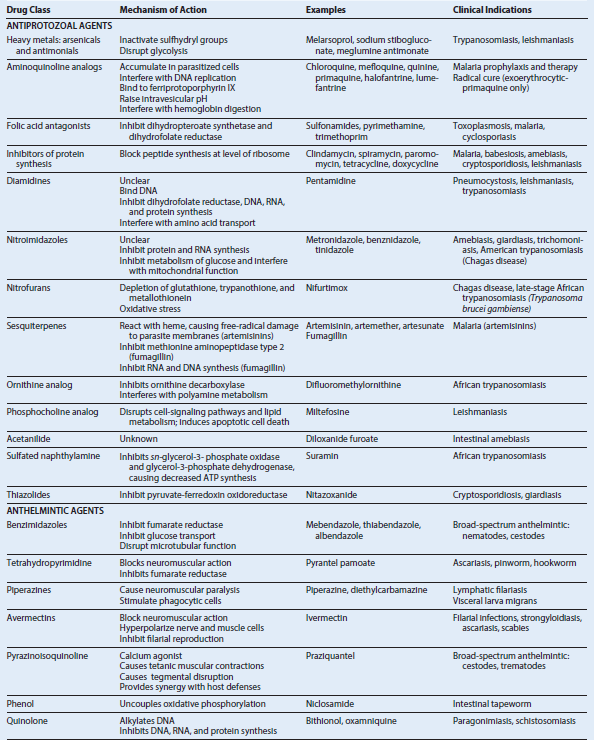
Iron deficiency, anemia Hookworms- *(A. duodenale, Necator americanus)*

Megaloblastic anemia (vitamin B12 deficiency) - *Diphyllobothrium latum*

**Chemotherapeutic Strategies That Exploit Differences between Parasite and Host**

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Mechanisms of Action and Clinical Indications for the Major Antiparasitic Agents

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***INTESTINAL AND UROGENITAL PROTOZOA***

**AMEBAE (AMOEBOZOA)**

**Trigger Words**

Protozoa, amebae, trophozoite, cyst, intestinal amebiasis, extraintestinal amebiasis, hepatic amebiasis, flask-shaped ulcer, *Entamoeba*

**Biology, Virulence, and Disease**

• Primitive unicellular organisms with a simple two-stage life cycle

• Motility accomplished by extension of a pseudopod (false foot)

• Most amebae found in humans are commensal organisms

• Human pathogens: *Entamoeba histolytica* (most important), *E.polecki*

**Epidemiology**

• *E. histolytica* has worldwide distribution, with highest incidence in tropical and subtropical regions

• As many as 50% of the population in some areas are infected (average prevalence, 10% to 15%); U.S. prevalence is 4% to 5%

• Many carriers asymptomatic; pass cysts in stool (reservoir)

• Main source of food and water contamination is asymptomatic carrier who passes cysts

**Diagnosis**

• Microscopic examination of stool allows identification of cysts and trophozoites of *E. histolytica*

• Must differentiate from nonpathogenic and commensal species of amebae

• Specific serologic tests can confirm diagnosis

• Examination of stool samples may be negative in extraintestinal amebiasis

• Newer diagnostic approaches: fecal antigen, PCR, DNA probe

**Treatment, Prevention, and Control**

• Acute amebiasis treated with metronidazole, followed by iodoquinol, diloxanide furoate, or paromomycin

• Carrier state may be eradicated with iodoquinol, diloxanide furoate, or paromomycin

• Elimination of cycle of infection requires introduction of adequate sanitation measures, education about routes of transmission, chlorination, and filtration of water supplies

• Travelers to developing countries should avoid consumption of water (including ice cubes), avoid unpeeled fruits and raw vegetables, boil water, and thoroughly clean fruits and vegetables before consumption

**CILIATES (METAMONADA [FORMERLY FLAGELLATES])**

**Trigger Words**

Giardiasis, trichomoniasis, worm egg, contaminated stream, stool antigen test, cilia, wet mount, diarrhea, IgA deficiency

**Biology, Virulence, and Disease**

• Clinically important Metamonada: *Giardia duodenalis (lamblia/intestinalis), Dientamoeba fragilis, Trichomonas vaginalis*

• *G. duodenalis* life cycle has both cyst and trophozoite stages; *D. fragilis* has a trophozoite stage (cyst stage in mice); *T. vaginalis* has only a trophozoite stage

• Most flagellates move by lashing of cilia that pull organism through fluid environments

• Infection with *G. duodenalis* initiated by ingestion of cysts; asymptomatic carriage (50% of infected individuals); symptomatic disease ranges from mild diarrhea to a severe malabsorption syndrome

• Most infections with *D. fragilis* asymptomatic

• *T. vaginalis* causes urogenital infections

• Diseases produced by Metamonada result from mechanical irritation, inflammation of gastrointestinal and genitourinary (*Trichomonas*) mucosa

**Epidemiology**

• *G. duodenalis* has a worldwide distribution

• Giardiasis acquired by fecal-oral route

• Risk factors for giardiasis: poor sanitary conditions, travel to known endemic areas, consumption of inadequately treated water, day-care centers, oral-anal sexual practices

• *D. fragilis* has a worldwide distribution; transmission by fecal-oral and oral-anal routes

• *T. vaginalis* has a worldwide distribution; transmission primarily by sexual intercourse

**Diagnosis**

• *Giardia* may be detected by microscopic examination of fecal samples or duodenal aspirates

• Detection of *Giardia* fecal antigen by enzyme immunoassay, immunofluorescent microscopy

• Infection with *D. fragilis* diagnosed by microscopic examination of fecal specimens

• Trichomoniasis: microscopic examination of vaginal or urethral discharge

**Treatment, Prevention, and Control**

• Drug of choice for treatment of giardiasis (both symptomatic patients and carriers): metronidazole or nitazoxanide; alternatives: furazolidone, tinidazole, paromomycin, albendazole, quinacrine

• Prevention and control of giardiasis involves avoidance of contaminated water and food

• No consensus on best approach for treating *D. fragilis* infections; infection can be avoided by adequate sanitary conditions

• Drug of choice for trichomoniasis is metronidazole; personal hygiene, avoidance of shared toilet articles and clothing, and safe sexual practices are important preventive actions

**CILIATES (CILIOPHORA)**

**Trigger Words**

Macronucleus, pig feces, cytostome, cilia, intestinal ulceration

**Biology, Virulence, and Disease**

• Protozoan organisms whose locomotion involves coordinated movement of rows of hairlike structures (cilia)

• *Neobalantidium coli:* only Ciliophora parasite of humans

• *N. coli* has a funnel-like primitive mouth called a cytostome, a large and small nucleus involved in reproduction, food vacuoles, and two contractile vacuoles

• Disease produced by *N. coli* is similar to amebiasis; symptoms include abdominal pain, tenderness, tenesmus, nausea, anorexia, watery stools with blood and pus, ulceration of intestinal mucosa; extraintestinal infection very rare

**Epidemiology**

• *N. coli* distributed worldwide; swine and monkeys most important reservoirs

• Infections transmitted by fecal-oral route

• Outbreaks associated with contamination of water supplies with pig feces

• Person-to person spread has been implicated in outbreaks

• Risk factors include contact with swine and substandard hygienic conditions

**Diagnosis**

• Microscopic examination of feces for trophozoites and cysts

**Treatment, Prevention, and Control**

• Drug of choice is tetracycline; iodoquinol and metronidazole are alternatives

• Important preventive measures: personal hygiene, maintenance of sanitary conditions, careful monitoring of pig feces

**SPOROZOA**

**Trigger Words**

Coccidia, oocyst, chronic diarrhea, acid-fast, fecal antigen, waterborne transmission, contaminated fruits and vegetables

**Biology, Virulence, and Disease**

• Sporozoa constitute a very large group of protozoa called Apicomplexa or Coccidia

• All sporozoans demonstrate typical characteristics: asexual (schizogony) and sexual (gametogony) reproduction; share alternative hosts

• Intestinal sporozoan: *Cystoisospora belli, Sarcocystis spp., Cryptosporidium spp., Cyclospora cayetanensis*

• *C. belli:* coccidian parasite of intestinal epithelium; causes malabsorption syndrome

• *Sarcocystis* spp. can be detected in stool samples; nausea, abdominal pain, and diarrhea after ingestion of infected meat; muscular infections can occur if sporocysts ingested

• *Cryptosporidium* spp. cause intestinal disease, usually self-limited enterocolitis characterized by watery diarrhea without blood

• *Cyclospora:* illness self-limited in immunocompetent hosts, prolonged in HIV infected individuals

**Epidemiology**

• *Cystoisospora* organisms distributed worldwide; disease frequent in patients with AIDS; infection reported with increasing frequency in both healthy and immunocompromised patients

• *Sarcocystis* spp. are isolated from pigs and cattle

• *Cryptosporidium* spp. are distributed worldwide

• *C. hominis* and *C. parvum* cause most human infections; *C. ubiquitum* and *C. felis* are emerging human pathogens

• *Cyclospora:* worldwide distribution; infection acquired through contaminated water; U.S. outbreaks correlated with consumption of contaminated fruits and vegetables

**Diagnosis**

• *C. belli* infection best diagnosed by careful examination of concentrated stool sediment

• *Sarcocystis* spp. sporocysts may be detected in human stool specimens

• *Cryptosporidium* spp. may be detected in unconcentrated stool specimens from immunocompromised patients with diarrhea

• Diagnosis of cyclosporiasis is based on microscopic detection of oocysts in stool

• Both *Cryptosporidium* and *Cyclospora* infections may be diagnosed by PCR

**Treatment, Prevention, and Control**

• *C. belli:* treatment of choice is trimethoprim-sulfamethoxazole; prevention and control effected by maintaining personal hygiene and sanitation, avoiding oral-anal sexual contact

• No known treatment for intestinal or muscular sarcocystosis in humans

• No broadly effective therapy has been developed for managing *Cryptosporidium* infections in immunocompromised patients; nitazoxanide is approved by the FDA for the treatment of cryptosporidiosis in nonimmunocompromised individuals older than 12 months

• Cyclosporiasis has been treated with modest success using trimethoprimsulfamethoxazole

***BLOOD AND TISSUE PROTOZOA***

***PLASMODIUM***

**Trigger Words**

Malaria, quotidian, tertian, quartan, blackwater fever, cerebral malaria, benign tertian, malignant tertian, multiple ring forms, gametocytes, *Anopheles* mosquito, tropics and subtropics, prophylaxis

**Biology, Virulence, and Disease**

• Plasmodia: coccidian or sporozoan parasites of RBCs

• Five species that infect humans share a common life cycle

• Routes of acquisition: mosquito, transfusion, needle sharing, congenital

• *P. falciparum* produces daily (quotidian) chills and fever with nausea, vomiting, diarrhea progressing to tertian (36 to 48 hours) periodicity with fulminating disease (malignant tertian); no persistent liver stage

• *P. knowlesi* produces daily (quotidian) fever, chills, headache, rigors, abdominal pain, cough (severe symptoms in 7% of cases; respiratory distress and hepatorenal failure); no persistent liver stage

• *P. vivax* causes “benign tertian malaria” with paroxysms of fever and chills every 48 hours; a spectrum of severe, life-threatening syndromes similar to that with *P. falciparum* may be seen; a liver stage may cause relapses and recrudescence’s

• *P. ovale* causes benign tertian malaria similar to that of *P. vivax* with both relapses and recrudescence

• *P. malariae* has a long (18 to 40 days) incubation period and causes a moderate to severe disease with a 72-hour (quartan or malarial malaria) periodicity; no persistent liver stage

**Epidemiology**

• Infection with *Plasmodium* spp. Accounts for 216 million episodes with approximately 500,000 deaths annually, 90% of which are in Africa

• Vector is the *Anopheles* mosquito, which is widely distributed in tropical, subtropical, and temperate regions

• *P. falciparum:* occurs almost exclusively in tropical and subtropical regions

• *P. knowlesi:* infects Old World Monkeys, and increasingly humans, in Malaysia and neighboring countries throughout Southeast Asia

• *P. vivax:* widest geographic distribution (tropics, subtropics, temperate regions); 80% of cases occur in South America and Southeast Asia

• *P. ovale:* distributed primarily in tropical Africa; also found in Asia and South America

• *P. malariae:* occurs in same tropical and subtropical areas as other malarial parasites but less prevalent

**Diagnosis**

• Most widely used method: detection of parasites in thick and thin blood filmsstained with Giemsa or Wright stain

• Antigen detection using an RDT; used in both the field and diagnostic laboratories as an adjunct to microscopic examination of blood films

**Treatment, Prevention, and Control**

• Treatment of malaria is based on history regarding travel to endemic areas, prompt clinical review and differential diagnosis, accurate and rapid laboratory work, and correct use of antimalarial drugs

• Chloroquine or parenteral quinine is drug of choice for susceptible strains of *Plasmodium;* widespread resistance to chloroquine seen with *P. falciparum* and *P. vivax*

• Chemoprophylaxis with chloroquine, doxycycline, Malarone, or mefloquine coupled with avoiding mosquito bites (netting, insect repellents, clothing) required for prevention

• Elimination of mosquito breeding places

***TOXOPLASMA GONDII***

**Trigger Words**

Cat feces, raw meat, lymphadenitis, CNS lesion, encephalomyelitis, cat litter, congenital infection, AIDS

**Biology, Virulence, and Disease**

• Typical coccidian intracellular parasite found in a wide variety of animals, including birds and humans

• Essential reservoir host: common house cat and other felines

• Most *T. gondii* infections asymptomatic

• Symptoms occur when parasite moves from blood to tissues; include fever, chills, headaches, myalgia, lymphadenitis, fatigue

• Chronic disease marked by hepatitis, encephalomyelitis, and myocarditis

• Chorioretinitis may lead to blindness

• Congenital infection has serious sequelae

• Reactivation of cerebral toxoplasmosis is a major cause of encephalitis in patients with AIDS

**Epidemiology**

• Human infections ubiquitous

• Infection from ingestion of improperly cooked meat from intermediate-host animals or ingestion of infective oocysts from contaminated cat feces

• Transplacental infection can occur during pregnancy

• Rate of severe infection affected by patient’s immune status

• Illness in immunocompromised host believed to be caused by reactivation of previously latent infection rather than

new exposure to organism

**Diagnosis**

• Increasing antibody titers documented inserially collected blood specimens

• Panel of tests (TSP) is used to determine recent versus past acquisition of infection

• Diagnosis of *Toxoplasma* encephalitis usually involves imaging study of brain

• Microscopy, serologic, and moleculartechniques may be required for definitive diagnosis

**Treatment, Prevention, and Control**

• Treatment of choice: initial high-dose regimen of pyrimethamine plus sulfadiazine followed by lower doses of both drugs indefinitely (AIDS patients and other immunocompromised patients)

• Clindamycin or spiramycin may be used in first trimester of pregnancy

• High-risk patients may be considered for prophylaxis

• Additional preventive measures: avoid consumption and handling of raw or undercooked meat, avoid exposure to cat feces

***LEISHMANIA***

**Trigger Words**

Kala-azar, Dumdum fever, cutaneous and mucocutaneous disease, visceral leishmaniasis, sand fly, post–kala-azar dermal leishmaniasis

**Biology, Virulence, and Disease**

• *Leishmania:* obligate intracellular parasites transmitted from animal to human or human to human by bites from infected female sand fly

• Many different species can infect humans, producing a variety of diseases (cutaneous, diffuse cutaneous, mucocutaneous, visceral)

• Clinical syndromes depend on species involved; most common species: cutaneous *(L. tropica),* mucocutaneous *(L. braziliensis),* visceral *(L. donovani, L. infantum),* post–kala-azar dermal leishmaniasis *(L. donovani)*

**Epidemiology**

• Natural reservoirs: rodents, possums, anteaters, sloths, dogs, cats

• Infection may be transmitted by animalvector- human or human-vector-human cycle, by direct contact with infected lesion, or mechanically by flies

• Mucocutaneous leishmaniasis most often occurs in Bolivia, Brazil, Peru; cutaneous leishmaniasis much more widespread throughout Middle East and in focal areas of South America

• Visceral leishmaniasis (kala-azar, Dumdum fever): ≈50,000 cases per year, 90% localized to Bangladesh, Brazil, India, Nepal, Sudan

**Diagnosis**

• Diagnosis of visceral, cutaneous, or mucocutaneous leishmaniasis made on clinical grounds in endemic areas

• Definitive diagnosis depends on detecting amastigotes in clinical samples or promastigotes in culture; molecular techniques have been used for diagnosis, prognosis, and species identification

**Treatment, Prevention, and Control**

• Drug of choice for all forms of leishmaniasis is the pentavalent antimonial compound sodium stibogluconate (Pentostam)

• Fluconazole and miltefosine efficacious in cutaneous disease

• Stibogluconate remains drug of choice for mucocutaneous leishmaniasis

• Prevention involves prompt treatment of human infections and control of reservoir hosts, along with vector control

**TRYPANOSOMES**

**Trigger Words**

Sleeping sickness, tsetse fly, reduviid bugs, chagoma, Romaña sign, megaesophagus, Winterbottom sign, Chagas disease

**Biology, Virulence, and Disease**

• *Trypanosoma*, a hemoflagellate, causes two distinctly different forms of disease: African trypanosomiasis and American trypanosomiasis

• African trypanosomiasis (sleeping sickness): chronic disease of several years’ duration, transmitted by tsetse flies, fatal without treatment

• American trypanosomiasis (Chagas disease): asymptomatic, acute, or chronic forms, transmitted by reduviid bugs

**Epidemiology**

• *T. brucei gambiense* limited to tropical West and Central Africa, correlating to range of tsetse fly vector

• *T. b. rhodesiense* found in East Africa, especially cattle-raising countries

• Domestic and wild game animals act as reservoir hosts for *T. b. rhodesiense*

• *T. cruzi* occurs widely in both reduviid bugs and a wide variety of reservoir animals in North, Central, and South America

• Because of the chronic nature of infection, screening of solid organ and blood donors for Chagas disease has become important

**Diagnosis**

• Agents of sleeping sickness can be demonstrated in blood films, aspirations from lymph nodes, and concentrated spinal fluid

• *T. cruzi* can be demonstrated in blood films early in acute stage of disease

**Treatment, Prevention, and Control**

• Suramin: drug of choice for treating acute blood and lymphatic stages of both Gambian and Rhodesian forms of sleeping sickness; pentamidine is an alternative

• Melarsoprol: drug of choice for CNS disease

• Effective control measures: integrated approach to reduce human reservoir of infection, use of fly traps and insecticide

• Drugs of choice for treatment of Chagas disease: benznidazole and nifurtimox

• Vector control important: insecticide, eradication of nests, construction of homes to prevent nesting of bugs

***CNS,* Central nervous system; *PCR,* polymerase chain reaction; *RBC,* red blood cell; *RDT,* rapid diagnostic test; TSP, *T. gondii* serologic profile.**

**MEDICALLY IMPORTANT BLOOD AND TISSUE PROTOZOA**

*Plasmodium* species

*Babesia* species

*Toxoplasma* species

*Sarcocystis* species

*Acanthamoeba* species

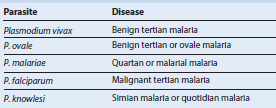
*Balamuthia* species

*Naegleria* species

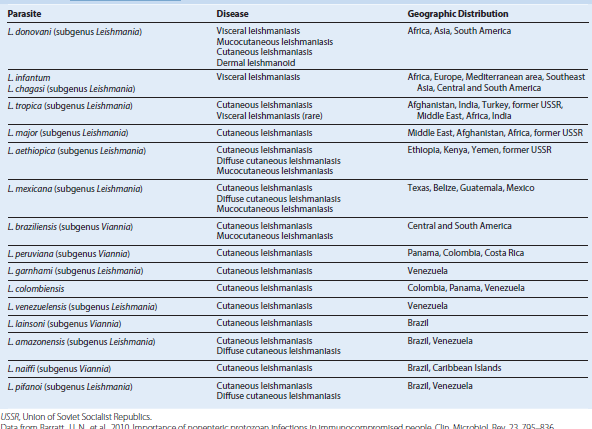
*Leishmania* species

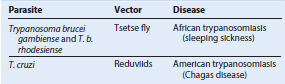
*Trypanosoma* species

**Human Malarial Parasites**

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**Leishmaniasis in Humans**

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**Trypanosoma Species Responsible for Human Diseases**