Digestive System

University of Jordan

Faculty of Medicine

Batch of 2013-2019

Medical Committee
The University of Jordan

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☐ Anatomy ☐ Embryology

☐ Physiology ☐ Histology

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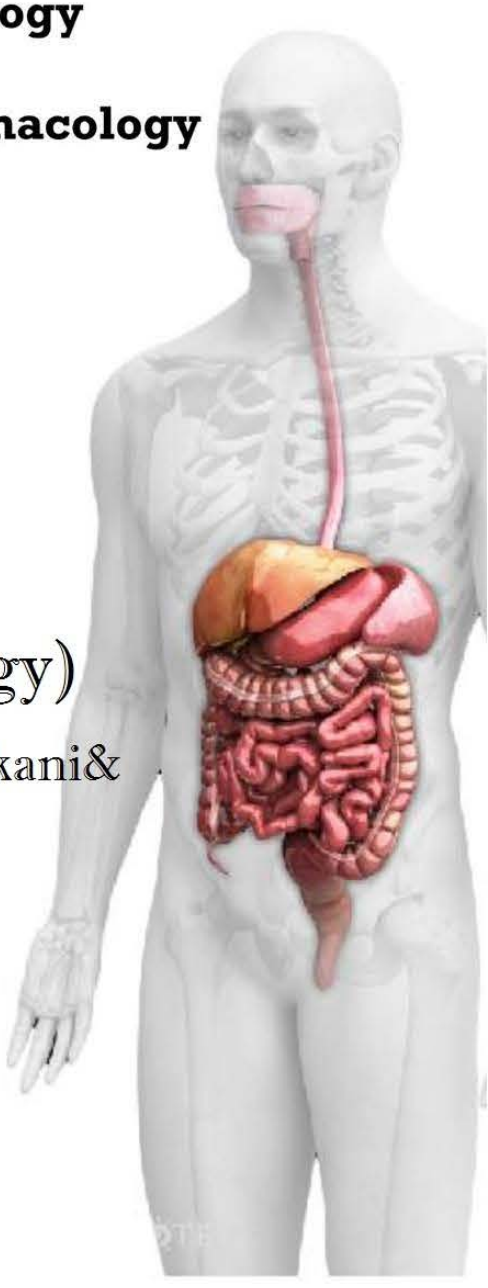

Sheet #: 5 (3-parasitology)

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Cestodes & Trematodes

In the past 2 lectures we discussed the parasites that infect the gastrointestinal tract and belong to the two groups; protozoa and nematodes. This lecture will carry on with the parasitology of the gastrointestinal tract, and will discuss both the cestodes, and trematodes – which belong to the family of flatworms. (Record = Section #2)

Taenia solium & Taenia saginata

The two most commonly encountered cestodes are the tapeworms known as *Taenia solium* and *Taenia saginata*. These two parasites vary in a few points. First of all, the intermediate hosts of the two parasites differ; in *Taenia solium* the intermediate host is the pig, while in *Taenia saginata* the intermediate host is usually cattle.

It is important to be able to differentiate morphologically between these two parasites:

When looking at the scolex of the worms, we notice that they both have 4 suckers, however *Taenia saginata* does not have a rostellum, while *Taenia solium* does. *Saginatum* is actually longer than *solium*, as it measures anywhere between 4-6 meters, while *solium* measures around 2-4 meters in length.

The eggs of the two parasites are exactly the same, and this is common to us, as we already said last semester that the majority of tapeworms have a similar morphology in their egg-form. This morphology is exhibited by a striated border, along with a hexacanth in the middle which contains the 6 hooks. And since their eggs are identical, they do not help us in distinguishing between the two.

When we come to the proglottids, there are differences, for example when we look to the mature proglottid, the proglottid of *Taenia saginata* tends to appear square-like in

shape, while the proglottid of *Taenia solium* is more extended to form a rectangular shape. If we look at the genital apparatus, we notice that *solium* has three ovaries, while *saginata* only has 2.

In the gravid proglottids, we can tell there is a difference by counting the number of lateral branches of the uterus; for example in the *solium* the number of lateral branches is around 7-15 branches, meanwhile that of the *saginata* is usually doubled (15-30 branches on each side of the uterus).

Solium usually has around 1,000 proglottids, while *saginata* can have 2,000 or more.

check the handout #3 for the images of proglottids and their comparison

Life Cycle:

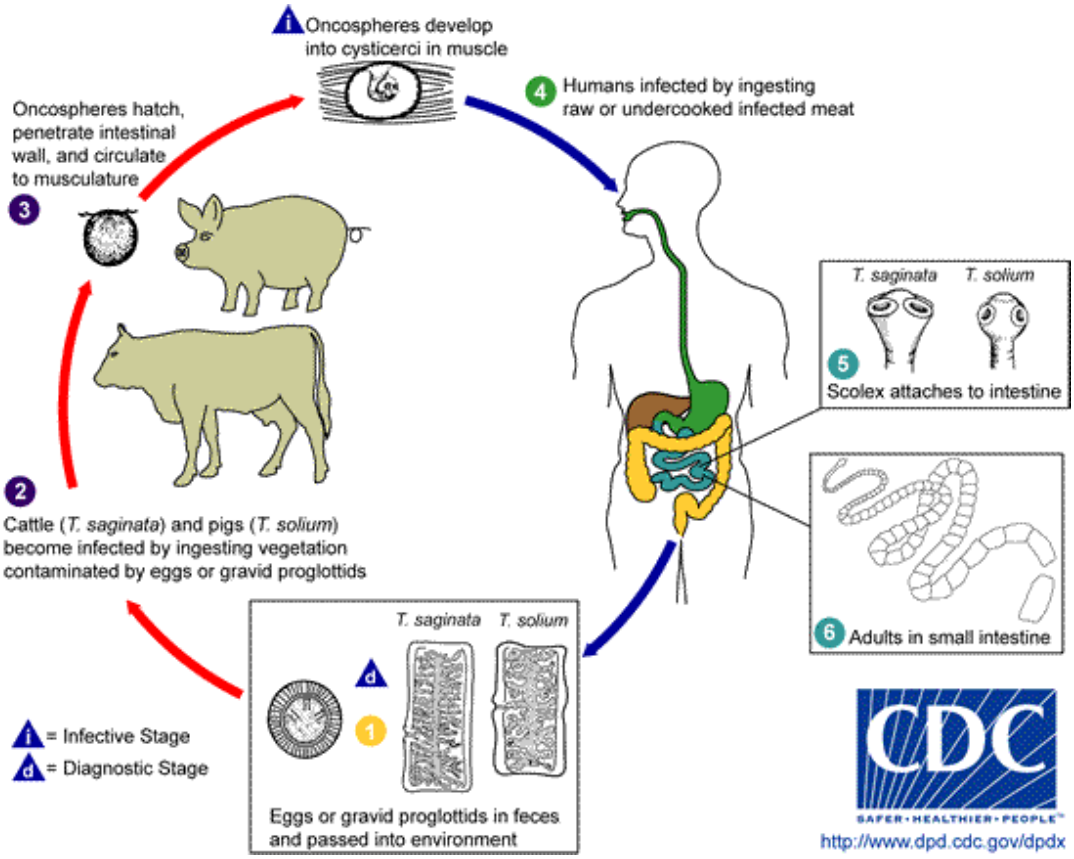
These two *Taenia* worms live in the small intestine of the human and are attached to the mucosa by means of the scolex. When the worm releases its gravid proglottids inside the lumen of the intestine, which soon exit the body along with the faeces, these proglottids disintegrate and release the eggs. These eggs then get passed onto the environment and remain in the soil, and can persist for some time before they are ingested by the intermediate host; whether it is pig (*solium*), or cattle (*saginata).* In the lumen of small intestine of the intermediate host, the **oncosphere** of the hexacanth which is embedded inside the egg is then released. (web: the oncosphere is the larval form of tapeworms once they have been ingested by an intermediate animal host)

The hooks of this oncosphere then attach to the walls of the small intestine, and soon the oncosphere penetrates through the wall of the intestine and passes into the lymphatics and the circulation. From there, it will then be distributed to all tissues of the body; namely the muscles, internal organs…etc. And wherever this oncosphere settles and ends up, it will then be converted into a **cysticercus**; which is a balloon like structure filled with clear fluid and inside it there is an invagination of something that looks like a scolex, however it is a rudimentary one**.**

This cysticercus remains dormant in the different tissues of the intermediate host, until it is eaten by the primary host (humans). Cooking the meat at high temperatures destroys the cysticerci, and freezing it below -21°C for a few days has the same effect. Thus in order for them to be transmitted to the primary host, the meat must be fresh and raw (undercooked).

So after a human (primary host) eats raw, undercooked meat which contains live cysticerci, these cysticerci will reach the small intestine, and the rudimentary scolex will now become active and will evaginate from the wall, attaching to the mucosa of the small intestine and holding itself in place. This attachment is followed by a sequence of events whereby the cysticerci begins to grow into a full grown adult worm.

The following graph helps give a short summary of the life cycle of the two *Taenia* worms: (if not clear, check the one in the handout #3)



The life span of these worms is actually quite a prolonged one, as these worms may live inside the human body for as long as 15-20 years. Furthermore, we usually only find one of these worms at a certain time inside the GI tract of the human, especially with *solium* since the word solium actually means 'single' or 'one', however in rare cases we may find up to a maximum of 2 to 3 worms living in the GI tract simultaneously. Very rarely some patients may experience intestinal obstruction due to the entanglement of these worms with one another.

Diagnosis:

Primary diagnosis of these *Taenia* worms can be by the individual himself, by finding the active, motile proglottids passed out with the faeces. To confirm the diagnosis, the doctor can examine for the presence of proglottids or eggs (rarely) in the faeces.

One thing to remember about *solium* is that there are some complications, other than just the presence of the worm inside your intestines. In *Taenia solium* infections there is a possibility that the human may become an intermediate host. Normally in *Taenia* infections the pig/cattle is the intermediate host, and the human is the primary host. However, specifically in *solium*, humans can become an intermediate host (i.e they can replace the pig). How does this happen? By the direct ingestion of eggs which had erupted from the proglottids, similar to the way in which the pigs had become an intermediate host. So the eggs will reach the small intestine, releasing their hexacanth, this hexacanth will then interact in the lumen of the small intestine, permeating the wall, entering the circulation, and eventually spreading all over the body in the muscles, brain, and all other organs. It will eventually change into cysticerci, which remain dormant in the human body tissues or the lumen and begin to initiate inflammatory responses leading to pathology.

This could actually be an indication that the tissues of the human are somewhat similar to those of the pig, allowing the hexacanth to develop in to the cysticerci and continuing its life cycle.

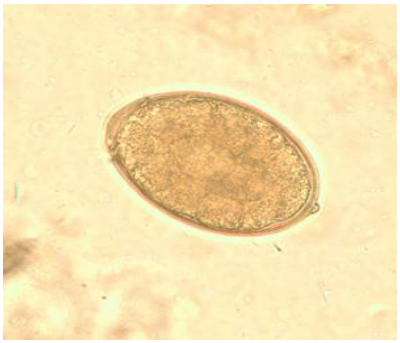
So now the problem is, you're actually a **dead end** intermediate host. So there's no fear of you transmitting the infection to somebody else unless we are dealing with cannibals; because no one is going to eat you if you have cysticerci in your flesh. But the problem is actually in the fact that these cysticerci settle in the muscles and in the human brain and may lead to epilepsy, and focal, motor and sensory deficits. Sometimes they may even settle in the retina of the eye and can elicit blindness or partial blindness. This disease entity is known as **cysticercosis**, and it occurs quite a lot in areas that are endemic to *Taenia solium* infections.

In Jordan there is no fear of *Taenia solium* because it barely exists here, however we do have cases of *Taenia saginata*. It is more likely that countries with lots of pigs, like European countries, will have more prominent cases of *Taenia solium*.

Keep in mind that epilepsy usually arises in humans at younger ages. So if an adult comes to you and says he experienced his first-ever bout of epileptic seizures, then you should keep *Taenia* infections in your mind as part of differential diagnosis.

Diphyllobothrium latum

Also known as the fish tapeworm. 'Bothrium' refers to sucker, 'latum' means flat. These worms actually have 2 suckers rather than the standard 4 in the majority of other cestodes. The scolex of this worm is elongated and it has two longitudinal sucking discs or sucktorial grooves on each side. From the neck to the end, proglottids prevail. This worm is the largest worm measuring around 10 meters – can be considered the 'giant' worm, and they contain 3,000 or more proglottids.



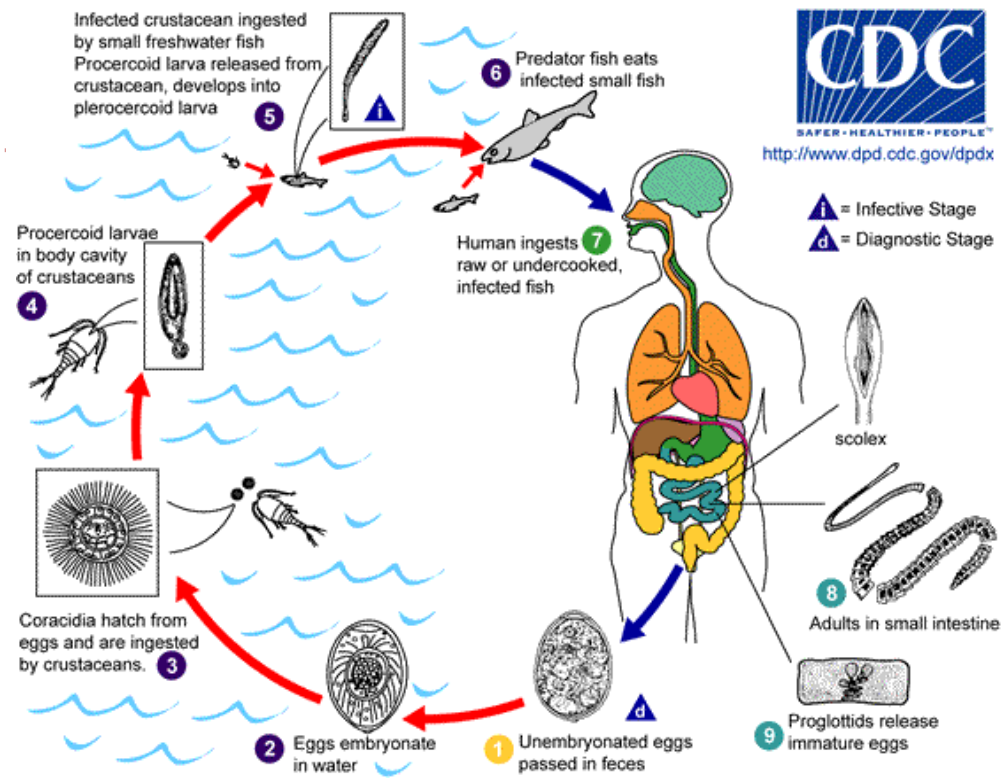
Another difference that separates this type of worm from the other two previously mentioned ones is the egg. We said normally the egg is characterized by a striated border and a hexacanth in the middle, however here we have an egg which is similar to those of trematodes; i.e. it is large, oval, and contains an **operculum**.

So this worm is named the fish tapeworm pertaining to the fish which hosts it as an intermediate host.

Life Cycle:

So the egg is released into the water, the operculum then opens up releasing the embryo, and this embryo, unlike the hexacanth seen previously, doesn't have any hooks because it doesn't actually need to attach to anything. On the contrary, it has **cilia**, which aid in its movement through the water medium, and these embryos are called coracidia (plural) or coracidium (singular). These ciliated coracidia leave the eggs, go into the water, and swim around for a while until they get ingested by certain crustaceans, which are considered the **1st intermediate hosts**. These crustaceans are usually copepods or cyclopses (different species). This coracidium then develops inside the first intermediate host until these hosts are eaten by the **2nd intermediate hosts** which are the fish. The coracidium will then migrate to the different tissues of the fish, and ultimately end up in humans upon ingestion of these coracidia when we eat fish. And once these coracidia end up in the human, they develop into the full grown adult worm and hence cause infection.

Check the below graph for a summary:



Now if the fish is cooked properly, then the coracidia will be destroyed and the person won't be infected, however if for some reason it wasn't fully cooked, or if the person ate raw fish, then the coracidia will still be active and will thus infest the different tissues of the body. Scandinavian countries (Northern Europe) like to eat raw fish, or pickled fish which has not been cooked, and so they can easily pick up these infections.

Diphyllobothrium latum lives in the small intestines of the human, but sometimes because of its length and size, it can affect the levels of vitamin B12 in the person's body. If the worm persists for a long time in the intestine of the human it can deplete all the vitamin B12 and affect any absorption of it from the gut, and hence lead to macrocytic / megaloblastic anaemia. Furthermore, since it is so long (10m) in comparison to the length of the average human's small intestine (6m), the worm may actually entangle around itself, and cause intestinal obstruction, with vague abdominal pain / malaise (discomfort).

Diagnosis:

We can diagnose this worm by examination of the faeces for the presence of the proglottids and the characteristic eggs.

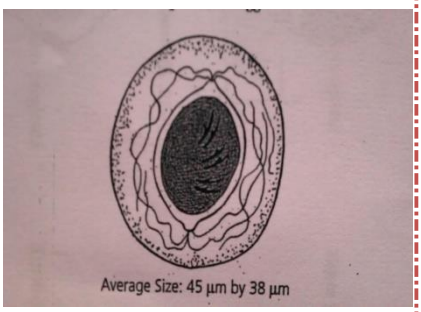
Hymenolepis nana

This is the smallest human tapeworm, it only measures about 2cm in length, and the number of proglottids is usually about 200, no more. (nana = greek for nanos = dwarf, indicating it's relatively small size)

It doesn't have a very long life span, unlike the *Taenia* which we said can live for up to 15-20 or maybe even 25 years, this worm can only live up to a few months or a few years maximum.

It usually has 4 suckers, it has a rostellum which is usually retractable, and it can actually come in and out of the rostellum.

The egg is different from the uniform origin of *Taenia* eggs and is characteristic of this species of flatworm. It has 2 membranes, with an outer and an inner one, the inner membrane has 2 thickenings on either of its ends known as **polar thickenings**, and from these thickenings project **polar filaments**. And within these 2 membranes, in the centre of the egg, you have the hexacanth. So really this is a distinctive egg of the species of this worm which helps us in diagnosis and distinguishing it from *Taenia* worms.



The worm lives in the small intestine, and the exception about *Hymenolepis nana* is that it requires no intermediate host – we said last semester that all cestodes require an intermediate host EXCEPT one worm, and this is that worm! :D

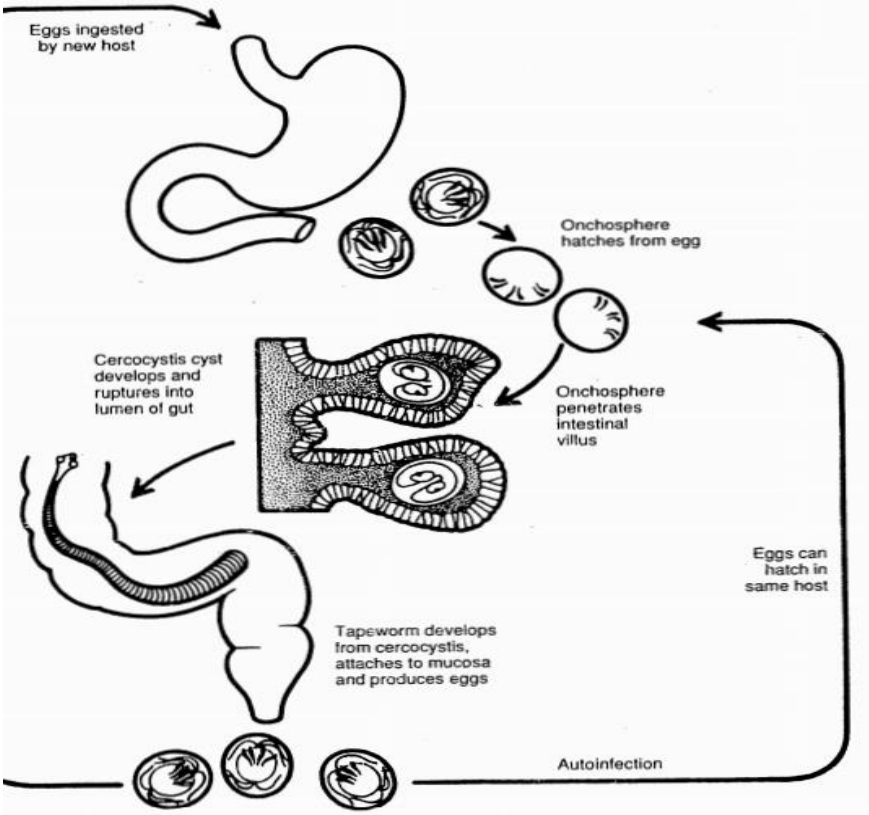
Life Cycle:

So the eggs are released in the intestine, and they come out in the faeces. They are then ingested by someone else directly from the faeces – by now you should be able to deduce that since its direct contact with faeces, obviously it is going to be an infection prominent in young children. Furthermore, these eggs cannot live for a long period outside the body. Once this egg has been ingested, it goes to the small intestine of the new host; it releases the hexacanth, which penetrates into the villus and matures inside of it, until it is transformed into a new worm, and then exits into the lumen of the small intestine.

Since the villi harbour the hexacanth and allow it to grow, some may consider the villi themselves as the intermediate host in this case. However it is essential to remember that no other creature or animal is involved other than the human being himself and the other human beings who are eligible to catch the infection by direct, close feco-oral contact.

Sometimes the eggs don't come out with the faeces and instead hatch inside of the small intestine releasing the hexacanths and producing more of the worms and further infection in the SAME individual; this is called **auto-infection**. This auto-infection can lead to an accumulation of hundreds of worms in the gut, however since they are only small in size, they rarely cause intestinal obstruction like the other cestodes, so the presence of the worm is not necessarily causing problem but IF they did accumulate to extreme levels, they may cause enteritis and may actually be associated with death.

The following graph shows the life cycle of *Hymenolepis nana* directly from the handout ☺ :



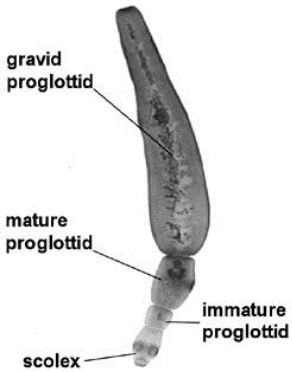
Diagnosis:

We usually diagnose this worm by examining the faeces for the characteristic eggs which were explained earlier (characterized by polar thickenings and polar filaments).

Echinococcus granulosus

It is a **tape worm** of canine animals such as dogs, foxes & wolves, they are considered as primary hosts for this worm and the intermediate host can usually be an herbivore (sheep, cattle or a goat) and occasionally human beings "**Never a primary host**".

Its length is about 9mm or a centimeter considered as small worm and consist of 3 proglottids: immature, mature & gravid. On its scolex (head) you can find **4 suckers and a rostellum** as a usual structure of scolex of a tape worm. The egg is typical an outer striated wall containing hexacanth in the tip. Tape worms when in the intermediate host usually form a morphology called cysticercus (invaginated rudimentary scolex) but in this case it's going to be just a rounded **cyst**.



Life cycle of the worm: as we said the primary host is the dog so the worm is present in the lumen of small intestine of the dog and produce these proglottids and eggs, the eggs are exectered with the feces > contaminate the grass > herbivores eat the grass > hexacanth comes from the egg penetrating the wall of small intestine > get distributed all over the tissues of the intermediate host and wherever it settles it will produce a cyst that stays there until its eaten by a primary host, like when a dog eats the offal "مصارين و معلاق" of the sheep that contain cysts thus the **dog** will acquire the **adult worms**.

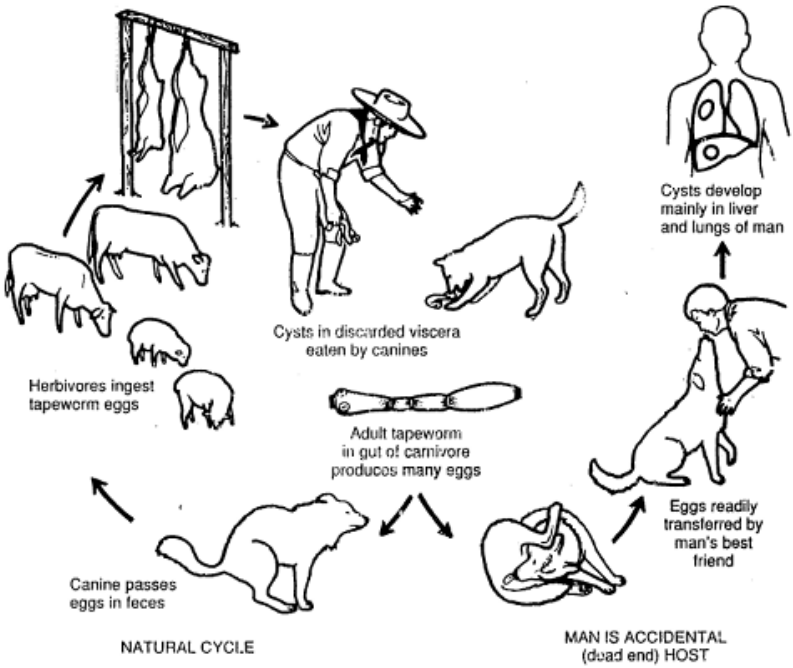


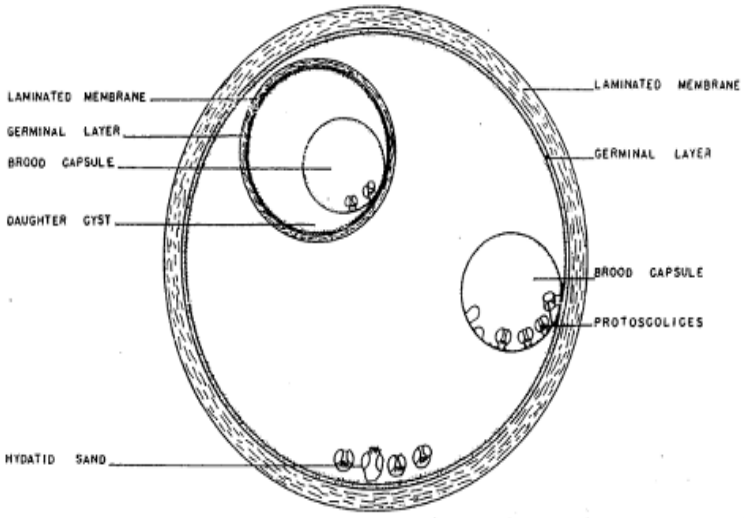
Figure 10–3. Life cycle of *Echinococcus granulosus*.

We "human beings" as **dead end intermediate hosts**, can get the cysts by ingesting the herbivore or eating something that has been contaminated by the dog's feces who has been infected or even through close contact with the dog " its tail or mouth" carrying the cysts, this cycle keeps going and shepherds "رعاة الغنم" are the most contaminated people by this. Eating uncooked sheep will not cause infection to humans because it can't develop in the small intestine and humans can't be a primary host.

Echinococcus granulosus causes hydatid cyst disease, as of the anatomy of **the hydatid Cyst** we can observe a **multilayer membrane** consisting of two membranes

1- **Outer**: aceullular laminated hyaline membrane
2- **Inside**: germinal layer made out of cells

Within the cyst we have yellowish clear fluid and the diameter of the cyst is about 1-2 cm, the germinal epithelium layer can give out new daughter cysts inside the original mother cysts and the daughter cysts can give out grand-daughter cysts causing the original cysts to get bigger and reach about 10-12cm in diameter giving it a neoplastic tumor look in the organ. Eventually we will get rounded structures "inside the original cyst" only having germinal epithelium without the laminar layer and we call them **brood capsules** and from these capsules we will get budding of small structures looking like scolex "but not as developed" and we call them **protoscolex** "primary scolex" containing suckers and beginning of rostellum. The protoscolices under the microscope looks like **grains of sand** (thus they're called hydatid sands) inside the hydatid cyst.



When this hydatid cysts bursts, it releases its fluid and contents of protoscolices which scatter and settle in tissues to produce new cysts giving it a **metastatic nature** like a tumor.

*Note: Hydatid cysts share some features of neoplastic tumors such as getting bigger and metastasizing in the tissues of the body but without being cancerous.

These cysts usually metastasize from GIT to **liver** (most common), **lungs** (2nd most common) and we may also find them in kidneys, bones, brain and skin.

Upon bursting of the cyst, it releases huge amount of antigens into the circulation which causes **anaphylactic shock** (an allergic systemic rxn that can lead to death).

Diagnosis: clinical presentation, CT scan, Ultrasound, X-ray and **cassoni test** which is a hypersensitivity skin test towards the E.granulosus antigen given as injection under the skin and we wait for 15-20min. If there's inflammatory rxn at the site of injection manifested by redness and swelling → positive test. It gives us 80% true positive test when inflammation happens, 100% negative when there is no inflammatory rxn.
The problem is that the test gives only (80% true positive) meaning that 80% of positive patients actually have the cysts in them and the other 20% false positive.

Treatment: we can give a drug but the treatment is usually by a surgical procedure to remove the cyst delicately and intact to avoid its rupture and spillage of its content that causes anaphylactic shock and dissemination in the adjacent tissues.

Trematodes (flukes)

Now in our last topic we are going to talk about Trematodes which are divided into many categories but we will consider intestinal, liver and pulmonary flukes.

Life cycle: We are familiar with the stages of the life cycle of the trematodes, as it goes something like this … Eggs (from urine/ sputum/ feces) discharged in open fresh water) > releases ciliated miracidium > enters a snail > become sporocyst/rediae > pass out of the snail as cercaria > either penetrate the skin of the host (as schistosoma) or encyst in an aquatic plant/fish and get ingested by the primary host as metacercaria (as the following flukes).

A- **Fasciolopsis buski**: a fluke that lives in the lumen of small intestine causing obstruction of the intestine, abdominal pain and may perforate the wall of the intestine.

In the next two flukes, the larvae can penetrate the wall of the intestines and reach either the liver or penetrate the diaphragm to reach the lungs

B- **Fasciola hepatica**: a fluke that affects the liver, living in the biliary passage of the liver causing jaundice, blockage of common bile duct, pancreatitis and enlarged tinder liver.

C- **Paragonimus westermani**: a fluke that lives in the lungs, causes coughing of blood (Hemoptysis) which is associated also with cancer and tuberculosis of the lung. This trematode has an alternative lifecycle where the eggs that are in the sputum are swallowed again into GIT and passes down the feces into water and contaminate crabs (2nd intermediate host) and we may eat raw crab and become infected.

Diagnosis: In all of them, the eggs can be found in the feces but in westermani we can also find the eggs in the sputum as it comes from mucous of the lungs.

* We recommend checking out the handout for some figures of lifecycles and images of worms, eggs & cysts that may come in the practical exam. *

ختامها مسك ان شاءالله☺

Quotes than can make u conquer the day:

-Nothing will work unless you do.

-The secret of getting ahead is getting started.

-You've got to get up every morning with determination if you're going to go to bed with satisfaction.

-Winners never quit and quitters never win.

-Will it be easy ? NOPE ... Will it be worth it ? ABSOLUTELY.

-Well done is better than well said.

To make this less time & paper consuming – Dedications to everyone we know! :D
(special dedication to Tariq and Q)