UNIT – ONE

INTRODUCTION TO MEDICAL PARASITOLOGY

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OUTLINE

- Definition of terms
- Scope of medical parasitology
- Concepts related to medical parasitology
- Epidemiology of parasites.
- General life cycle of parasites
- Parasitic diseases
- Host immunity & immuno – evasion of parasites
- Nomenclature and classification of parasites

Specific Learning Objectives

At the end of this chapter the student will be able to:

- Define common terms used in medical parasitology
- Describe Scope of Human parasitology
- Explain host-parasite relationship
- Discuss the geographical distribution, mode of transmission, source of infection, and portal of entry of parasites
- Explain the general life cycles of parasites
- Discuss the general pathogenesis of parasites
- Explain briefly host immunity & immuno – evasion mechanisms by parasites
- Describe classification of medically important parasites

Introduction to Medical parasitology

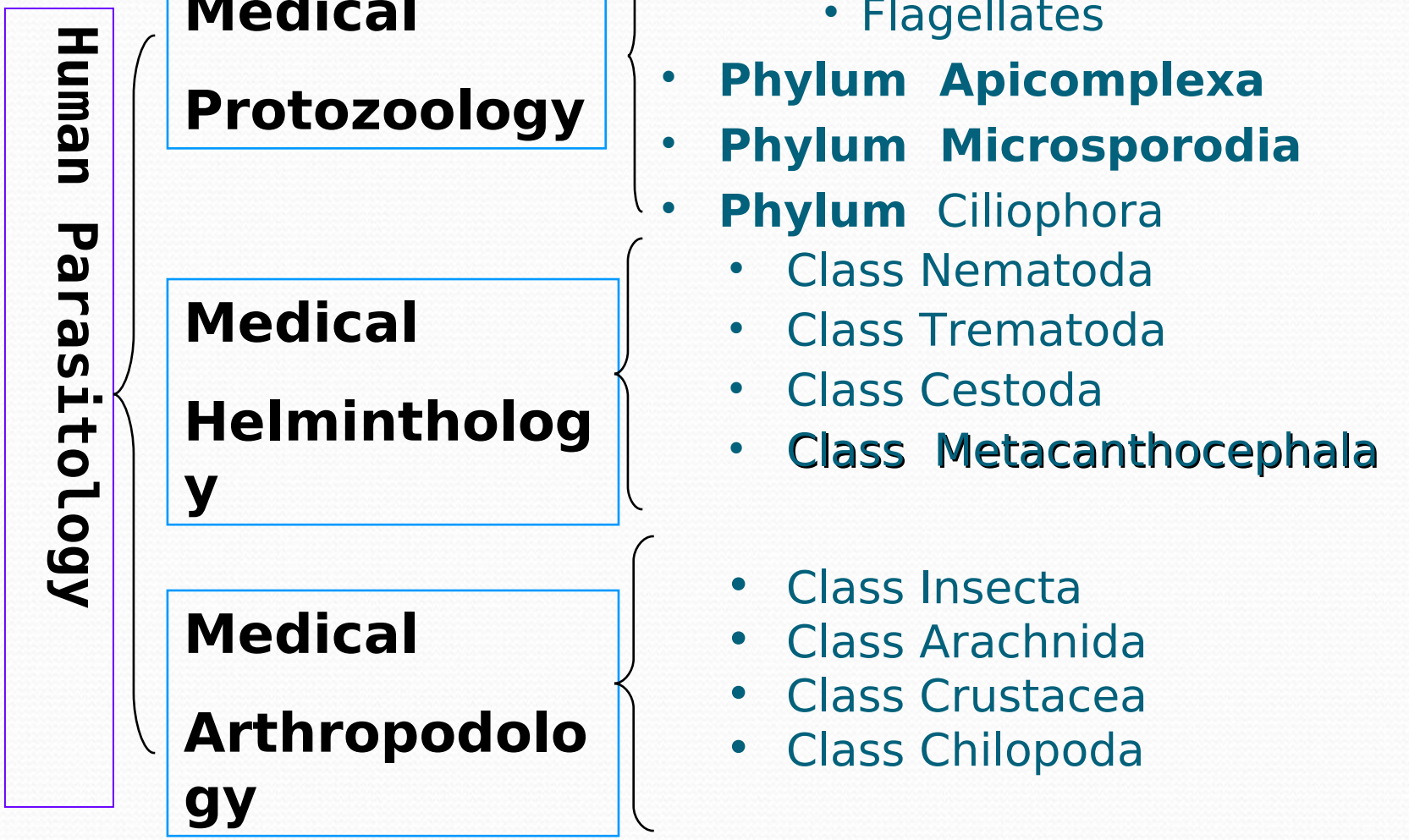
1.1. Definition

- **Medical parasitology (GK: para = beside Sitos = food**
  - **The study of the parasites of man and their medical consequences .**
- It is a subject that researches:
  - the biological features of human parasites,
  - the relationship between the human being and the parasites,
  - the prevention and treatment of the parasitic diseases.

1.2. Scope of Medical Parasitology

- **According to the very broad definition of parasitology, parasites should include:-**
  - **viruses, bacteria, fungi,**
  - **protozoa and metazoa (multi-celled organisms) which infect their host species.**
- **However, for historical reasons the first three have been incorporated into the discipline of Microbiology.**

- **Therefore, Medical parasitology consists of:-**
  - **Protozoa (single celled animals),**
  - **Helminths (worms)**
  - **Arthropods**


Human Parasitology
Medical Protozoology
Medical Helmintholog y
Medical Arthropodolo gy
• Phylum Sarcomastigophora
• Amoeba
• Flagellates
• Phylum Apicomplexa
• Phylum Microsporodia
• Phylum Ciliophora
• Class Nematoda
• Class Trematoda
• Class Cestoda
• Class Metacanthocephala
• Class Insecta
• Class Arachnida
• Class Crustacea
• Class Chilopoda

parasitology

- Six major tropical diseases to which WHO pays great attention include:
  - malaria,
  - schistosomiasis,
  - filariasis,
  - leishmaniasis,
  - trypanosomiasis and
  - leprosy.
- Five of them are parasitic diseases except leprosy.
- All the above diseases are prevalent in Ethiopia

selected?

- **Schistosomiasis – 200,000,000 infected**
  500,000-1,000,000 deaths/year
- **Malaria – 500,000,000 infected**
  2,500,000 deaths/year
- **Filariasis - 250,000,000 infected**
- **Trypanosomiasis - 25,000,000 infected**
  65,000 deaths/year
- **Leishmaniasis - 1,200,000 infected**

1.3. Concepts related to medical parasitology

1.3.1. Symbiosis

- Any association more or less permanent is called a symbiosis, with each member a symbiont.
- Two different organisms live together and interact,
- one partner lives in or on another one's body.
  - **3 types:**
    - **Mutualism**
    - **Commensalism**
    - **Parasitism**

Mutualism

- Permanent association between two different organisms that life apart is impossible,
- Two partners benefit each other,
- The mutuals are metabolically dependent on one another;
- One cannot survive in the absence of the other.

Commensalism

- Association of two different organisms
- One partner is benefited while the other neither benefited nor injured, such as E. Coli and man.

Parasitism

- Association of two different organisms
- One partner is benefited while the other is injured, such as ascaris lumbricoides and man.

1.3.1. Parasite and types of parasites

Parasite:-

- In parasitism, parasite is the benefited partner.
- It is an animal organism which lives in or on the host in order to obtain nourishment and shelter from the host as well as does harms to the host.

- In another words
  - A small organism (Parasite) has the potential to harm a larger organism (Host), and relies on said host for nutrients and shelter (a Niche).
  - The parasite generally has a much higher reproductive capability compared to its host.

Types of Parasites

Parasite can be Classified

I. According to their habitat

- Endoparasite
  - Lives inside the body of the host
  - May be just under the surface or deep in the body
    - Tapeworms, flukes, protozoans
- Ectoparasite
  - Stays on outside surface of the host
    - leeches, ticks, fleas, brood parasites

- II. Based on dependency on the host
- Obligate Parasite
  - Requires finding and invading the host to complete its life cycle
  - Most of the parasites we will cover are obligate parasites
- Facultative Parasite
  - May become parasitic if it is given the chance but does not require a host.

III. Amount of time spent

- Permanent Parasite
  - Lives entire adult life stage on or in a host
  - Usually endoparasites
    - One exception is eyelash mite
- Temporary Parasite
  - Spends only a short time on a host
  - Usually ectoparasites

III. According to their Pathogenicity:

- **Pathogenic parasites**
- **Non-Pathogenic (commensal)**
- **Opportunistic parasites**

IV. Based on their life cycle

- **Monoxenous parasites:**
  - Those with direct life cycles (i.e., with one host).
- **Heteroxenous parasites:**
  - Those with inderect life cycles requiring an intermediate host (i.e., involves 2 or more hosts).
- **Heterogenetic Parasites:**
  - One with alteration of generations e.g., Coccidial parasites and Strongyloides

V. Based on host ranges

- **Euryxenous parasites:**
  - Those with a broad host range.
- **Stenoxenous parasites:**
  - Those with a narrow host range;

Other terminology

Aberrant parasite:

- Found in locations in the host where they normally do not occur;
- e.g., Ascaris larvae may migrate to the brain

Insidental parasite:

- Occurs in hosts where it does not normally occur;
- e.g., Fasciola normally does not occur in man but is incidental if found in man's liver.

1.3.3. Hosts and types of hosts

- **Host:-Hosts are organism which harbors the parasite.**
  - **In parasitism, it is the injured partner**
- **Types of Hosts: -**
  - **Definitive host:-**
  - **Intermediate host:-**

- **Definitive host:-**
  - **What characterizes the primary host?**
    - **Where sexual reproduction takes place.**
    - **Normally where the adult parasites live.**
    - **Normally the larger of the hosts, usually a vertebrate.**
    - **Convention - (parasites which only reproduce asexually)**
    - **Specificity - frequently, a large number of host species can act as intermediate host and only one or a few can act as a definitive host**

- **Intermediate host:-**
  - sexually immature or larval stage of a parasite
  - Asexual multiplication takes place
  - may harbor many immature stages of a parasite;
  - e.g., Cercaria, Redia and Sporocysts which are all immature stages of Fasciola in the snail intermediate host.
- Some parasites:
  - require more than one intermediate host which are then designated as first, second intermediate,

Other terminology

- Paratenic or Transport Host
  - No development occurs but parasite remains alive and infective to another host
  - May go dormant
  - May cause damage
  - **e.g.,** Toxoplasm species in cattle
- Accidental or Incidental Host
  - Parasite is in the “wrong” species.
  - Parasite usually wanders around and causes great damage because it doesn’t know where to go then dies.

Types of Hosts

- Reservoir Host
  - Any animal that carries a parasite that can cause infections in humans.
    - Even if it is the normal host for that parasite.
  - Related to the medical perspective of parasitology
- **Carrier host: -**
  - A person who harbors parasites has no any clinical symptom. He is an important source of infection in epidemiology
    - e.g. human beings harboring cyst form of E.histolytica

1.3.4. Host specificity

- The number of species the parasite can use as a definitive or intermediate host.
- Parasites show varying degrees of host specificity
  - A few parasites will infect only one species
  - Most parasites will infect a few closely related species (or similar anatomy)
  - Some parasites can infect a large group of animals
  - A few parasites have little or no host specificity

1.3.5. Vector and types of vectors

Vector:-an organism (usually an arthropod) which transfers

infective forms of a parasite from one host to the

other.

- Classification
  1. **Biological vectors**:-
  2. **Mechanical (Parathenic or transport) Vectors**:

1. **Biological vectors**:-

- characterized by the development of the parasite before its transfer to another host
  - **Propagative.**
    - **E.g. *Yersinia pestis* in fleas**
  - **Cyclopropagative**
    - **E.g. *Plasmodium vivax* in Anopheles mosquitoes.**

- **Cyclodevelopmental**
  - E.g.*Onchocerca volvulus* in black flies.

2. **Mechanical vector**
   - no parasitic development of reproduction occurs

1.3.6. Other terminologies

- *Infective Stage : it is a stage when a parasite can invade human body and continue to live there. The infective stage of ascarid is the embryonate egg.
- *Infective Route is the specific entrance through which the parasite invades the human body. Hookworms invade human body by skin. Man gets infection with ascarid by mouth.
- Infective Mode means how the parasite invades human body, such as the cercariae of the blood fluke actively penetrate the skin of a swimming man and the infective ascaris eggs are swallowed by man.

- Geohelminth
  - refers to the helminths which complete their life cycles not requiring the processes of the development in intermediate hosts.
  - They have only one host and a simple life cycle, such as ascarid, hookworm, pinworm and etc.
- Biohelminth
  - refers to the helminths which have to undergo the development in intermediate hosts to complete their life cycles, such as filaria, liver fluke, pork tapeworm and so on.

- Alternation of Generation:
  - In life cycles of some parasites, there is the regular alternation of sexual and asexual reproductions, eg.Plasmodium vivax

- *Trophozoite is a living stage of protozoa when they can move, take food and reproduce. (It is usually the pathogenic stage.)
- *Cyst is the resting stage of a protozoa with a protective wall. It is usually the infective stage. Its functions are protection, transmission and multiplication.

Encystation

- Trophozoite ⇄ Cyst

Excystation

1.4. Epidemiology of parasite

- Epidimology: The study of the patterns of diseases within populations
- For parasites, this includes:
  - Host range – what can it infect?
  - Geographic range – where is it?
  - Is it a zoonotic agent?
    - Can it infect humans?
  - Does it have a reservoir?
    - A group of vertebrates maintaining the parasite
  - Does it have a nidus?
    - A small ecosystem that possesses all the factors to maintain the parasite..

1.4.1. Geographic Distribution

- Global distribution
  - parasite occur globally,
  - the majority occur in tropical regions,
  - Factors
    - **Favorable environmental conditions**
    - **poverty, poor sanitation and personal hygiene**

The burden of some major parasitic infections

Parasite	Diseases	No. people infected	Deaths/yr
Plasmodium	malaria	273 million	1.12 million
Soil transmitted helminths: ▪ Roundworm (*Ascaris*) ▪ Whipworm (*Trichuris*) ▪ Hookworm (*Ancylostoma* and *Necator*)	 Pnemonitis, intestinal obstruction Bloody diarrhoea, rectal prolapse Coughing, wheezing, abdominal pain and anaemia	2 billion	200,000
Schistosoma	Renal tract and intestinal disease	200 million	15,000
Filariae	Lymphatic filariasis and elephantiasis	120 million	Not fatal but 40 million disfigured or incapacitated
Trypanasoma cruzi	Chagas disease (cardiovascular)	13 million	14,000
African trypanosomes	African sleeping sickness	0.3 – 0.5 million	48,000
Leishamania	Cutaneous, mucocutaneous and visceral leishmaniasis	12 million; 2 million new cases/yr	50,000

Factors (Endemicity):

1. Presence of a suitable host
2. Habits of the host
3. Escape from the host
4. Favorable conditions outside of host
5. Economic and social conditions

1.4.2. Transmission of parasites

- **Factors required:(Three key links of parasitic disease transmission)**
- **1. Source of infection**
- **2. Mode of transmission**
- **3. Susceptible people**

1.4.2.1. source of exposure

- **1. primary Source**
  - **infected persons**
  - **carriers**
  - **animals**

- **1. Sources of Exposure to Parasitic Infections**
  - ***Contaminated soil:-***
    - **Soils polluted with human excreta is commonly responsible for exposure to infection with geohelminthes**

2. *Contaminated water*:-

Water may contain

- (a) viable cysts of Amoeba, flagellates etc,
- (b) cercarial stages of human blood fluke,
- (c) Cyclops containing larva of *Dracunculus medinensis*
- (d) fresh water fishes which are sources for fish tape worm, and intestinal flukes infection
- (e) crab or cray fishes that are sources for lung fluke and
- (f) Water plants which are sources for *Fasciolopsis buski*.

C. Raw or *Insufficiently cooked meat of pork, beef and fish*

- *E.g., Trichinella spiralis, Taenia* species, *D.latum*.

D. Blood sucking arthropods:

- Malaria - anopheles mosquito,
- *Leishmania* - sand flies
- *Trypanosoma* - tsetse flyb

E. Animals (a domestic or wild animals harboring the parasite),

- e.g, 1. Dogs- the hydatid cyst caused by *E. granulosus*

- ***F. Human beings:-***
  - A person his/her clothing, bedding or the immediate environment that he/she contaminated
  - **Autoinfection: -** e.g., *S. stercoralis, E. vermicularis,* and *T. solium*

1.4.2.2. Mode of Transmission

Direct mode of Transmission:-

classified as:

- ***I.*Horizontal Direct mode of transmission**:
  Transmission is mainly effected through:-
  - Feco-oral route: most intestinal parasites transmitted in this way.
  - Sexual intercourse
  - Blood transfusion
  - Direct skin penetration

II. **Vertical Direct Mode of Transmission*:***

Transmission of the parasite is from the mother to child through:

- Congenital / transplacental
- Transmammary (breast milk

- **II- Indirect Mode of Transmission:-**
  - If the parasite
    - has complex life cycle
    - requires biological vectors and/or
    - one or more intermediate hosts

Route of Transmission

I. By ingesting infective stage of parasites:

- In food, water or hands contaminated with faeces,
  - E.g. *E. histolytica, E. vermicularis, etc*.
- In raw or undercooked meat, e.g. *T. saginata, T. solium, T. spiralis*
- In raw or undercooked fish, crab, or water vegetation e.g. intestinal flukes
- Water containing Cyclope e.g., *D. medinensis*

II. Penetration of Skin When in Contact with:

- Faecally polluted soil, e.g., *S.stercoralis*, Hook worms
- Water containing infective stages of the parasite E.g., Cercaria of Schistosome species .

III. Through Insect Bite,

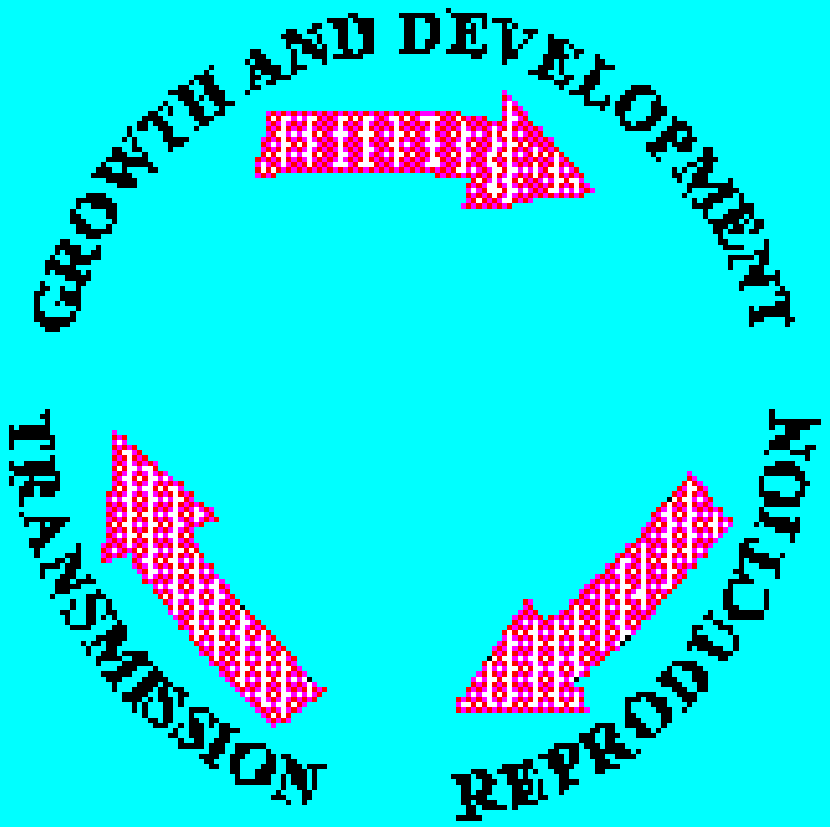
- E.g., filarial worms, *Trypanosoma* sp, Plasmodium sp. etc.

- **Sexual Contact,** e.g., *Trichomonas vaginalis*
- **Transmammary,** e.g., *S. stercoralis*
- **Inhalation of contaminated air**, e.g., *E. vermicularis, P. carnii*
- **Transplacental**, e.g., *T. gondii*
- **Kissing**, e.g., *Trichomonas gingivalis, T. tenax*

1.5 General Life Cycles of parasites

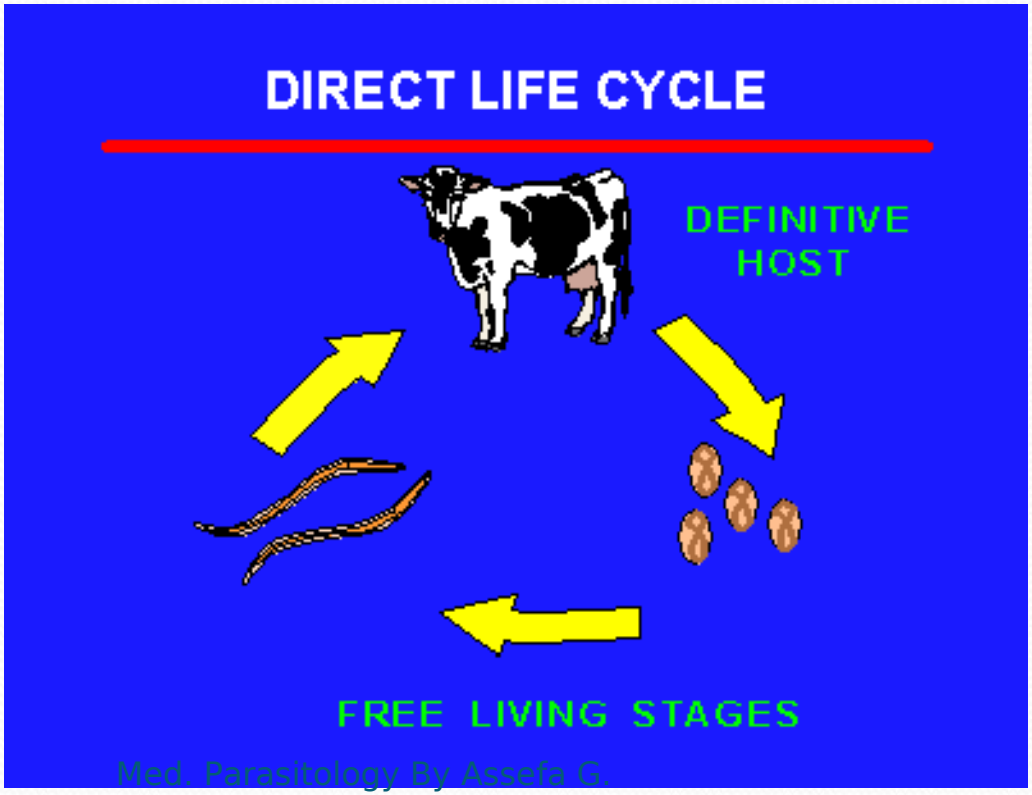
- Describes the cycle of development of the parasite,
- This may involve
  - Passing through a number of developmental stages & enviroment
  - Parasitic and non-parasitic stages.
- The life of a parasite can be divided into a number of phases:
  - Growth and maturation,
  - Reproductive (sexual and asexual) and
  - Transmission phases.
  - All vitally important for the successful survival of the parasite.
- Can be simple or complex depending on how many different hosts it requires to complete its cycle

MAJOR COMPONENTS OF A PARASITE LIFE CYCLE



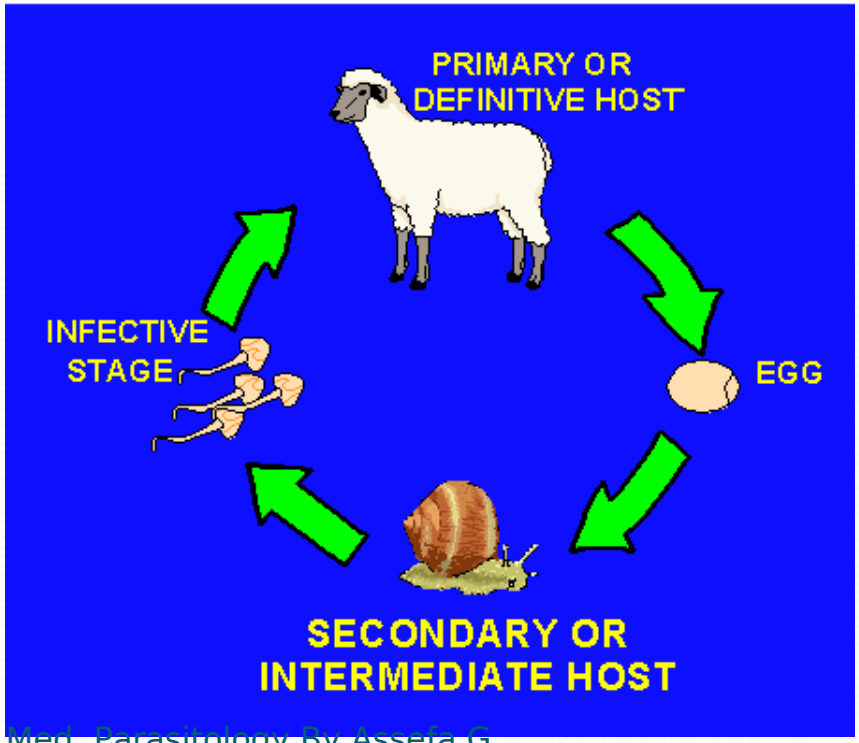
Simple or Direct Life Cycle (monoxenous)

- only one host is required to complete its cycle
- the parasite often spends most of its life, usually as an adult, and where it reproduces
- Transmitted from one host to another through the air, by a fomite, or in contaminated food or water.



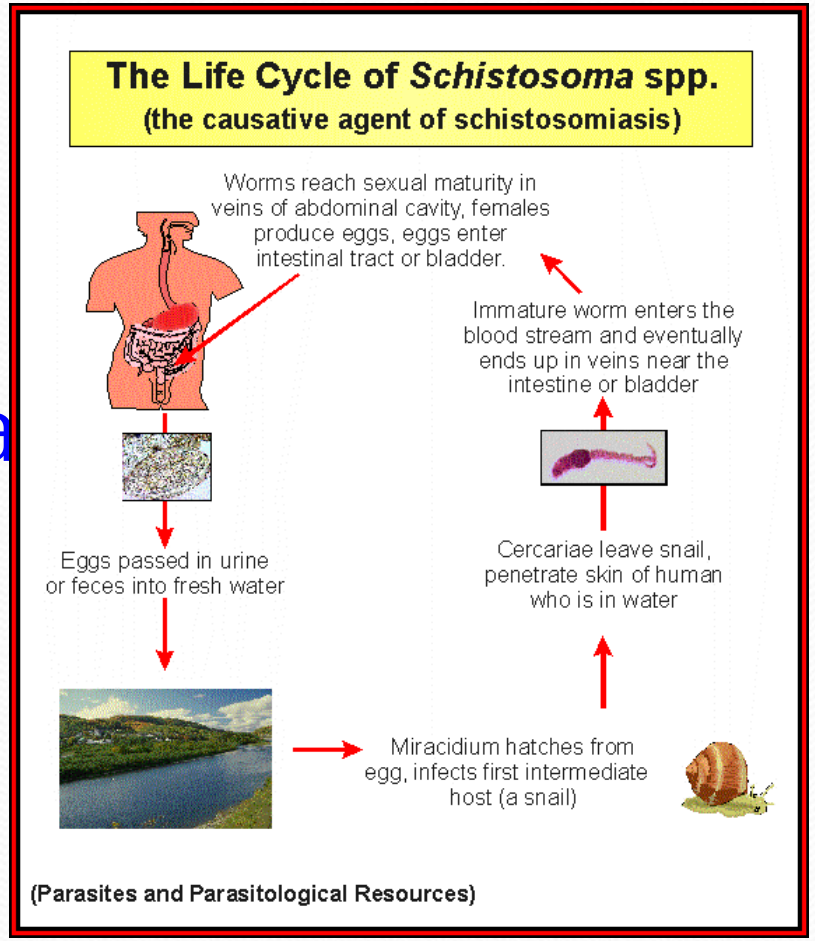
Indirect or heteroxenous life cycles

- requires 2 or more hosts (a vector or intermediate host) to reproduce or grow in
- Frequently this may involve passing through a number of developmental stages & Evt.



1.5.3. Why study life cycles?

Control.
Treatment.
Epidemiology.
Fundamental resea



1.6 Parasitic Infections & Disease:

- Not all parasitic infections cause disease of clinical significance.
- Both host and parasitic factors are involved for the parasitic infection to cause disease or not

1.6.1. Host Factors

1. Genetic factors, E.g. Black population who lack Duffy antigen resist *P.vivax*
2. Age,
3. Sex : e.g., *T.vaginalis*
4. Level of immunity: natural and acquired immunity
5. Nutrition (malnutrition or under nutrition)
6. Intensity and frequency of infections
7. Presence of co-existing disease or conditions, which reduces immune response. e.g. Pregnancy, HIV
8. Life style and occupation

1.6.2. Parasite factors

1. Strain of the parasite and adaptation to human host
2. Parasite load (number of parasite)
3. Site (s) occupied in the body
4. Metabolic processes of the parasite, particularly the nature of any waste products or toxins produced by the parasite during its growth and reproduction..

1.6.3. How do Parasites Cause Inquiry to their Host?

- **Competition for the host's nutrients**
  - Eg. D.latum absorbs vitamin B-12, can cause anemia
  - other tapeworms absorb large amounts of proteins and sugars

  Use of host's fluids
  - hookworm ingests blood, can be up to 250 ml/day
- **Destruction of host tissues**
  - some injure upon entry, some after established
  - eg. Swimmers itch, cercariae penetrate and cause inflammation
  - intestinal worms, after established cause small lesions in gut, possible secondary infection
  - Entamoeba actively digest epithelial cells in large intestine

- **Tissue changes**

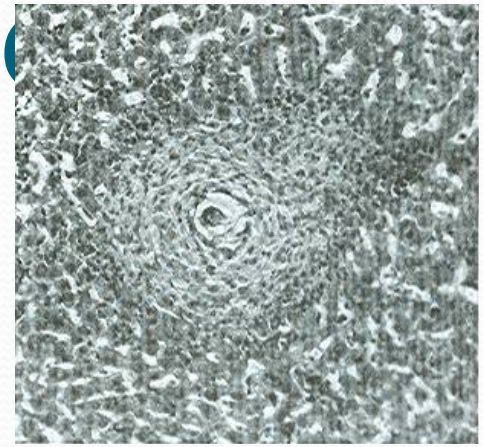
  - may cause serious consequences to host
  - hyperplasia,. Eg Fasciola
  - hypertrophy,
  - metaplasia, change of tissue cell type to another type. Eg. Paragonims (lung fluke)
  - neoplasia, growth of cell to form a new structure. Eg. Tumors

- **Toxins and secretions**
- - some may cause pathogenic response, some may inhibit immune function
  - eg. Mosquito saliva
- **Mechanical interference**
- - Elephantiasis (filarial worms) blocks lymphatic system
  - Tapeworms in large numbers can block intestine
  - Plasmodium can cause RBC's to stick together and clog capillaries

Host Immunity & Immuno – evasion of the parasite

1.7. Host Immunity & Immuno – evasion of the parasite

1.7.1.Host Respons



Nonspecific immunity

- Macrophage endocytosis
  - Common for bacteria and small protozoa
- Inflammation
  - Acute – edema and increase of leukocytes
  - Subacute – monocytes and lymphocytes present, with fibrocytes binding parasite with collagen.
  - Chronic – plasma cells present and form a granuloma
- Hyperplasia – parasite causes host to produce more cells
  - Liver fluke simulating enlargement of bile duct
- Neoplasia (cancer) – rare parasites have been associated with cancer, but mechanisms are still unknown.

Host Responses

Specific Immunity

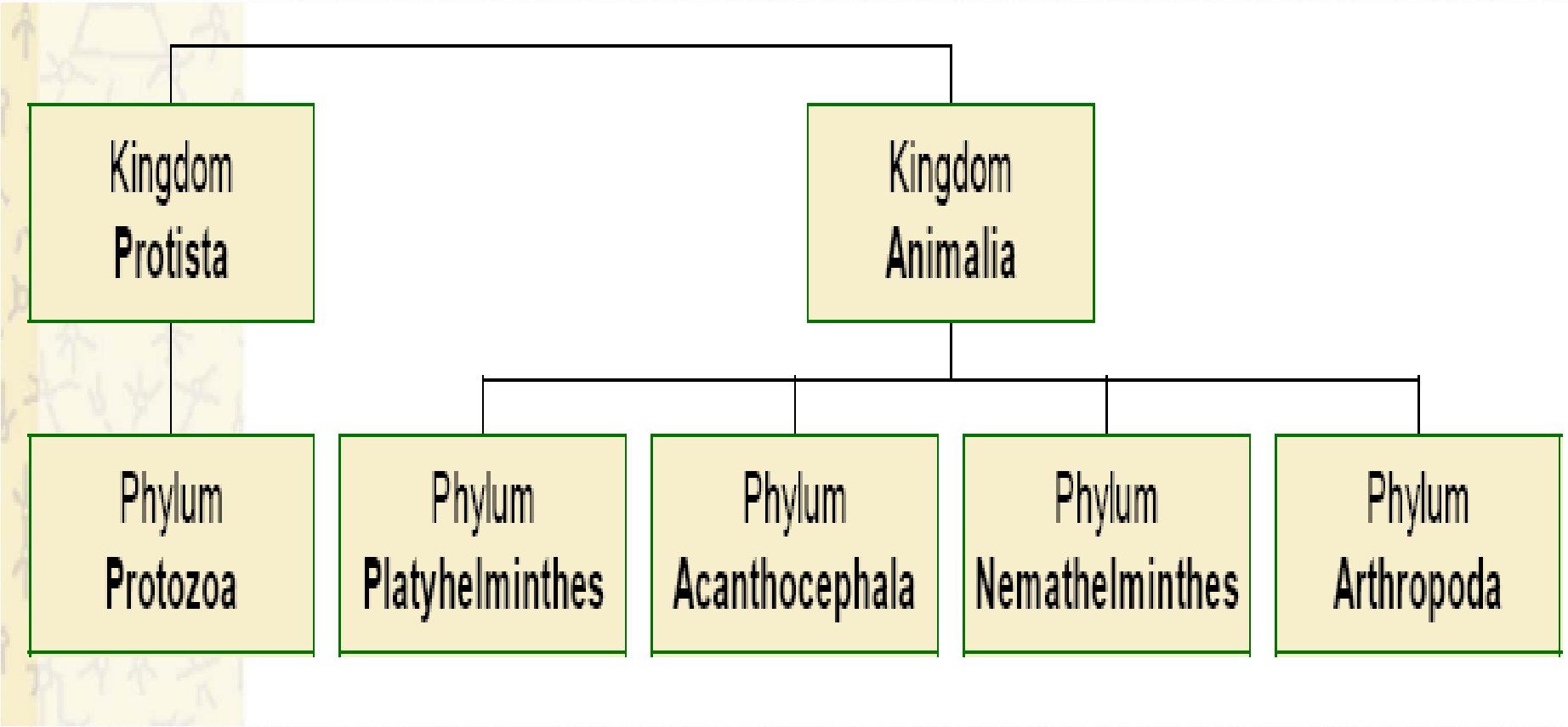
- Humeral response: Formation of antibodies or immunoglobulin s(Ig) by B cells.
  - IgE fights helminths
  - IgM and IgG important against protozoans
- Cell mediated response: uses T-cells
  - Cytotoxic T cells inject invading parasites
  - Also release cytokines, which promote nonspecific immunity. (interconnected)

1.7.2.Parasite Responses

- Antigenic variation
  - Change surface glycoproteins regularly
- Being poorly antigenetic
  - Don’t induce a response, or a most a mild one
- Hide within host cells
  - Host can’t kill what it can’t find
- Camouflage
  - Use bits of host cells and attach to parasite’s surface
- Depress host’s immune response
  - Modulate produce of host T cell production

Taxonomy and nomenclature of parasites

- Taxonomy



Taxonomic classification of helminths

Sub kingdom	Phylum	Class	Genus – examples
Metazoa	**Nematodes** Round worms; appear round in cross section, they have body cavities, a straight alimentary canal and an anus	 	Ascaris (roundworm) Trichuris (whipworm) Ancylostoma (hookworm) Necator (hookworm) Enterobius (pinworm or
	Platyhelminthes Flat worms; dorsoventrally flattened, no body cavity and, if present, the alimentary canal is blind ending	Cestodes Adult tapeworms are found in the intestine of their host They have a head (scolex) with sucking organs, a segmented body but no alimentary canal Each body segment is hermaphrodite	 

Taxonomic classification of protozoa

Sub kingdom	Phylum	Sub-phylum	Genus-examples	Species-examples
Protozoa	Sarcomastig-ophora further divided into	Sarcodina-- - move by pseudopodia	Entamoeba	*E. histolytica*
		Mastigophora move by flagella	Giardia	*G. lamblia*
	Apicomplexa no organelle of locomotion		Plasmodium	*P. falciparum,* *P. vivax,* *P. malariae,* *P. ovale*
	Ciliophora move by cillia		Balantidium	*B. coli*
	Microspora Spore		Enterocyto-zoa	*E. bienusi*

Nomenclature of parasites

- Common name vs scientific name
- Parasites named by binomial nomenclature
  - Genus (capitalized)
  - Species (not capitalized)
- Binimial name underlined or separately italicized

  Example: Ascaris lumbricoides, *Ascaris lumbricoides*