



Partners in Global Health Education

An introduction to Medical Parasitology

1. How to use this module
2. Learning outcomes
3. Key definitions
4. Epidemiology
5. Burden of parasitic infections
6. Classification of protozoa
7. Classification of helminths
8. Schistosomiasis
9. Hookworm
10. Lymphatic filariasis
11. Sources of information



For more information about the authors and reviewers of this module, [click here](#)



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How should you study this module?

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- We suggest that start with the learning objectives and try to keep these in mind as you go through the module slide by slide, in order.
- You should research any issues that you are unsure about. Look in your textbooks, access the on-line resources indicated at the end of the module and discuss with your peers and teachers.
- Finally, enjoy your learning! We hope that this module will be enjoyable to study and complement your learning about TB from other sources.



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Learning Outcomes

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After completing this SDL, you should be able to:

- Discuss how important parasites can be classified according to kingdom and phylum
- State the meaning of commonly-used terms
- Describe how parasitic infections affect communities in poor countries and that knowledge of their life cycle is necessary for effective prevention and control
- Discuss the epidemiology, basic life cycle, clinical presentation, management and control of some important parasitic infections

Note: This SDL will contain many unfamiliar terms. You are NOT expected to remember the classifications and names of all of the different parasite species. The emphasis is on understanding basic concepts and being able to illustrate these with some important examples.

After completing this SDL, try the associated quiz to assess your learning.



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Key definitions: What is?

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- **Medical parasitology:** “the study and medical implications of parasites that infect humans”
- **A parasite:** “a living organism that acquires some of its basic nutritional requirements through its intimate contact with another living organism”. Parasites may be simple unicellular protozoa or complex multicellular metazoa
- **Eukaryote:** a cell with a well-defined chromosome in a membrane-bound nucleus. All parasitic organisms are eukaryotes
- **Protozoa:** unicellular organisms, e.g. Plasmodium (malaria)
- **Metazoa:** multicellular organisms, e.g. helminths (worms) and arthropods (ticks, lice)
- **An endoparasite:** “a parasite that lives within another living organism” – e.g. malaria, Giardia
- **An ectoparasite:** “a parasite that lives on the external surface of another living organism” – e.g. lice, ticks



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- **Host:** “the organism in, or on, which the parasite lives and causes harm”
- **Definitive host:** “the organism in which the adult or sexually mature stage of the parasite lives”
- **Intermediate host:** “the organism in which the parasite lives during a period of its development only”
- **Zoonosis:** “a parasitic disease in which an animal is normally the host - but which also infects man”
- **Vector:** “a living carrier (e.g. an arthropod) that transports a pathogenic organism from an infected to a non-infected host”. A typical example is the female *Anopheles* mosquito that transmits malaria



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Epidemiology

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- Although parasitic infections occur globally, the majority occur in tropical regions, where there is poverty, poor sanitation and personal hygiene
- Often entire communities may be infected with multiple, different organisms which remain untreated because treatment is neither accessible nor affordable
- Effective prevention and control requires "mass intervention strategies" and intense community education. Examples include:
 - General improved sanitation: pit latrines, fresh water wells, piped water
 - Vector control: insecticide impregnated bed nets, spraying of houses with residual insecticides, drainage, landfill
 - Mass screening and drug administration programmes which may need to be repeated at regular intervals



The burden of some major parasitic infections

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Parasite	Diseases	No. people infected	Deaths/yr
<i>Plasmodium</i>	malaria	273 million	1.12 million
Soil transmitted helminths: <ul style="list-style-type: none"> Roundworm (<i>Ascaris</i>) Whipworm (<i>Trichuris</i>) Hookworm (<i>Ancylostoma</i> and <i>Necator</i>) 	Pneumonitis, intestinal obstruction Bloody diarrhoea, rectal prolapse Coughing, wheezing, abdominal pain and anaemia	2 billion	200,000
<i>Schistosoma</i>	Renal tract and intestinal disease	200 million	15,000
Filariae	Lymphatic filariasis and elephantiasis	120 million	Not fatal but 40 million disfigured or incapacitated
<i>Trypanasoma cruzi</i>	Chagas disease (cardiovascular)	13 million	14,000
African trypanosomes	African sleeping sickness	0.3 – 0.5 million	48,000
<i>Leishmania</i>	Cutaneous, mucocutaneous and visceral leishmaniasis	12 million; 2 million new cases/yr	50,000



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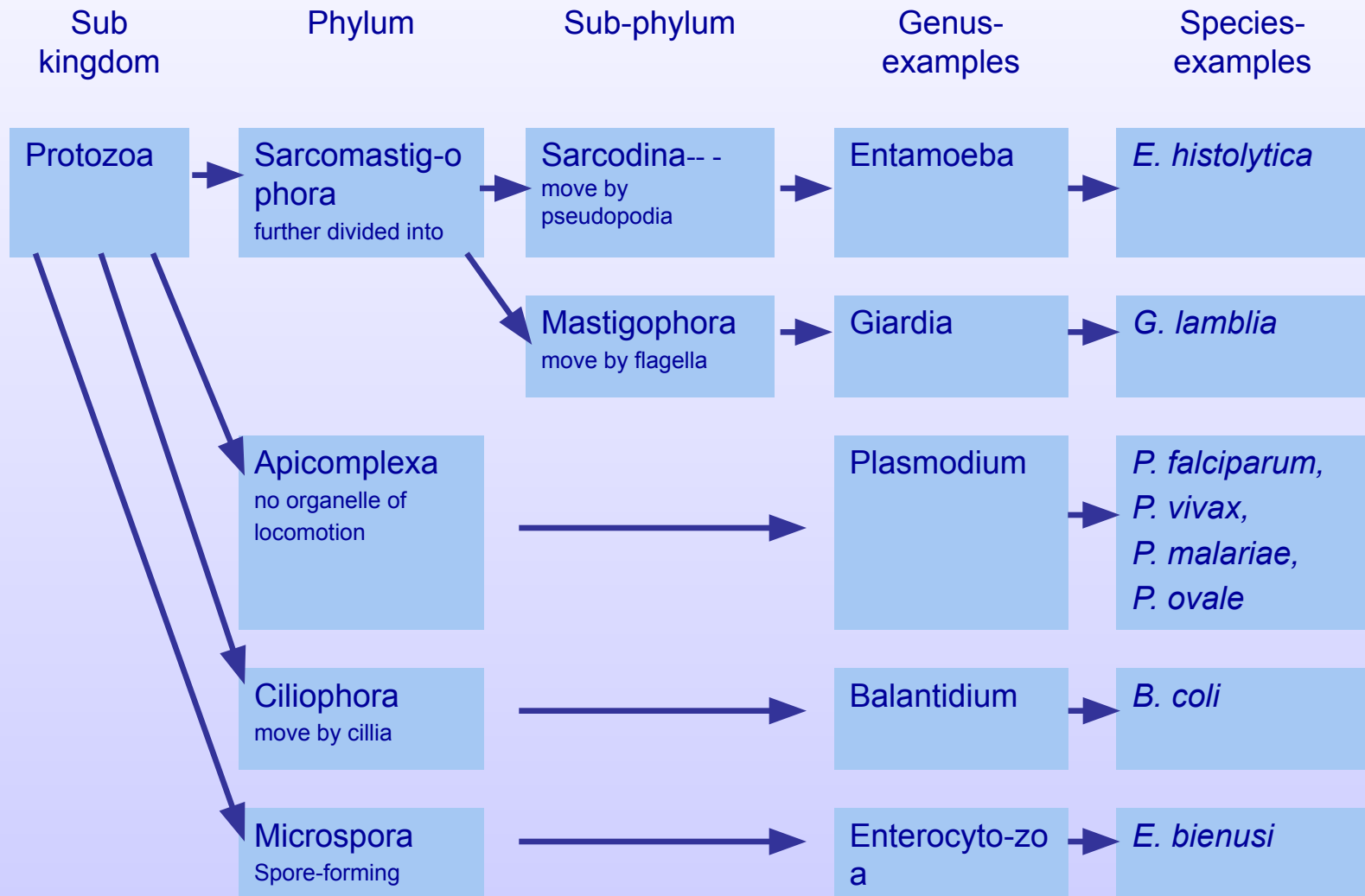
Taxonomic classification of parasitic organisms

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- The classification of parasites is controversial - there is no universally accepted system
- Parasites form part of the animal kingdom which comprises some 800,000 identified species categorised into 33 phyla (but it is estimated that there may be ~10m species in total)
- The parasitic organisms that are of importance for human health are eukaryotes - they have a well defined chromosome in a nuclear membrane (as opposed to prokaryotes which have no nuclear membrane, e.g. bacteria)
- Parasites are classified into 2 sub-kingdoms: protozoa (unicellular) and metazoa (multicellular)
- Protozoan (unicellular) parasites are classified according to morphology and means of locomotion. There are 45,000 protozoa species. Most species that cause human disease belong to the phyla sarcomastigophora and apicomplexa
- Metazoa (multicellular) include the worms (helminths) and arthropoda (posses an external skeleton) e.g. ticks, lice
- Note that the genus starts with a capital letter and the species is always written in italics, e.g. *Plasmodium falciparum*, *Giardia lamblia*

Taxonomic classification of protozoa

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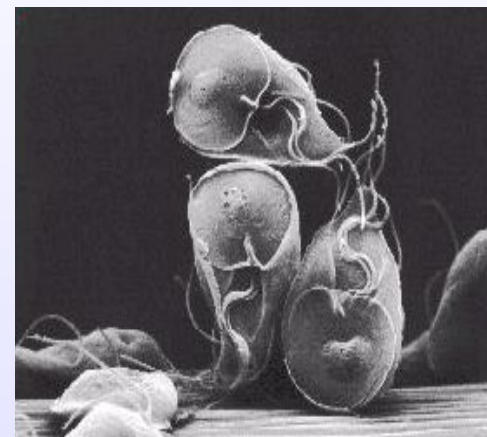


Examples of important intestinal protozoa

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Transmitted by the faecal-oral route and cause diarrhoea

- *Giardia lamblia*: world-wide distribution, lives in the small intestine and results in malabsorption
- *Entamoeba histolytica*: may invade the colon and cause bloody diarrhoea – amoebic dysentery. Also causes amoebic liver abscess.
- *Cryptosporidium parvum*: more prevalent in the immunocompromised
- *Cyclospora cayentanensis* - parasitises the small intestinal mucosa and may cause diarrhoea for several weeks
- *Balantidium coli*: a large motile ciliated parasite that lives in the colon of pigs, humans and rodents and can lead to colonic ulceration
- *Enterocytozoon bienusi*: a microsporidian that parasitises the small intestine. Also more common in the immunocompromised.



Electron micrograph of *G. lamblia* trophozoites (feeding stage)



Typical flask-shaped ulcer due to *E. histolytica* in the colonic mucosa

Examples of important systemic protozoa

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Typical lesion of cutaneous leishmaniasis



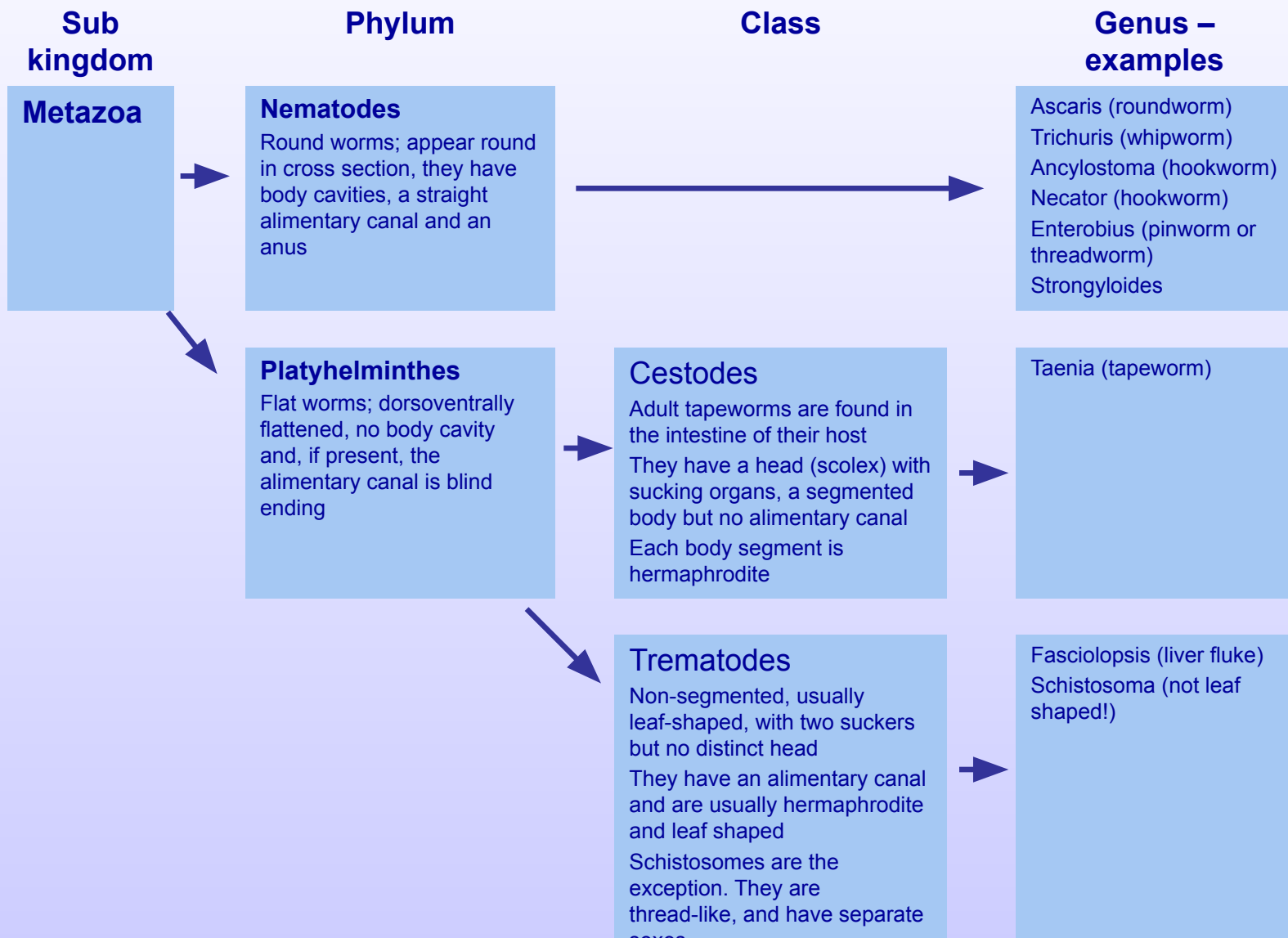
**Tsetse fly – the vector of African trypanosomiasis
It has a painful bite!**

Detected in the blood

- *Plasmodium*: the cause of malaria. There are 4 species that infect man: *P. falciparum*, *P. vivax*, *P. ovale* and *P. malariae*
- *Toxoplasma gondi*: transmitted by the ingestion of oocysts from cat faeces. Infection can lead to ocular problems and is also a cause of neonatal toxoplasmosis
- *Leishmania*: transmitted by sand flies, can lead to visceral, cutaneous and mucocutaneous leishmaniasis
- *Trypanosoma*: haemoflagellates which cause
 - In Africa - sleeping sickness (transmitted by the Tsetse fly)
 - In South America - Chagas disease (transmitted by the Reduviid bug)

Taxonomic classification of helminths

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Examples of important metazoa – intestinal nematodes

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- *Trichuris* (whipworm)
 - A soil transmitted helminth
 - prevalent in warm, humid conditions
 - Can cause diarrhoea, rectal prolapse and anaemia in heavily-infected people
- *Ancylostoma* and *Necator* (hookworms)
 - A major cause of anaemia in the tropics
- *Strongyloides*
 - inhabits the small bowel
 - infection more severe in immunosuppressed people (e.g. HIV/AIDS, malnutrition, intercurrent disease)
- *Enterobius* (pinworm or threadworm)
 - prevalent in cold and temperate climates but rare in the tropics
 - found mainly in children

- *Ascaris* (roundworm)
 - Found world-wide in conditions of poor hygiene, transmitted by the faecal-oral route
 - Adult worms live in the small intestine
 - Causes eosinophilia



Heavy intestinal infections may occur with *Ascaris*. Adult worms can be several cms long.



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Examples of important metazoa –systemic nematodes

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Filaria including:

- *Onchocerca volvulus* – Transmitted by the simulium black fly, this microfilarial parasite can cause visual impairment, blindness and severe itching of the skin in those infected
- *Wuchereria bancrofti* – The major causative agent of lymphatic filariasis
- *Brugia malayi* – Another microfilarial parasite that causes lymphatic filariasis

- Toxocara
 - A world-wide infection of dogs and cats
 - Human infection occurs when embryonated eggs are ingested from dog or cat faeces
 - It is common in children and can cause visceral larva migrans (VLM)

Examples of important flatworms - cestodes

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1. Intestinal - (“tapeworms”)

- *Taenia saginata*
 - worldwide
 - acquired by ingestion of contaminated, uncooked beef
 - a common infection but causes minimal symptoms
- *Taenia solium*
 - worldwide
 - acquired by ingestion of contaminated, uncooked pork that contains cysticerci
 - Less common, but causes cysticercosis – a systemic disease where cysticerci encyst in muscles and in the brain – may lead to epilepsy

2. Systemic

- *Echinococcus granulosus* (dog tapeworm) and *Echinococcus multilocularis* (rodent tapeworm)
 - Hydatid disease occurs when the larval stages of these organisms are ingested
 - The larvae may develop in the human host and cause space-occupying lesions in several organs, e.g. liver, brain

Examples of important metazoa –trematodes (flukes)

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Intestinal

Fasciolopsis buski - A common parasite of humans and pigs in South- east Asia. This parasite is one of the largest trematodes to infect man (8cm in length) and lives in the upper intestine. Chronic infection leads to inflammation, ulceration and haemorrhage of the small intestine



Adult *Fasciolopsis buski* trematode

© Dr. Peter Darben, Queensland University of Technology

- *Fasciola hepatica* (liver fluke)- Primarily, a parasite of sheep, humans become infected when they ingest metacercariae that have encysted on watercress. The adult trematode lives in the intra-hepatic bile ducts of the liver. “Fascioliasis” can lead to severe anaemia in humans
- *Clonorchis sinensis* (liver fluke)- Widespread in China, Japan, Korea and Taiwan, this parasite is acquired by ingestion of infective metacercariae in raw or pickled fish
- *Paragonimus westermani* (lung fluke)- Widespread in the Far East and South east Asia, the parasite is acquired by ingestion of infective metacercariae in raw or pickled crustaceans
- *Schistosoma haematobium*, *S. mansoni* and *S. japonicum* – see below



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Schistosomiasis (bilharzia)

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Schistosomiasis (1)

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Epidemiology

- 200m people in 74 countries infected, 85% of whom live in sub-Saharan Africa
- *S. haematobium* - Africa and middle east (most prevalent)
- *S. Mansoni* - Africa and Latin America
- *S. japonicum* – Pacific region

Life cycle

- Transmission occurs in fresh water
- Infective cercariae released from snails of the genera *Bulinus*, *Biomphalaria* *Oncomelania*
- Cercariae penetrate the skin of people who drink, swim or bathe in infected water
- Adult worm live in the veins that drain the urinary system (*S. haematobium*) or mesenteric blood vessels intestines (*S. mansoni*, *S. japonicum*) and release eggs into water in urine or faeces
- Eggs develop into miracidia which then infect snails



Bulinus globosus, the intermediate host snail for *S. haematobium* (source: WHO/TDR/Stammers)



S. haematobium cercaria (differential interference contrast microscopy; source: WHO/TDR/Stammers)

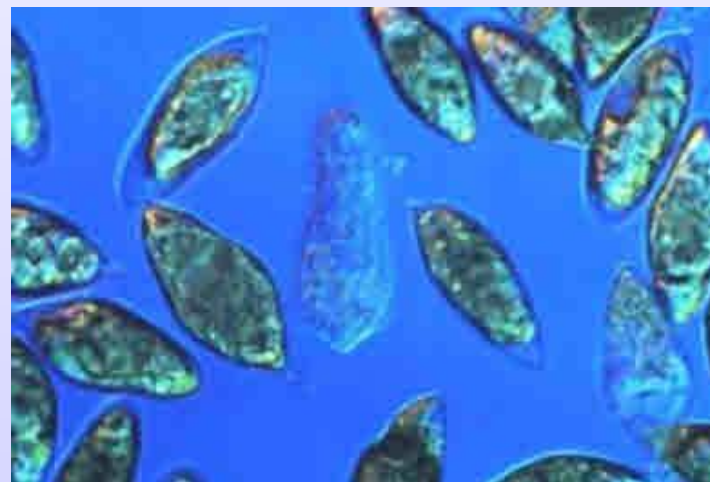
Schistosomiasis (2)

Pathology

- Schistosoma eggs become trapped in the tissues of the urinary tract (*S. haematobium*) and intestines (*S. mansoni*, *S. japonicum*)
- This results in inflammatory response and tissue damage



Adult worms of *S. haematobium* are 1-2 cm long (source: WHO/TDR/Stammers)



S. haematobium eggs measure 140 x 50 μm (differential interference contrast microscopy; source: WHO/TDR/Stammers)

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Schistosomiasis (3)

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Symptoms and signs

- Urinary Schistosomiasis:
 - *S. haematobium*
 - Gross haematuria
 - Dysuria
 - Bladder, ureters and kidneys damaged
 - Cancer of the bladder is common
- Intestinal schistosomiasis
 - *S. mansoni*, *S. japonicum*
 - Gradual enlargement of liver and spleen
 - hypertension of the abdominal blood vessels which begin to bleed
 - Blood in the stools
- **Diagnosis**
- Microscopy for eggs:
 - urine sediment for *S. haematobium*
 - concentrated stool samples for *S. mansoni*, *S. japonicum*
- Serology – all species
- Rectal biopsy - *S. mansoni*, *S. japonicum*

Treatment

- Praziquantel: effective against all species
- *S. haematobium*: single dose (40 mg/kg)
- *S. mansoni*, *S. japonicum*: 2-3 doses of 30mg/kg



Haematuria due to *S. haematobium*
(source: WHO/TDR)



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Schistosomiasis (4)

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Prevention and control

- Educate people to not urinate or defecate in fresh water supplies
- Eliminate snail vectors by making the water habitat unsuitable (increase water flow, remove vegetation)
- Provide piped water to avoid direct contact with cercariae
- Mass drug treatment of communities to reduce reservoir of infection

Concrete irrigation ditches do not allow breeding of *Oncomelania* snails (source: WHO/TDR/Crump)





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Hookworm (1)

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Epidemiology

- >1200m infections each year of which 100m are symptomatic
- It is due to 2 parasites both of which occur worldwide:
 - *Necator americanus* - predominant species in sub-Saharan Africa, south Asia and the Pacific
 - *Ancylostoma duodenale* –predominant in S. Europe, N. Africa, western Asia, northern China, Japan and the west coast of America



Hookworm is a major cause of anaemia

Hookworm (2)

Life cycle

- Adult worms live in the intestine and excrete eggs in the faeces
- In the absence of latrines, eggs contaminate soil and develop in warm, damp conditions
- eggs hatch and infective filariform larvae develop in about one week and remain infective in soil for many weeks
- filariform larvae penetrate the skin when a person walks barefoot in the soil
- larva migrate from the skin to the lungs via the lymphatic and blood systems
- larvae penetrate the capillary wall to enter the alveolus
- Larvae are propelled up the respiratory tree to the epiglottis where they are swallowed
- Develops to adult stage in upper intestine; adult worms are fully mature after about 5 weeks
- Eggs are excreted in the faeces
- Note: eating soil (pica) is a common practice. Ingested filariform larvae of *A. duodenale* can pass directly to the gut mucosa



Egg of *A. duodenale* in faecal smear
(size 57-76 µm by 35-47 µm)

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Filariform larvae

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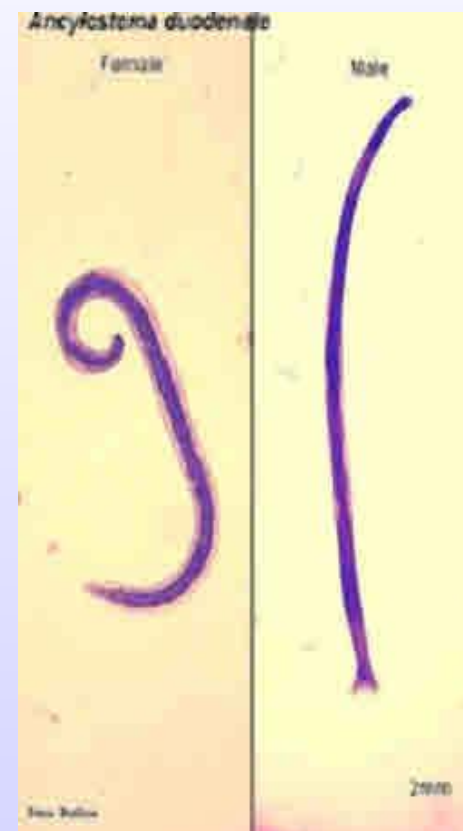
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Hookworm (3)

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Pathology

- Hookworms move several times a day to different attachment sites in the upper intestinal mucosa to ingest blood
- They secrete an anticoagulant which causes the old attachment sites to continue to bleed
- Heavy hookworm infection results in chronic haemorrhage from the duodenal and jejunal mucosa
- The combination of constant blood loss due to hookworm infection and poor iron intake in the diet results in iron deficiency anaemia
- *A. duodenale* ingests 4-5 times more blood each day than *N. americanus*
- In a child, the continued daily loss of 10ml of blood can lead to severe anaemia



Adult male and female worms of *A. duodenale*

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Hookworm (4)

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Symptoms and signs

Minor

- Often itchy papules are found at the site where the larva penetrated the skin
- There may be cough and wheezing as the larva migrates through the lungs

Major

- Hookworm anaemia
 - Tiredness, aches and pains
 - Pallor
 - Breathlessness
 - Oedema

Diagnosis

- Microscopic examination of faecal smears to demonstrate significant numbers of hook worm eggs
- Measure Hb, serum ferritin, iron
- Exclude other causes of anaemia

Treatment

- Mebendazole (cheap) – 100mg, twice daily for 3 days
- Mebendazole is contraindicated in pregnancy – use Bephenium hydroxynaphthoate “alcopar”
- For anaemia: ferrous sulphate 200-400 mg three times a day for 3 months (adult regimen)

Prevention and control

- Health education and improve sanitation facilities – install pit latrines
- Encourage use of protective footwear
- Discourage soil eating (pica)
- Mass drug treatment of communities
- Iron supplementation in areas of low iron intake

Lymphatic filariasis (1)

Epidemiology

- 120m people infected in >80 countries in Africa, Asia, the Pacific islands and South and Central America
- 40m of those infected are disfigured or severely incapacitated
- 95% cases due to *Wuchereria bancrofti*, other species include *Brugia malayi* and *Brugia timori*



A female *Anopheles* mosquito taking a blood meal

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Lymphatic filariasis (2)

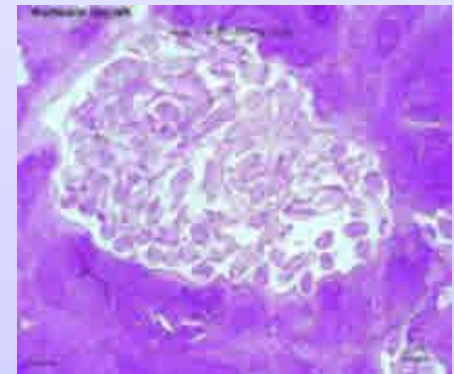
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Life cycle

- *Wuchereria bancrofti* is mainly transmitted by
 - *Culex* mosquitoes in India
 - *Anopheline* mosquitoes in Africa
- *B. malayi* and *B. timori* are transmitted mainly by *Mansonia* mosquitoes
- Larval forms of the parasite (microfilariae) are taken up by a female mosquito when it takes a blood meal from a human infected with adult worms
- The microfilariae develop inside the mosquito
- When the mosquito takes another blood meal the infective filariform larvae enter the bite wound
- Filariform larvae migrate to the lymphatics and lymph glands
- Larvae develop into sexually mature adult worms over 3-12 months depending on the species of filarial worm



Microfilaria of *B. malayi* in thick blood film (H&E stain; source: CDC)



Adult worms of *B. malayi* in section in a lymph node (source: Univ South Carolina)



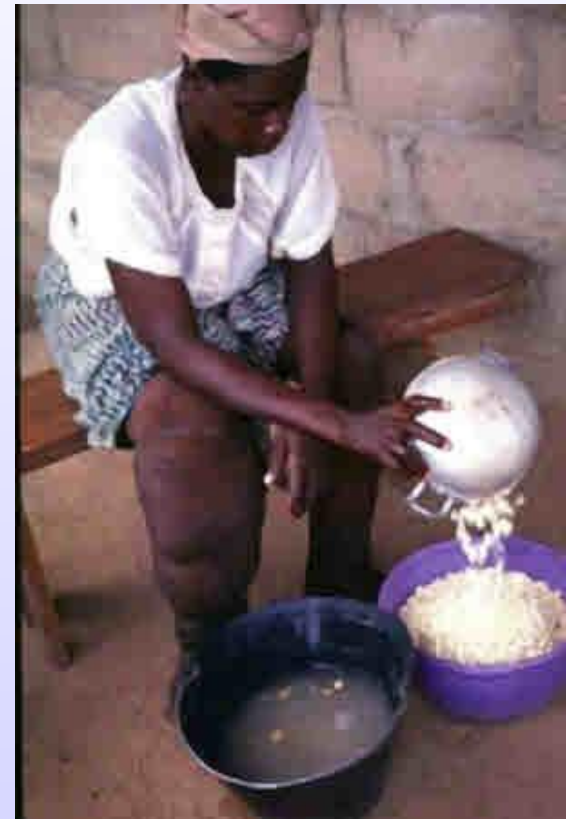
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Lymphatic filariasis (3)

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Pathology

- Adult worms live in the afferent lymphatic vessels and cause severe disruption to the lymphatic system
- Scrotal damage and massive swelling may occur when adult *Wuchereria bancrofti* lodge in the lymphatics of the spermatic cord
- Late stage disease is typified by elephantiasis – painful and disfiguring swelling of the limbs
- Trauma and secondary bacterial infection of affected tissues is common



Elephantiasis of the leg
(source: WHO/TDR/Crump)

Lymphatic filariasis (4)

Symptoms and signs – 3 stages

1. Asymptomatic stage

- There is internal damage to the lymphatics and kidneys

2. Acute stage – Filarial lymphangitis

- Characterised by bouts of fever
- heat, redness, pain, swelling and tenderness of the lymph nodes and ducts

3. Chronic stage

- Usually results in elephantiasis as a result of chronic lymphoedema
- There is a massive overgrowth of tissue resulting in severe deformities
- The legs are often affected and result in inability to walk
- The scrotum is often affected in men and the breasts and vulva in women



Elderly male with massive hydrocoele, and elephantiasis of the leg. Also has nodules in the groin due to onchocerciasis (source: WHO/TDR/Crump)

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11. Sources of information



Partners in Global Health Education

Lymphatic filariasis (5)

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Diagnosis

- Microscopic examination of Giemsa stained thick blood films for the presence of microfilariae
- *W. bancrofti* shows marked nocturnal periodicity, so it's best to collect blood samples between 10pm and 1 am
- Serology

Treatment

- Diethylcarbamazine (DEC) rapidly kills microfilariae and will kill adult worms if given in full dosage over 3 weeks
- Release of antigens from dying microfilaria causes allergic-type reactions – add an antihistamine and aspirin to treatment regimen
- Other treatment options are
 - ivermectin
 - combination of DEC and albendazole

Prevention and control

- Rapid diagnosis and treatment of infected individuals
- Mass drug administration to at risk communities
- Vector control: eliminate mosquito breeding sites through improved sanitation and environmental management
- Personal protection against mosquito bites by insecticides, bednets and repellants



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- The Special Programme for Research and Training in Tropical Diseases (TDR UNICEF, UNDP, World Bank, WHO) website: www.who.int/tdr/media/image.html
- University of South Carolina School of Medicine: <http://pathmicro.med.sc.edu/book/parasit-sta.htm>
- Lecture notes on Tropical Medicine, Dion R Bell, Fourth edition, 1996, Blackwell Science.
- Parasites and human disease, W. Crewe and D.R.W. Haddock, 1985, First edition, Edward Arnold.



Authors and reviewers

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