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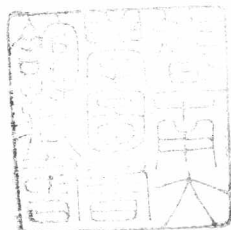
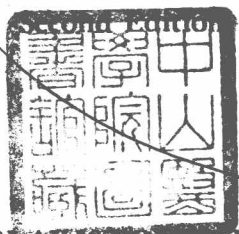
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MEDICAL PARASITOLOGY

For Medical Students and Practicing Physicians

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MEDICAL PARASITOLOGY

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PREFACE

Medical Parasitology is intended for the use of medical students and practicing physicians. The subject is presented from the medical point of view to provide the essential information necessary for the understanding of parasitic diseases. Zoological data are included only insofar as they aid in, and contribute to, the specific diagnosis and the tracing of the pathogenesis and epidemiology.

The reception and reviews of the first edition have encouraged corrections and amendments. Additional clinical data have been incorporated, particularly in the discussion on the protozoa. The chapter on treatment has been revised on the basis of recent studies but has remained separate, since usually parasitology is taught before pharmacology, and discussion of the two subjects at the same time might attract attention prematurely to therapy. Some general practical considerations on diagnostic, therapeutic, and preventive aspects of parasitic diseases are presented in a synopsis at the end of the book. The vocabulary, with the etymology of technical names, has been retained in the second edition because teachers and students have commented on its usefulness.

Specific references again have been omitted, but the author wishes to acknowledge explicitly that the manual is based on studies by others. He accepts, however, responsibility for the selection of the material and for errors and mistakes.

Grateful appreciation is expressed to Dr. W. H. Perkins, Professor of Preventive Medicine, The Jefferson Medical College of Philadelphia, for critically reading the manuscript; to Dr. Harry Most, Professor of Preventive Medicine (Tropical Medicine), New York University, for his helpful comments on the treatment of parasitic diseases; and to Dr. Henry Stempen, Assistant Professor of Bacteriology, The Jefferson Medical College of Philadelphia, for the meticulous and skillful drawings in this edition.

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INTRODUCTION

Parasitology is the science of parasitism, i.e., the relationship between parasites and hosts. Parasites live on or within and at the expense of some other living organism. They belong either to the plant kingdom or to the animal kingdom. Those of the plant kingdom are studied in bacteriology, virology, and mycology. Those of the animal kingdom are studied in parasitology. It is in this strict sense that the term parasites is used in this manual, i.e., denoting parasitic organisms belonging to the animal kingdom.

The hosts of parasites may be plants, animals, or man. Parasites of plants are studied in plant parasitology. Parasites of animals are studied in animal parasitology. Parasites of man are the subject of medical parasitology.

DEFINITIONS

Parasitism: the association of two specifically different organisms, in which one partner lives upon or within the other and feeds at its expense.

Commensalism: the association of two specifically different organisms, in which one partner is benefited, the other neither benefited nor injured.

Symbiosis: the permanent association of two specifically different organisms so dependent on each other that life apart is impossible.

Host: the organism that harbors a parasite.

Definitive host: the host that harbors the adult or sexual stage of a parasite.

Intermediate host: the host that harbors the larval or asexual stage of a parasite.

Reservoir host: the animal that harbors the same species of a parasite as may man.

Carrier: a person who, without apparent symptoms, harbors a parasite and may serve as a source of infection to others.

Infection: the result of the entry and multiplication of any pathogenic organism except Arthropoda upon or within another organism. The term is applied, although loosely, to the establishment of nonpathogenic parasites as well.

Infestation: the establishment of Arthropoda (insects and related animals) upon or within a host.

Endoparasite: a parasite established within a host.

Ectoparasite: a parasite established on or in the skin of a host.

Obligate parasite: a parasite depending for its existence on its host.

Facultative parasite: a parasite capable of living as an independent organism or as a parasite.

Pathogenic parasite: a parasite causing injury to the host mechanically, by obstructing a lumen, by feeding on its tissue, and/or by releasing injurious substances.

Spurious parasite: a parasite of organisms other than man which passes through the human body without further development or without causing damage.

CLASSIFICATION OF PARASITES

The animal kingdom is divided into two subkingdoms and these into phyla. The parasites of man belong to the following divisions:

Subkingdom Protozoa
Subkingdom Metazoa

Phylum Protozoa
Phylum Nematelminthes
Phylum Platyhelminthes
Phylum Arthropoda

Each phylum is divided into classes; these, into orders, families, genera, and species. The names applied follow the International Rules of Zoological Nomenclature and consist of the names of the genus and the species.

A genus is defined as a group of animals (or plants) which embraces one or more structurally or phylogenetically related species.

A species is a distinct kind of animal (or plant) which has characters distinguishing it from all other kinds. Members of a species reproduce their characters in their offspring.

The initial letter of the name of the genus is capitalized, while the name of the species is not. Names of genera and species are printed in italics. Example: *Entamoeba histolytica*.

CLASSES OF THE ANIMAL KINGDOM

containing medically important parasites

KINGDOM	ANIMALIA			
SUB-KINGDOM	Protozoa	Metazoa		
PHYLUM	Protozoa	Helminths		Arthropoda
	Protozoa	Nemathelminthes	Platyhelminthes	Arthropoda
CLASS	1. Rhizopoda (amebas) 2. Mastigophora (flagellates) 3. Ciliata (ciliates) 4. Sporozoa (sporozoas)	1. Nematoda (roundworms)	1. Cestoda (tapeworms) 2. Trematoda (flukes)	1. Chilopoda (centipedes) 2. Crustacea (crustaceans) 3. Arachnida (spiders, ticks, mites) 4. Insecta (insects)

PROTOZOOLOGY	HELMINTHOLOGY	ENTOMOLOGY
MEDICAL PARASITOLOGY		

PROTOZOA

Protozoa are unicellular animals consisting of a nucleus, or nuclei, and cytoplasm.

The nucleus of some species is merely a mass of chromatin. In others it consists of a nuclear membrane containing the nuclear sap in which the karyosome (comparable to the nucleolus of metazoan cells) is found. The nucleus is concerned with multiplication. The morphological structure of the nucleus is used in the identification of a number of protozoa.

The cytoplasm is differentiated into an inner portion, the endoplasm, and an outer layer, the ectoplasm.

The endoplasm is of sirupy consistency and represents the "viscera" of the organism. It is concerned with nutrition. It may contain ingested material, which may be found within food vacuoles. Contractile vacuoles, which occur in some protozoa, are believed to eliminate waste products.

The ectoplasm is a dense, resilient structure. It performs the functions of the skin (protection), the limbs (locomotion), the mouth (ingestion of food), and the excretory organs of the higher animals. Locomotion is accomplished by ectoplasmic organelles.

The amebas move by means of ectoplasmic protrusions, i.e., pseudopodia.

The flagellates move by means of long, threadlike filaments, i.e., flagella.

The ciliates move by means of short, hairlike filaments, i.e., cilia.

The sporozoas are protozoa which have a sexual stage in their life cycle.

Some species of protozoa encyst, i.e., the ectoplasm is modified into a resistant cyst wall.

PROTOZOA PARASITIC IN MAN

The parasitic protozoa can be divided into those which infect chiefly:

The intestinal tract, i.e., the intestinal protozoa.

The mouth, vagina, and urethra, i.e., the atrial protozoa.

The blood and blood-forming organs, i.e., the blood protozoa.

PROTOZOA PARASITIC IN MAN

CLASS	INTESTINAL PROTOZOA	ATRIAL PROTOZOA	BLOOD PROTOZOA
RHIZOPODA	Intestinal Amebas 1. <i>Entamoeba histolytica</i> 2. <i>Entamoeba coli</i> 3. <i>Endolimax nana</i> 4. <i>Iodamoeba bütschlii</i> 5. <i>Dientamoeba fragilis</i>	Atrial Amebas 1. <i>Entamoeba gingivalis</i>	
MASTIGOPHORA	Intestinal Flagellates 1. <i>Giardia lamblia</i> 2. <i>Chilomastix mesnili</i> 3. <i>Trichomonas hominis</i>	Atrial Flagellates 1. <i>Trichomonas tenax</i> (buccalis) 2. <i>Trichomonas vaginalis</i>	Haemoflagellates 1. <i>Leishmania tropica</i> 2. <i>Leishmania brasiliensis</i> 3. <i>Leishmania donovani</i> 4. <i>Trypanosoma gambiense</i> 5. <i>Trypanosoma rhodesiense</i> 6. <i>Trypanosoma cruzi</i>
CILIATA	Intestinal Ciliates 1. <i>Balantidium coli</i>		
SPOROZOA	Intestinal Coccidia 1. <i>Isospora hominis</i>		Haemosporidia 1. <i>Plasmodium ovale</i> 2. <i>Plasmodium vivax</i> 3. <i>Plasmodium malariae</i> 4. <i>Plasmodium falciparum</i>
UNKNOWN			1. <i>Toxoplasma gondii</i>

Intestinal Protozoa

DEFINITIONS

Trophozoite: the motile stage of a protozoon which feeds, multiplies, and maintains the colony in the host.

Cyst: the immotile stage protected by a cyst wall. It is in this stage that the protozoon is readily transmitted to a new host.

Encystation: the transformation of a trophozoite into a cyst.

Excystation: the hatching of the cyst with the liberation of a motile, metacystic trophozoite.

Karyosome: the dot or mass of chromatin within the nucleus, comparable to the nucleolus of metazoan cells.

Chromatin: the portion of the nucleus which is readily stained.

Chromatoidal body: the material within the cytoplasm which stains like chromatin but is not part of the nucleus.

Blepharoplast: the chromatin dot from which the flagellum arises and which functions as its neuromotor apparatus.

Axonema: the intracellular portion of the flagellum.

Axostyle: the axial rod, functioning as a support.

Cytostome: the mouth of ciliates.

Cytopyge: the anal opening of ciliates.

PATHOGENICITY OF INTESTINAL PROTOZOA

Entamoeba histolytica is the only pathogenic ameba. It lives in tissue and causes amebiasis. Its primary focus of infection is the colon, resulting in amebic colitis with or without dysentery. It may metastasize to liver, lungs, and other organs, producing abscesses.

The other amebas, with the possible exception of *Dientamoeba fragilis*, are nonpathogenic. They live in the lumen of the bowel and feed on its contents. *D. fragilis* is believed by some authors to cause colitis.

Giardia lamblia may cause giardiasis (intestinal disturbances). The other intestinal flagellates are not pathogenic.

Balantidium coli causes balantidiasis (colitis, dysentery)

Isospora hominis causes intestinal coccidiosis (enteritis).

LIFE CYCLES OF INTESTINAL PROTOZOA

***Entamoeba histolytica*.** *E. histolytica* has four stages in its life cycle: the trophozoite, the precyst, the cyst, and the metacystic trophozoite.

The trophozoite is the motile, feeding stage which multiplies by binary fission, about once every 12 hours. It invades tissue and establishes a colony there. The invasive power of *E. histolytica* is due to a proteolytic enzyme and mechanical locomotion. Trophozoites feed on tissue-cell juice and blood. They are found in tissue, in the mucus of the colon, and in liquid feces.

The precyst is a rounded trophozoite. It is a transitory stage prior to encystment which takes place in the lumen of the colon but not outside the host.

The cyst is immotile and does not feed. Glycogen accumulates in a mass, and, in addition, bar-shaped chromatoidal bodies (probably food storage) appear. The cyst wall is formed from the ectoplasm and serves as a protection against an environment unfavorable for reproduction. Only partial multiplication takes place. The nucleus enlarges and divides, giving rise to a binucleated cyst. A second division forms a trinucleated or quadrinucleated cyst. The glycogen and chromatoidal bodies are gradually consumed as the cyst ages. Cysts are found in the lumen of the colon and in formed feces. They are the infective stage by which the infection is transmitted to other persons.

The metacystic trophozoite emerges from the cyst in the lumen of the small intestine after the cyst has been ingested and passed through the stomach. It is a transitory stage found in the lower portion of the ileum and is terminated by the division of the quadrinucleated trophozoite into four uninucleated trophozoites.

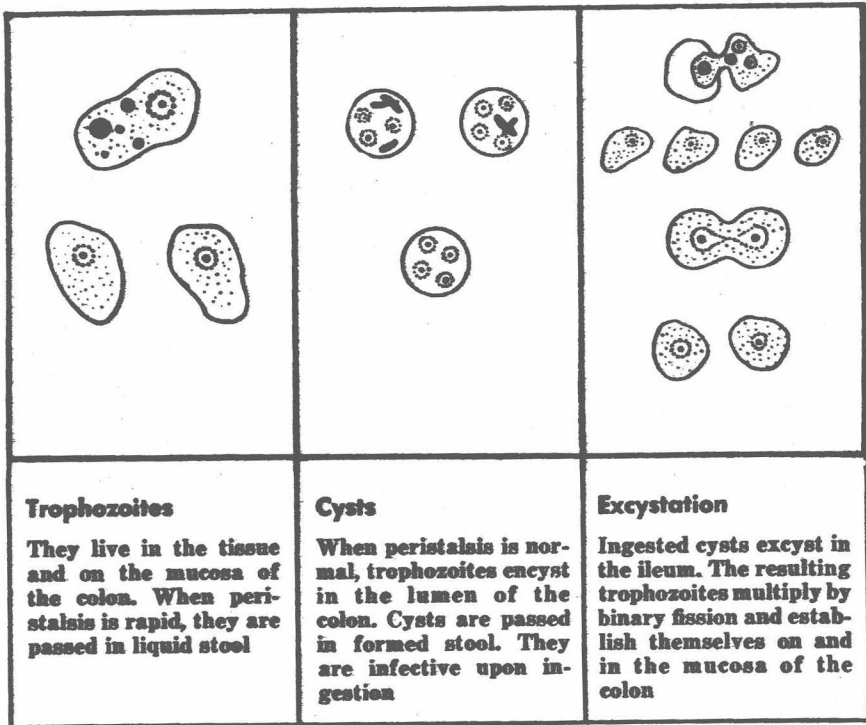


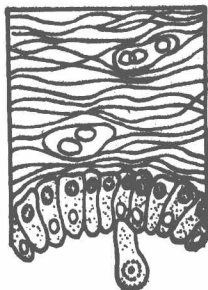
Fig. 1. Life Cycle of *Entamoeba histolytica*

Amebiasis

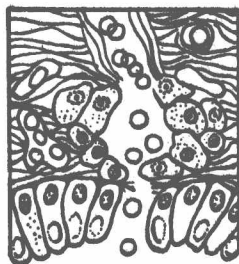
Pathogenesis

Cysts or trophozoites, depending on the rapidity of flow of the colonic contents, are passed in the feces of infected individuals. Cysts are passed in formed stools; cysts and/or trophozoites, in mushy stools; and trophozoites, in liquid stools.

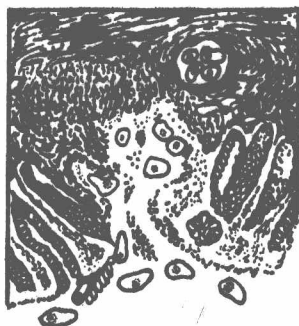
Man acquires the infection by ingesting cysts of *E. histolytica* in food or drink contaminated with infected fecal matter. Trophozoites are fragile animals which die quickly outside the host, and, even though viable trophozoites occasionally may be ingested, they are destroyed by the gastric secretion. Cysts, however, can survive outside the host for several days and when ingested pass unharmed through the stomach. While the trophozoite is the tissue stage, the cyst is the infective stage. The cyst wall, in-



The trophozoites of *Entamoeba histolytica* attach themselves to the epithelial cells of the mucosa, usually of the cecum. They liberate proteolytic enzymes dissolving the tissue cells. The amebas enter into the lesion by means of their own motility



Beneath the epithelial layer the amebas feed on the nutrient cell fluid and multiply by binary fission. They establish a colony which spreads. An inflammatory tissue reaction is not necessarily provoked



The destructive process may involve the muscularis mucosae and submucosa but rarely penetrates the muscular layers. The amebas spread laterally, undermining the mucosa and producing a flask-shaped ulcer. The invasion of veins may result in the transportation of the amebas to other organs



Trophozoites may be transported by the blood to the liver, producing liver abscess. Involvement of lungs, brain, or other organs is a rare occurrence, although the amebas have been found in almost every organ of the human body

Fig. 2. Pathogenesis of Amebiasis