

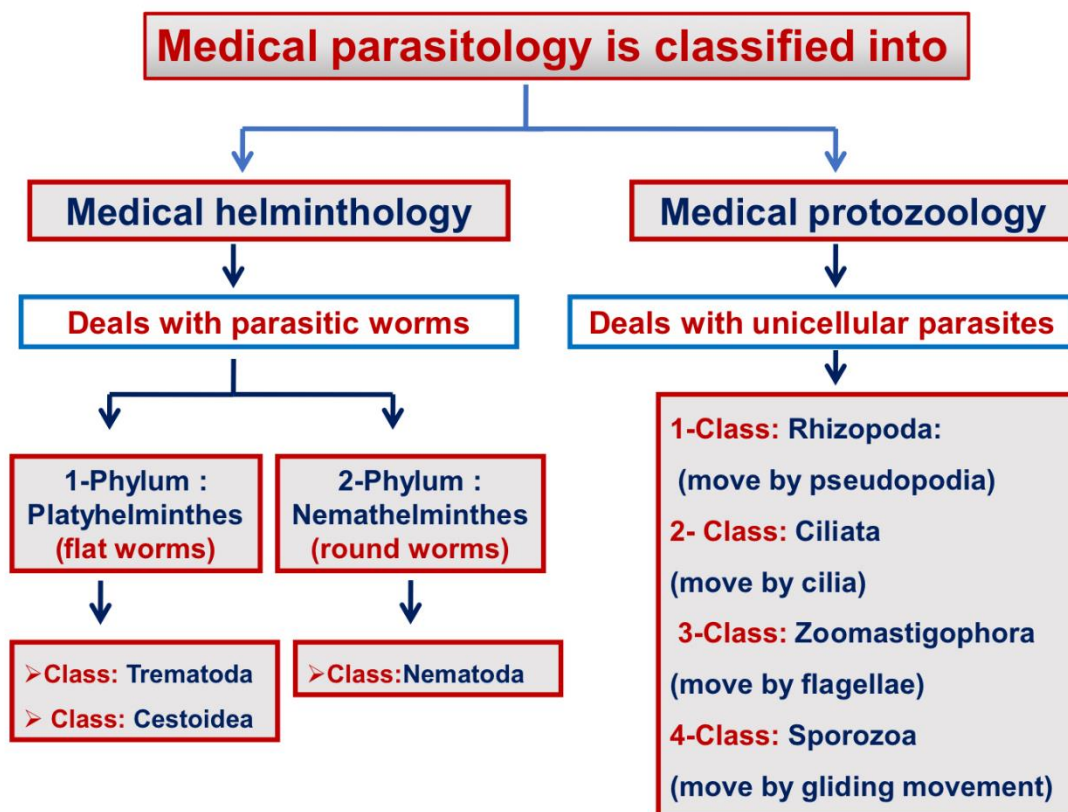


Parasitic Helminths

In this lecture we're going to discuss Medical Helminthology...

Medical Parasitology is divided into:

- A) Medical protozoology (Protozoa): it deals with unicellular microscopic eukaryotic parasites.
- B) Medical helminthology (Metazoa, Parasitic worms, Helminths): it deals with multicellular eukaryotic organisms. Their prevalence is very high, especially in developing countries which have insufficient sanitation. Infections to humans are usually benign, except for some organisms and organisms that cause benign infections can cause diseases (especially intestinal ones that cause mechanical obstructions in the intestinal tract) if present in large numbers.



*Helminths are classified into 2 main Phylums (Nematodes + Platyhelminths)

*Note that:

- Platyhelminths (الديدان المسطحة) are dorsoventrally flattened in cross sections.
- Trematodes are called leaf-like worms or flukes. They may exist in the lymphatic system, liver and lungs.
- Cestodes are also called flat ribbon-like worms or tapeworms.
- Nemathelminthes (الديدان الأسطوانية) appear round in cross sections. Nematodes have **separate sexes** (male & female), in contrast to Platyhelminths which are **Hermaphroditus** (have both male

and female reproductive organs) (خُنثى) except for Schistosomes (that cause schistosomiasis), they have 2 separate sexes.

- Nematodes have well developed digestive system (dependent on digestion), in contrast to Platyhelminths which are dependent on absorption.
- **No multiplication** happens in helminths (one egg → will give one larva → one adult). Unlike protozoa, by which multiplication occurs (recall that one cyst gives 8 trophozoites in some organisms). An exception to this rule (among helminths) is Echinococcus granulosus that causes hydatid cyst, by which multiplication occurs.
- Note that in some helminths, infections start by ingesting the infective stage (eggs). In some of them that doesn't happen, eggs hatch and leave larva which penetrates the skin to enter the body. Others have no eggs in their life cycle, the adults lay larva instead.

Nematodes:- Intestinal Nematodes:

1 - ASCARIS LUMBRICOIDES

- ✓ They are the species that cause Ascaris disease or Ascariasis (an infection to the small intestine).
 - ✓ One of the commonest helminthic infections in human, related to poor sanitation or night soil (human feces used for fertilizing the soil) that causes infection persistent in nature.
 - ✓ Mostly benign infections.
 - ✓ The disease is caused by **ingestion of eggs**, which can be also observed in **stool samples for diagnosis**.
 - ✓ They have a definite life span (less than 2 years)
-
- Infect by eggs ,that are strongly resistant to dissection and environmental conditions.
 - Eggs are 75x40 with a thick mamillated brownish shell.
 - Freshly passed eggs with stool are ***not infective** they require 2-3 weeks to develop to be embryonated (contain larva). Eggs that are produced are not immediately infectious, they need to be incubated until they can become infectious when ingested (**soil transmitted Helminths** * this is a general term of either they're soil-borne, food-borne or waterborne*)
 - Ascaris lumbricoides is the largest nematode (roundworm) parasitizing the human intestine. (Adult females: 20 to 35 cm; adult male: 15 to 30 cm.)
 - Humans can also be infected by pig roundworm (Ascaris suum). Ascaris lumbricoides (human roundworm) and Ascaris suum (pig roundworm) are indistinguishable. It is unknown how many people worldwide are infected with Ascaris suum.

Pathology and pathogenesis:

- If present in high numbers, adult worms may cause **mechanical obstruction** of the bowel and bile and pancreatic ducts. If not, the infection is usually benign and asymptomatic.
- Worms tend to migrate if drugs such as anesthetics or steroids are given, leading to bowel perforation and peritonitis, **changes in the bowel movement (sometimes constipation** -large

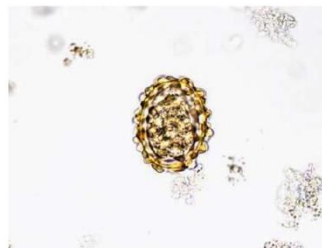
number causes mechanical obstruction , other times diarrhea) due to the irritation caused by the presence of Helminths in the lumen of the intestines , anal passage of worms, vomiting, and abdominal pain/discomfort.

- Larvae has a **transpulmonary route** (although they are intestinal) which **migrates through lungs and induce an inflammatory response (pneumonitis, hypersensitivity reaction - cough, hemoptysis (cough with blood)-), especially after second infection, leading to bronchial spasm, mucus production, and Löffler syndrome (cough, eosinophilia, and pulmonary infiltrates).** *this reflects an important point by which we can diagnose the disease through a sputum sample. (An intestinal disease may be diagnosed by a sputum sample due to the passage of the causative agent in the lungs during its life cycle).

☒ **Löffler's syndrome** is a disease in which eosinophils accumulate in the lungs in response to a parasitic infection [Pulmonary infiltrate]

☒ **Pneumonitis**: related to the host immune response (the inflammation of the lung is not caused directly by the infection process). In case of *Ascaris Lumbricoides*, the problem is due to the response of the body. *Remember that in bacterial infections the CDC will show high levels of neutrophils, but in parasitic infections, CDC would show high amounts of eosinophils (Eosinophilia).

☒ **Pneumonia**: related to the perpetrator (the attacking microorganism).



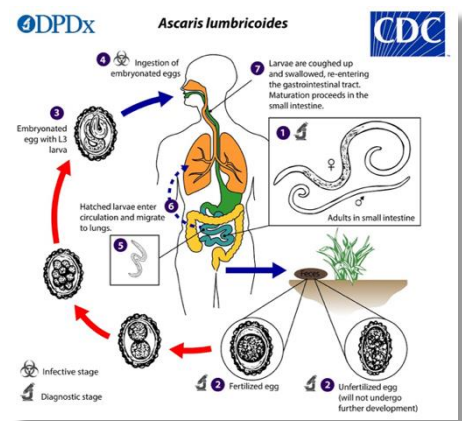
- In the 1st picture to the left, we can observe that the female is bigger than the male, the male has a curved posterior end called copulatory spicule (the place where mating with the female occurs).
- In the 2nd picture you can see the Egg's characteristics: the egg is distinct by brown shell with bumps or lumps. (It is the only egg with bumps) In addition, it is surrounded by an albuminous coat (it helps the egg in surviving different conditions). The eggs are seen under the microscope

ASCARIS LIFECYCLE

The life cycle of *Ascaris lumbricoides* begins with the ingestion of an embryonated egg (the infective stage), through contaminated (water, food, soil).

Note that the egg must be **embryonated not fertilized**.

Then it crosses the digestive system (passes through the stomach) and reaches the small intestine, the eggs hatch in the small intestines.



Larva will cross the mucosa&sub-mucosa of the intestinal wall and move to the blood until they reach the lungs. [Alveoli—>bronchioles—>bronchi then go out].

They reach up and the patient swallows it again. Then they go back to the intestines for the 2nd time where they mature (become adults) and put the eggs (ova position). Eventually, eggs will reach the anus and can be excreted with stool (diagnostic stage).

The presence of adults in the small intestine causes Ascariasis. Note that females -whether they're fertilized by a male or not- lay down approximately 200000 ova per day in the intestines. The unfertilized ones will be excreted in the stool and won't complete the cycle. On the other hand, fertilized eggs will continue their cycle and these are the ones that pose a threat.

Again, fertilized eggs aren't immediately infective that they take around 3 weeks in the soil to move from the '**fertilized egg stage to the embryonated egg stage**' to becomes infectious and this contaminated soil may reach the vegetables and so on. If humans ingested contaminated food with fertilized eggs, they wouldn't be infected because fertilized eggs must become embryonated outside of the body and specifically in the soil, then they become infective and can cause diseases to humans if ingested. That's why they're called "**Soil Transmitted Helminths**".

One of the theories about their life cycle states that if the embryonated egg reaches the small intestine immediately, they can be discharged by the peristalsis movement. So, it goes to the transpulmonary route to become an adult and establish pathogenesis.

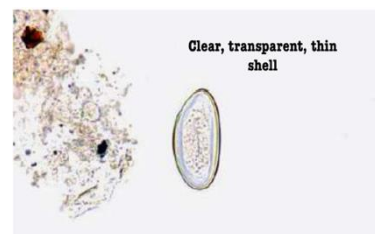
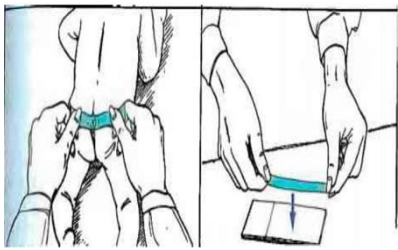
To Sum up the main points in this life cycle (extremely important)

- **The infective stage>>> embryonated egg**
- **The diagnostic stage> either the fertilized or the unfertilized egg. If the infection was severe, adults may slip too.**
- **ASCARIS has pulmonary route (it passes through the lungs)**
- **It is a soil transmitted helminths (needs 3 weeks in the soil before becoming infective)**

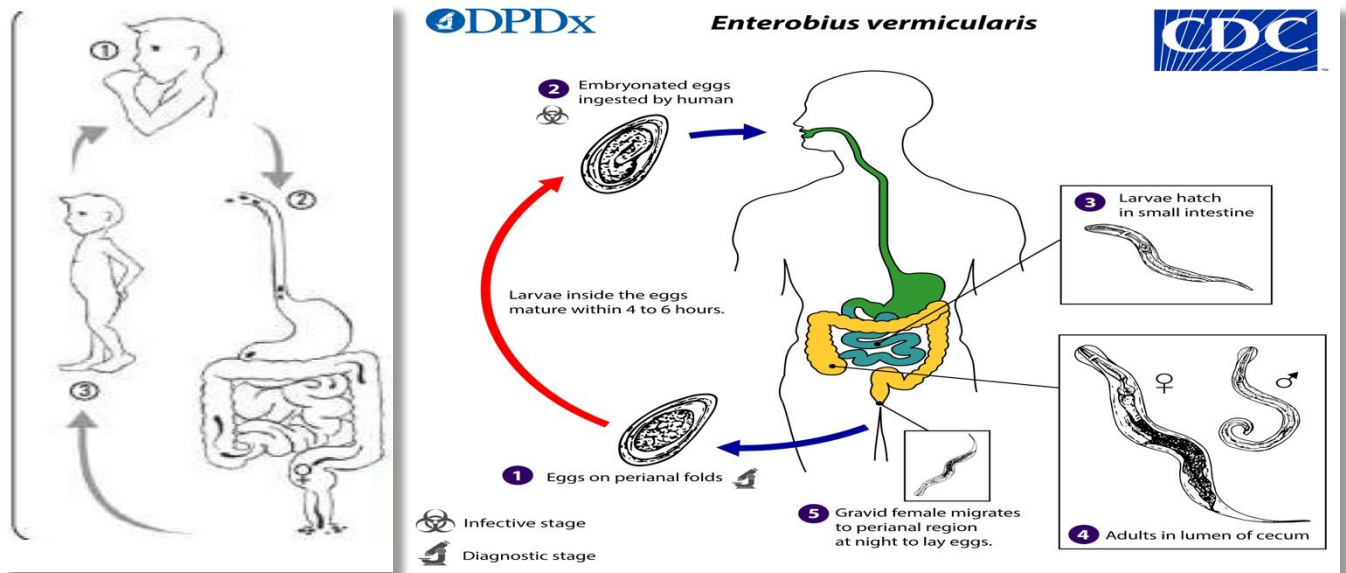
2- ENTEROBIUS VERMICULARIS

(Pinworm—intestinal nematode)

- Female pinworms (about 10 mm in length) have a slender, pointed posterior end. Males are approximately 3 mm in length and have a curved posterior end.
- Pinworms are found worldwide (one of the most common) but more commonly in temperate than tropical climates. They are among the most common helminthic infection and infect mostly children.
- Eggs are football shaped, have a thin outer shell, and are approximately 50-60 μm in length. Infectious larvae are often visible inside the egg.
- Eggs are recovered using the "Scotch Tape" technique in the morning before a bowel movement. They're easily diagnosed and you can even perform this in your clinic if you have a small microscope, by which you put the scotch around the perianal region (or on the anal cleft) then transfer it to the slide of the microscope. You'll observe the eggs (football shaped), they're clear or transparent by which the larvae may be also observed.



- The main symptom associated with pinworm infections is perianal pruritus, especially at night (this is related to cortisone levels), caused by a hypersensitivity reaction to the eggs that are laid around the perianal region by female worms, which migrate down from the colon at night. This causes itchiness (Pruritus) especially among children, which will prevent the child from getting good sleep (very irritating and annoying) and that may reflect in developmental delays.
- Diagnosis: By Eggs (we may find worms but usually eggs)
- The eggs of ENTEROBIUS VERMICULARIS are immediately infective. They need from 4-6 hours, unlike the ASCARIS LUMBRICODES which are soil transmitted helminths and not immediately infective because they need around 3 weeks in the soil. Now, being immediately infective means that the child may cause infection to himself (Auto infection) which occurs if he/she puts his fingers in their mouth after itching the perianal region or even by touching contaminated bed covers or fomites (indirectly transmissible).

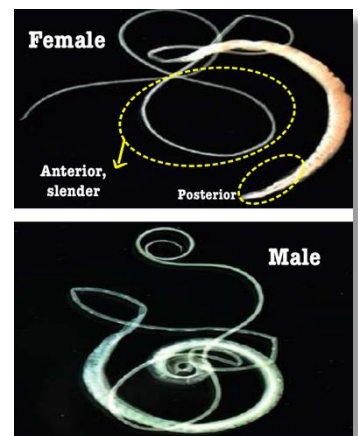


***ENTEROBIUS VERMICULARIS** goes immediately to the intestines, hatches and gives the adult stage, unlike *Ascaris lumbricoides* which goes through a transpulmonary route.

- Life span: less than *Ascaris lumbricoides*
- The diagnostic stage: **eggs** found at the perianal region.
- The infective stage: **embryonated** eggs.

3- TRICHURIS TRICHIURA (Whipworm — intestinal nematode)

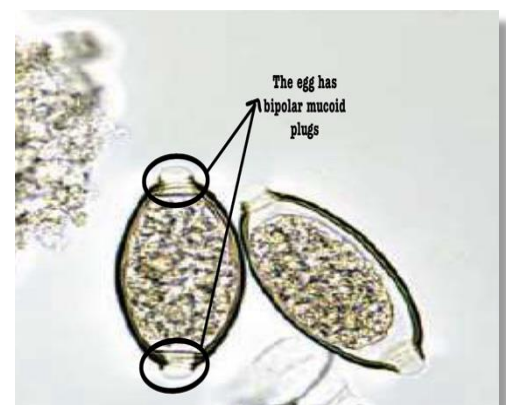
- Adult female whipworms are approximately 30-50 mm in length; adult male worms are smaller. The anterior end of the worms is slender, and the posterior end is thicker, giving it a "buggy whip" appearance, hence the name whipworm.
- Adult whipworms inhabit the colon, where male and female worms mate. Females release eggs that are passed in the feces, and eggs become infective after about 3 weeks of incubation in moist and shady soil.
- Whipworm eggs (50 μ m) with distinct polar plugs.



(Soil transmitted helminths(2weeks-month) & not immediately infective).

Diagnosed by eggs

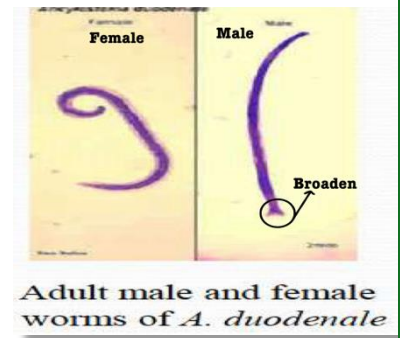
Note: All 3 helminths mentioned above has "feco-oral route" (need to be ingested), regardless if it's immediately infectious or soil transmitted.



4-ANCYLOSTOMA DUODENALE AND NECATOR AMERICANUS

(Human hookworms-intestinal nematode)

- Female hookworms (called so because they have hook like structures 'علاقات') are approximately 10 mm in length; males are slightly smaller and have a taxonomically characteristic copulatory bursa (**broadened posterior end**), which is used to mate with females. Females can release more than 10,000 eggs per day into the feces, where a **larva hatches from the egg (outside the body)** within a day or two.
- Life cycle: Eggs are oval 60x40 mm, they hatch in 48h to give the rhabditiform larva, after 2 days it moults to filariform **larva which is the infective stage that penetrate skin and mucous membranes.**
- ❖ The most important thing here is that these hookworms do not cause disease by ingestion of eggs. Rather, the disease is caused by the larvae **penetrating** the skin and the body by different and random routes. Infection caused by penetration mainly through **ankle and feet.**



Adult male and female worms of *A. duodenale*



Egg of *A. duodenale* in faecal smear

Pathology

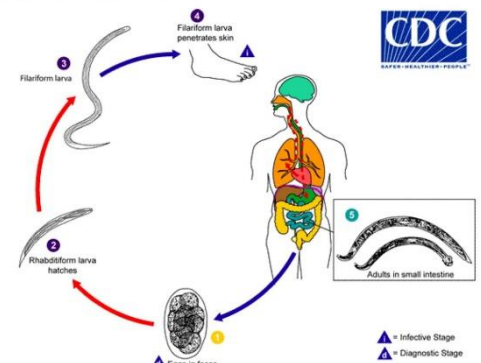
- Larvae can survive in moist soil for several weeks, waiting for an unsuspecting barefooted host to walk by. These larvae **penetrate host skin and migrate throughout the host** similarly to *Ascaris* and end up in the small intestine (reach by several routes) where they mature into adult worms.
- In the intestine, adult worms attach to intestinal villi with their buccal teeth (hooks) and feed on blood and tissue with the aid of anticoagulants (which lead to the presence of blood in stool and if the bleeding was severe, the patient will come with symptoms of anemia -chronic and excessive inflammation due to the fixed hooks ☹-)
- A few hundred worms in the intestine can cause **hookworm disease**, which is characterized by severe anemia and iron deficiency. Intestinal symptoms also include abdominal discomfort and diarrhea. The initial skin infection by the larvae causes a condition known as "**GROUND ITCH**," characterized by erythema and intense pruritus. Feet and ankles are common sites of infection due to exposure from walking **barefoot.**

***Important Notes:

1. Reaches by penetration not ingestion.
2. Hatches outside the body
3. Goes through the transpulmonary route.

Life Cycle

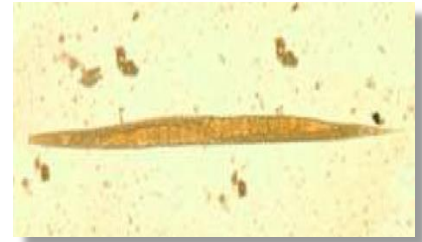
Intestinal Hookworm Infection



5-STRONGYLOIDES STERCORALIS

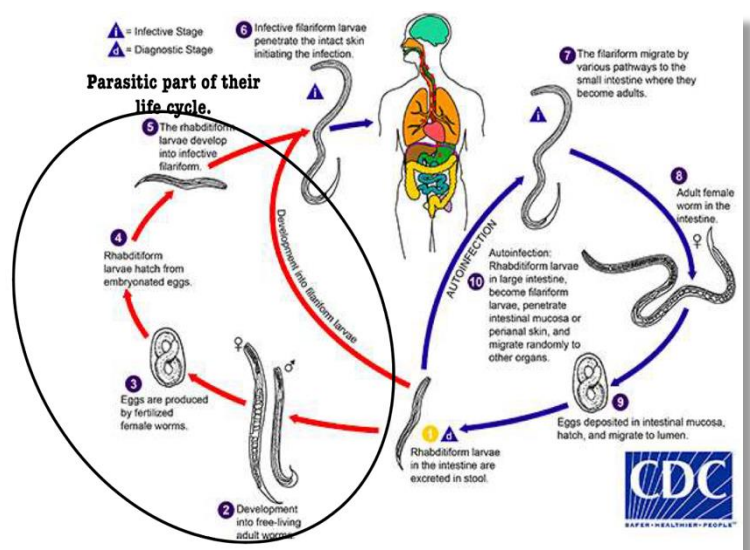
(Human threadworm— intestinal and tissue nematode) الدودة الخيطية

- Adult females (about 2 mm long) of *Strongyloides stercoralis* that inhabit the intestine are parthenogenic; that is, they do not need to mate with male worms to reproduce.
- Life Cycle: (They have 3 parts during their life cycle: 1. Auto infection 2. Parasitic 3. Free living). They lay eggs within the intestine; larvae hatch from the eggs and are passed into the feces. It also goes through transpulmonary route. These larvae can either develop into parasitic forms or develop into free-living male and female worms that mate and produce several generations of worm in the soil, a great example of an evolutionary adaptation to sustain a population. **The diagnostic stage is larvae.**



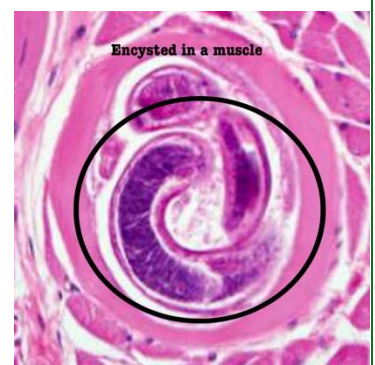
- (INTERNAL AUTO INFECTION): it's the only one that's able to complete its whole life cycle inside the body, the eggs of these thread worms hatch inside the body and stay there to complete their complex life cycle. No need for them to go outside of the body and this is different from other types of worms.

- **Parthenogenetic:** Type of asexual reproduction involving the development of eggs without any fertilization. Other organisms were obligated to exist outside the body in some of their life cycles.
- Larvae penetrate the skin then reach the intestine. (They could be ingested as well).



TRICHINELLA SPIRALIS (Intestinal and tissue nematode)

- The only **INTRACELLULAR** helminthic infection from the helminths that we've discussed. All of the helminths that we've explained were extracellular because they were macroscopic (large).
- These worms do not lay eggs, they put larvae directly then larvae undergo encystation. **كانها تلد ولا تضع بيوض**
- *Trichinella spiralis* is acquired by eating raw or improperly cooked pork infected with the larval stage of these nematodes. In the small intestine, the larvae molt into adult worms, and, after mating with male worms, **the female worms release live larvae. The larvae penetrate the intestine, circulate in the blood, and eventually encyst in muscle tissue (cardiac, skeletal, smooth and brain).**
- Adult female worms live for several weeks and after the first week of infection may cause diarrhea, abdominal pain (while in the intestines), and nausea. Intestinal symptoms are mild to none and often go unnoticed because they mainly encyst in muscles.



Tissue Nematodes

- Adults are parasite of the lymphatic system or connective tissue .they are filariform or thread like.
- Female lay larvae but not eggs. *Trichinella Spiralis*: تلد ولادة مثل
- Larvae require an intermediate host (a vector that bites) to complete development resulting in the production of the infective stage which is *Microfilaria* larvae.
- Prefer to exist in body cavities, lymphatic system and connective tissue.

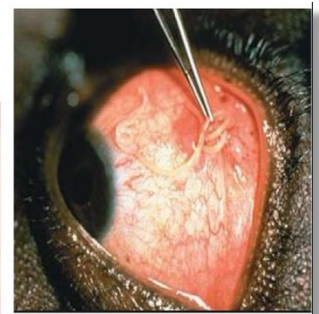
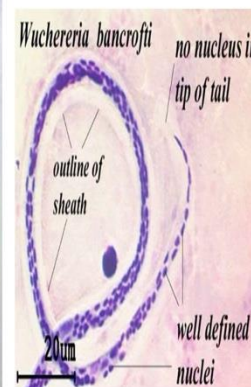
*Family Filariidae, members are :

- *Wuchereria bancrofti* (Mosquito)
- *Brugia malayi* (Mosquito)

-These two (*Wuchereria bancrofti* - *Brugia malayi*) cause **elephantiasis** (blockage of lymphatic circulation in one of the forelegs, so it has the morphology and texture of the elephant's leg) because they're parasites of the lymphatics.

- *Loa loa* (eye worm) (fly -genus *Chrysops*, day-biting flies)
- *Onchocerca volvulus* (River blindness) (black flies)

-These two (*Loa loa* and *Onchocerca volvulus*) cause **eye unilatera worm disease**.



Onchocerca volvulus



LYMPHATIC FILARIA

- Members to be found in lymphatics, body cavities and subcutaneous tissues.
- Progenies are embryos which are not fully developed (*microfilariae*), these are between eggs & larvae.
- *Microfilariae* require an intermediate host which sucks them . the infection is transmitted by mosquitoes.

- Elephantiasis; true elephantiasis is the result of parasitic infection caused by The filarid nematodes, *Wuchereria bancrofti*, *Brugia malayi*, and *Onchocerca volvulus*, are long, slender worms whose adult forms are found in tissues. The long thread like worms blocks the lymphatic system causing fluid to collect in tissues which lead to great swelling called "lymphedema". Limbs can swell so enormously that they resemble an elephant's foreleg in size texture and color.

We're DONE with Nematodes!!!

Platyhelminthis(flat worms)

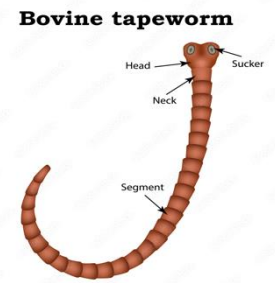
Platyhelminthes are flatworms that are dorsoventrally flattened in cross section and are hermaphroditic except Schistosomes which cause Bilharzia. They absorb, so they compete with the human system by absorbing not digesting!

All medically important species belong to two classes:

- ❖ **Cestoda (tapeworms)** الديدان الشريطية

Ribbon like, have 2 muscular suckers on their heads (scolex) and a neck. The rest of their bodies are segmented into structures known as **Proglottids**; these segments can be found in stool (which help in diagnosing).

- ❖ **Trematoda** leaf shaped with two muscular suckers. (**flukes**) either blood flukes, lung flukes or liver flukes (depending on where the adult lives).



Families: Fasciolidae, Heterophyidae and schistosomatidae(Bilharzidae)

~ The Trematodes: fertilization occur either cross between 2 worms or self fertilization (hermaphroditic).All trematodes undergo a complex asexual reproductive phase larval stage in a snail (their 1st intermediate host).eggs are oval, operculated, pass to fresh water, hatch and release a ciliated snail seeking the **1st larval form -meracedium-swims** to find its snail host and develops to the final larval stage **-cercariae (infective stage)-**these swarm out to penetrate a 2nd intermediate host and may encyst as **metacercariae (infective stage)**.

Intermediate hosts are snails.

Meracedium need 1 or 2 intermediate hosts before reaching the human.

After the first host it's called (**Cercariae**), after the second host it's called (**Metacercariae**). (Cercariae and Metacercarie) are the **infective stages** .


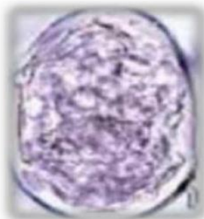

Hermaphroditus can be fertilized either by itself (has female and male organs), or by another male fertilizing the female by **cross fertilization**.

FASCILODAE

- Large sized trematodes in which the ventral sucker is near the anterior end.
- ❖ They usually require more than 1 intermediate host.
- ❖ They affect specific organs.
- Liver flukes:
 - CLONORCHIS SINENSIS (Chinese/oriental liver fluke)
 - FASCIOLA HEPATICA (Sheep liver fluke)
- Lung fluke:
 - PARAGONIMUS WESTERMANI (lung fluke)(causes paragonimiasis)

SCHISTOSOMA MANSONI, S JAPONICUM, AND S HAEMATOBIMUM (BLOOD FLUKES)

- The adult worms are long and slender (males are 6-12 mm in length; females are 7-17 mm in length) and can live for 10-20 years within the venous system.
- ❖ Mechanism of infection to human: penetration
- ❖ Note: S. haematobium is the major agent of schistosomiasis or bilharzi, it causes granulomatous reaction which leads to fibrosis that causes metaplasia which may ultimately lead to urinary cancer. معلومة عالهامش: كانت هي السبب بوفاة عبد الحليم حافظ
- ❖ Sianatotim intermediate is bulinus snail
- ❖ Diagnostic stage: eggs

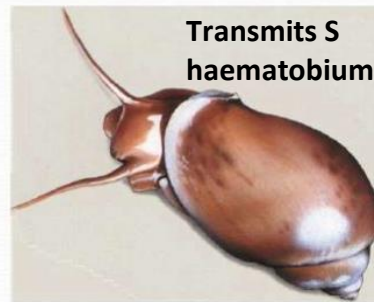
<u>S. mansoni</u>	<u>S. japonicum</u>	<u>S. haematobium</u>
<i>inferior mesenteric veins of large intestine</i>	<i>inferior and superior mesenteric veins of small intestine</i>	<i>veins of urinary bladder</i>
fresh water <i>snails of <u>Biomphalaria alexandrina</u> are important hosts</i>	fresh water <i>snails of the <u>oncomelania</u> genus are important host</i>	fresh water <i>snails of the <u>bulinus truncatus</u> are an important hosts</i>
It has round eggs with <u>lateral spine (very important)</u>	Egg has a small <u>curved rudimentary spine</u>	Egg has a <u>terminal spine</u>
		

Schistosomiasis pathology

- The most significant pathology is associated with the schistosome **eggs, not the adult worms**. Female schistosomes can lay hundreds or thousands of eggs per day within the venous system. When eggs are released, many are swept back into the circulation and lodge in the liver (*S mansoni* and *S japonicum*) or urinary bladder (*S haematobium*), while other eggs are able to reach the lumen of the intestine and pass out with the feces or urine.
- A granulomatous reaction surrounds the eggs and leads to fibrosis of the liver with *S mansoni* and *japonicum*. In chronic cases, blood flow to the liver is impeded, which leads to portal hypertension, accumulation of ascites in the abdominal cavity, hepatosplenomegaly, and esophageal varices.
- With *Shaematobium* infections, there is urinary tract involvement: urethral pain, increased urinary frequency, dysuria, hematuria, and bladder obstruction leading to secondary bacterial infections.



Biomphalaria



Transmits *S haematobium*

Bulinus

Cestoda (Tapeworms)

- Flat-ribbon like chain of segments with no mouth or digestive tract, adult worms are hermaphroditic, have complex life cycle and human acquire infection by eating infected flesh.
- The segments may be seen with the patient feces (diagnostic structures).
- Proglottids that are nearest to the head are immature.
- The furthest are the mature ones which may fall down with feces.

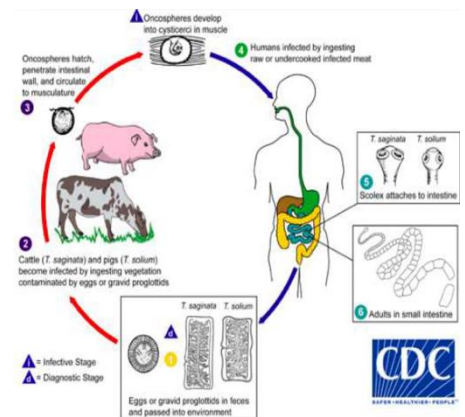
3 groups infect humans:

- *Taenia*
- **ECHINOCOCCUS GRANULOSUS**
- *Diphyllobothrium latum*

A) TAENIA SAGINATA (BEEF TAPEWORM)

- Worldwide, acquired by ingestion of contaminated, undercooked beef (containing larvae) (cysticercus), a common infection but causes minimal symptoms. Intermediate host is Cattle.

- It is about 6-7 mm in width. The adult *T.saginata* usually grows to be about 4-8 m in length with about 1000 segments called proglottids. It cause Teniasis (benign).
 - Diagnostic stage: ribbon like segments or eggs.



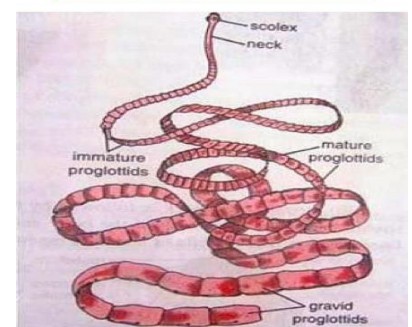
B) Taenia solium (pork tapeworm)

- Morphologically similar to *T.saginata*, *Taenia solium* is slightly shorter and have a modified scolex. the adult tapeworm grows to be about 6mm in width and 2-7 meter in length with about 800 proglottids.

- Cysticercosis is the presence of larval stage (*cysticercus cellulosae*) in human tissue . It is a systemic disease where cysticerci encyst in muscle and in the brain, may lead to epilepsy.

-Usually patient eats contaminated beef that has encystated larvae , but if the patient eats the egg directly, the larva will do encystation inside his **brain** causing **neurocysticercosis(that happens with taenia solium especially)**.

- The human is called the **definitive host** (remember: Sexual multiplication, forms adult worms)



when he eats the contaminated beef (**larvae**) and that cause teniasis (benign disease).

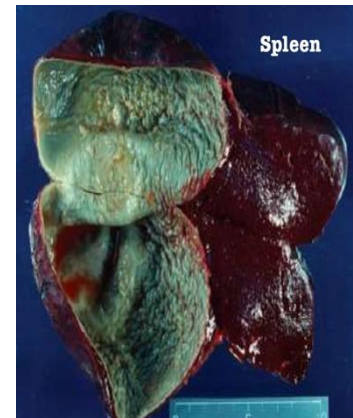
- The human is called the **intermediate host** when he eats the eggs directly (because the **immature** stage is happening inside him), and that caused **neurocysticercosis** (more serious).

ECHINOCOCCUS GRANULOSUS (Hydatid cyst)

- Echinococcus granulosus is a small, **three-segmented** tapeworm found only in the intestine of dogs (the definitive host) and other canids. But has important intermediate host such as live stock and humans.

Where it causes hydatid cyst.

- The adult tapeworm is about 5mm .
- In humans, cysts containing the larvae develops after ingestion of eggs .Cysts forms primarily in the liver and the lung (hydatid cyst).
- Infective stage: (**protoscolices**) → very infectious.
- Teated by surgery, although it's very dangerous because cysts are in sacs and when trying to remove these sacs they may rupture and cysts will leak into the abdominal cavity which causes an anaphylactic shock which leads to death.



DIPHYLLOBOTHRIMUM LATUM (Broad fish tapeworm —intestinal cestode)

- Diphyllobothrium latum, the broad fish tapeworm of humans (and many other fish-eating animals), reaches enormous size, sometimes exceeding 10 m in length (the longest one).
- Humans acquire the infection when they eat improperly cooked or raw fish that is infected with the larvae known as plerocercoids, which look like white grains of rice in the fish flesh.

- ❖ Human is the definitive host when he ingests larvae, but an intermediate host when he ingests eggs.
- ❖ Requires 2 intermediate hosts.



- In the intestine, the worm rapidly grows and develops a chain of segments capable of releasing more than 1 million eggs per day.
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 - ❖ Note that (*Taenia saginata*, *Taenia solium*, *DIPHYLLOBOTHRIUM LATUM*) doesn't cause a big problem when the human is the definitive host.
 - ❖ The problem happens when the human is the intermediate host!

THE END

V2 : Slide 9

Larvae penetrate the skin then reach the intestine. (They could be ingested as well.)

instead of

are ingested

Slide 8: the picture at the end of the slide