NATIONAL OPEN UNIVERSITY OF NIGERIA

# NSC 106

## Medical Mircobiology and Parasitology

## Module 6

# NSC 106 (Medical Microbiology and Parasitology) Module 6

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# Module 6: Introduction

The cestodes consist of two separate subclasses, the Cestodarians, parasites of fish and other cold blooded vertebrates. These are non-segmented parasites, with only a single set of sexual organs. In contrast, the more well-known members of the Subclass Eucestoda are parasites of both warm and cold blooded vertebrates, including mammals such as man. The module has three units and deals with basic body plan of a cestode, tapeworms and examples and tapeworms of man and other human's cestodes

## Objective

At the end of this module, you should be able to:

- describe tapeworms of man and other human cestodes.

# Unit 1 Basic Body Plan of a Cestode

## 1.0 Introduction

Cestodes resemble a colony of individual animals in that their bodies are divided into a series of segments (the proglotids), each with their own complete set of internal organs. There may be many hundreds of these proglotids, resulting in the complete parasite having a long, ribbon-like body. The appearance of this long body is the origin for the common name for these parasites, the tapeworms. The common names of these parasites are often derived from their intermediate hosts, ingestion of which results in their infection, e.g. the Fish, Beef and Pork Tapeworms. Alternatively, they may be named after the definitive hosts that the adult parasites are normally found in examples are the rat tapeworm H. diminuta and the dog tapeworm Dipylidium caninum. The study of the morphology of the cestode body may be divided into two distinct areas.

Firstly, the morphology of the adult cestode (the tapeworm) and secondly the morphology of the cestode larvae, or metacestode.

## 2.0 Objectives

At the end of this unit, you should be able to:

- identify the striking features of cestodes
- describe the egg, larva and adult stage morphology of common cestodes.

# 3.0 Main Content

## 3.1 The Adult Parasite

The body of the adult tapeworm may be divided into three regions.

**The Scolex**
This is the "head" and attachment organ of the parasite. There are four main types of scolex, by which the tapeworm may be taxonomically classified.

**No special attachment organs**
The scolices of some tapeworms of the order Caryophyllidea (parasites of freshwater fish) have no special attachment organs. (NB. Some authors do not recognise this taxonomic order, placing these parasites within the Pseudophyllidea).

**A Bothria**
This is composed of a pair of shallow, elongated, weakly muscular grooves. Tapeworms of the order Pseudophyllidea are equipped with bothria on their scolices.

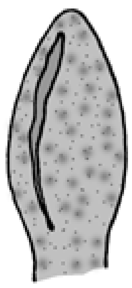

Fig. 1: The bothria of Pseudophyllidea

**A Bothridia**
These are broad, leaflike muscular structure, exhibiting a large degree of variation. Some bothridia are sessile, some are stalked, whilst others are hooked with accessory suckers. Tapeworms of the order Tetraphyllidea and others are equipped with bothridia.

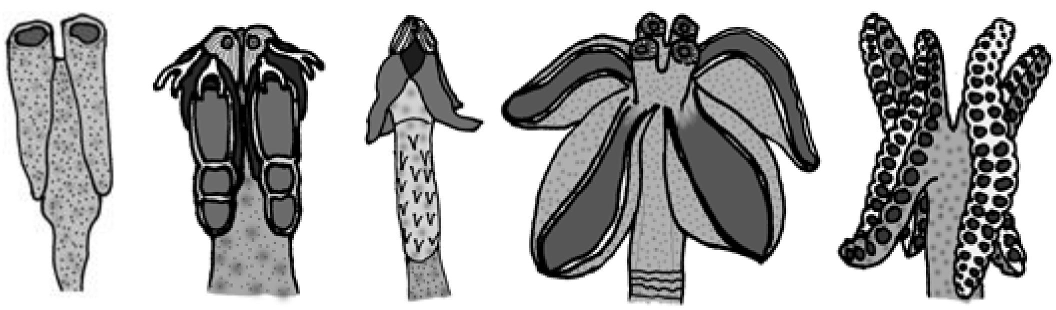

*Fig. 2:*

**Acetabulate Suckers**
Tapeworms of the order cyclophyllidea are equipped with four acetabulate suckers. Parasites in this order may also have additional features at the apex of the scolex such as;

- Glandular areas
- Protrusible suckers
- Suckers armed with hooks
- Hooks (e.g. Taenia)
- A rostellum, an eversible muscular proboscide, often covered with hooks

  (e.g. Hymenolepis, Echinococcus, and Dipylidium)
- A Myzorhynchus (a protrusible muscular mass).

**The Neck**
This is the area of proliferation of the parasite, from which the proglottids of the strobila grow.

**The Strobila**
This is composed of a series of proglottids. Each proglottid contains a complete set of male and female reproductive organs, although these organs usually mature at different rates. Usually the male organs develop before the female organs, and degenerate before the female organs mature. The large, gravid proglottids at the posterior end of the tapeworm are full of developing, or in the extreme terminal proglottids, mature eggs.

## 3.2 The Cestode Tegument

The related cestodarians that also belong within the cestodes, have a tegument that appears to be intermediate with that of the eucestodes and monogeneans. This is another piece of evolutionary evidence that indicates a monogenean origin for the tapeworms. In this case the surface of the cestodarian tegument is covered with numerous microvilli, similar in form to the eucestode microtriche (see below), but lacking the electron dense cap seen in these parasites.

The cesode tegument is a syncytial layer, showing many features typical of that found in other parasitic platyhelminthes.

*Fig. 3: Diagram Showing Eucestode Tegument*

There are however, a number of distinguishing features present in these parasites. On the very outer surface of the tegument a surface glycocalyx is seen to cover the outer plasma membrane. Below this glycocalyx, a characteristic feature of the eucestode tegument is the presence of numerous microtriches (Mt), long spine like processes that are in fact a highly modified form of micovilli. Each microthrix has a hard, pointed, electron dense cap which is seperated from the rest of the microthrix by a crescent shaped membranous cap. The mirotriches are thought to serve two functions.

Firstly, the tapeworms do not possess a gut and must absorb all of their nutrients across the surface tegument. The microtiches greatly increase the surface area of the parasite, and can be seen as an adaptation to maximise the amounts of nutrients available to the parasite. This is supported by the finding of microtubles in the shaft of the microtriches. Secondly, the Spine like character of the microtriches probably helps the parasite maintain its position in the gut. This can be more clearly seen by comparing the microtriches found in different regions of the parasite's body. It has been noted in many species that the microtriches found covering the scolex, the attachment organ of the parasite, were much longer than those covering the strobila, and in some species show special adaptations.

For example the microtriches covering the strobila of E. granulosus have been found to show curved hooks or sometimes even barbs. Below the layer of microtriches the main syncytial layer of the tegument is found. This has been seen to contain numerous vesicles and membrane bound, electron dense rod-like structures, refered to as disc-shaped bodies (Db).

Finally, numerous mitochondria, mainly in the distal region of the tegument, may be seen. These are unusual in that they do not have many cristae, reflecting the anaerobic metabolism of the organism. The tegumental nuclei are however not located in this outer layer, but are found within subtegumental cell bodies (StC), located beneath the circular (Cm) and longitudinal muscle (Lm) layers, embedded within the parenchymal tissues (P) and mesenchymal musculature (M). These subtegumental cell bodies also contain other cellular elements such as golgi apparatus and lipid inclusion bodies (L) which are connected to the outer syncytium and areas of glycogen storage (Gs) by long protoplasmic extensions (Pe). The location of these important cellular elements away from the outer surface of the parasite, exposed to immunological attack by the parasites host, is an important adaptation to a parasitic lifecycle adopted by all of the parasitic platyhelminthes.

The parenchymal tissues are similar to those of the trematodes and fill the spaces between the parasites internal organs (all cestodes and other platyhelminthes being acoelomate organisms). These tissues are a syncytial network formed by anastomosis of mesenchymal cells, with spaces filled with carbohydrate rich parenchymal fluid.

## 3.3 Larval Metacercaria

The Larval Cestodes

**The Cestodarians**
The cestodarians larvae or lycophore are free swimming, being covered in cillia. They have a set of ten hooks at the extreme anterior of the body, thus differing from the larval eucestodes, which are equiped with 3 pairs of hooks. Anteriorly they are armed with penetration glands. The bodily form of these larvae bears a marked resemblance to the

larvae of the trematodes, such as the miracidium in the digeneans, and the larval monogenean, the oncomiracidium.

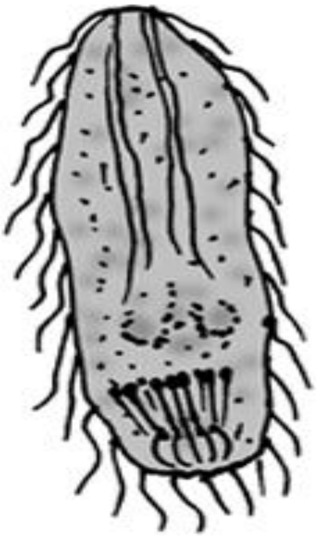

*Fig. 4: A lycophore*

**The Eucestodes (Tapeworms)**

The eggs of Pseudophyllidean and Cyclophyllidean cestodes differ considerably. The egg of the pseudophyllidean tapeworm closely resembles that of the trematodes, having a thin shell wall, and an operculum, which on hatching opens to reseales the free swimming larvae. This illustrates the close relationship between the two major groups of platyhelminth parasites. In contrast, the egg of the cyclophyllideans tapeworms is very different, having a very thick, resistant egg shell, with no operculum.

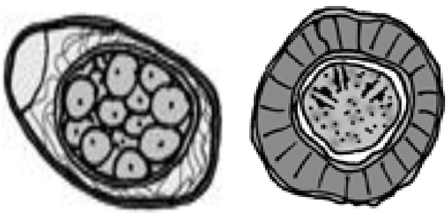

*Fig. 5: The Pseudophyllidean and Cyclophyllidean Ova*

The larvae emerging from these eggs also differ. The pseudophyllidean egg hatches to release free swimming larvae called a coracidium. This has an outer layer of ciliated epidermal cells with which it swimms through the water before being ingested by the parasites first intermediate host. This is often a copepod. Inside the copepod the ciliated epidermis is shed, to release larvae that initially resemble that of the newly hatched cyclophyllideans. This has 6 hooks, arranged in pairs, and is a common feature throughout the eucestodes. On the basis of the presence of these hooks, present in both the eucestodes and cestodarians, many authors believe that the cestodes originally evolved from an ancestor common to the extant monogeneans.

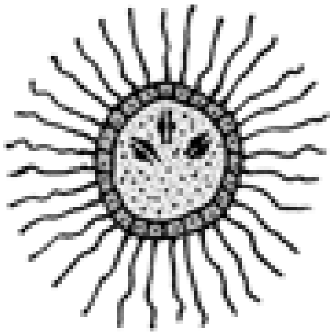

*Fig. 6: Coracidium Larva*

The larval cyclophyllidean, as with the pseudophyllidean, is equiped with 3 pairs of hooks. Both groups use these hooks to penetrate the gut wall of its intermediate host after being ingested, before developing into the other larval forms described below in more detail.

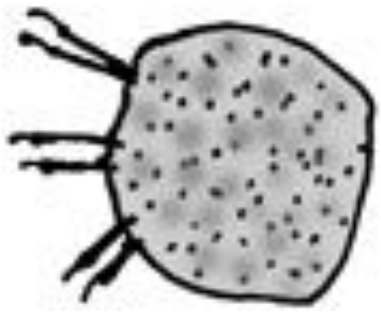

*Fig. 7: Larva of Cyclophyllidean*

## 3.4 Metacestodes

A number of different larval forms of cestodes (metacestodes) are seen, these include the following:

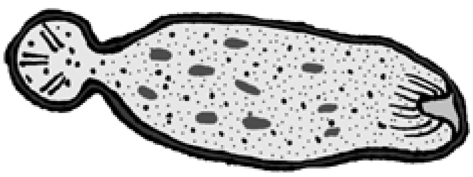

*Fig. 8: A Procercoid of Pseudophyllidean (e.g D. Latum)*

A larval form of Pseudophyllidean cestodes, examples are D. latum and Ligula intestinalis. Here the two forms of the procercoid are shown. Firstly, an immature procercoid, and secondly a mature infective procercoid. In the lifecycle of these parasites there are two intermediate hosts. The Procercoid being found in the first of these (usually a small crustacean e.g. Cyclops). In appearance these larvae have solid bodies with the remains of the embryonic hooks from the onchosphere larvae at the posterior of the parasite.

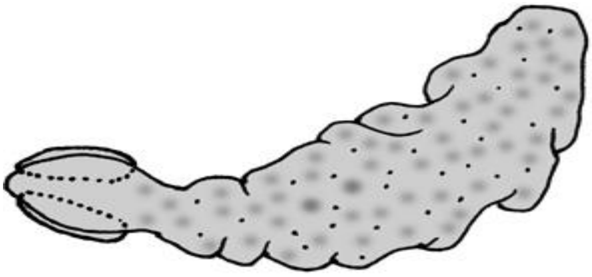

***Fig .9: A Plerocercoid of Pseudophyllidean (e.g D. Latum)***

A larval form of Pseudophyllidean and other Cestodes are samples of D. latum and Ligula intestinalis. In the lifecycle of these parasites there are two intermediate hosts see the cestode life cycle page. The plerocercoid found in the second of these,is usually a fish or amphibian.

In appearance, these are elongated larvae with solid bodies which are much larger than the preceding procercoid larvae. In these stages the embryonic hooks are absent. The plerocercoids of some Pseudophyllideans already show the start of the development of the sexual organs (e.g. Schistocephalus solidus, Ligula intestinalis), whilst those of Schistocephalus Solidus is also already divided into proglottids).

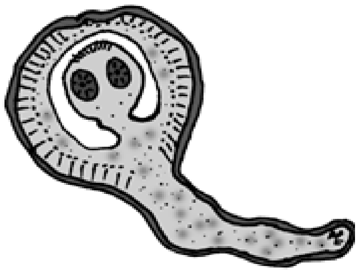

***Fig.10: A Larval Form of Cyclophyllidean Cestodes, (E.G. Hymenolepis Sp.)***

A larval form of cyclophyllidean cestodes,e.g. hymenolepis sp. This larval form is usually found in species where the intermediate host is an invertebrate, usually an insect.

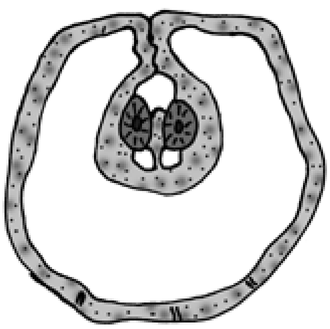

**Fig.11: A Larval Form of Cyclophyllidean Cestodes,** *(E.G. Taenia Solium)*

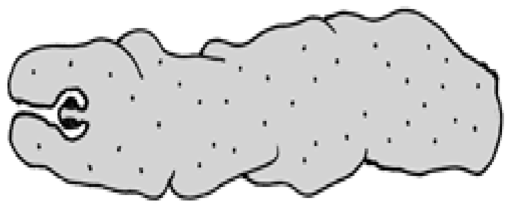

**Fig.12: A Larval Form of Cyclophyllidean Cestodes** *(E.G. Mesocestoides Sp.)*

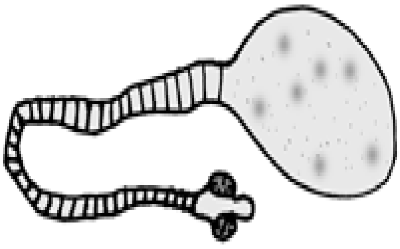

**Fig.13: A Larval form of Cyclophyllidean Cestodes** *(e.g. Taenia Taeniaeformis)*

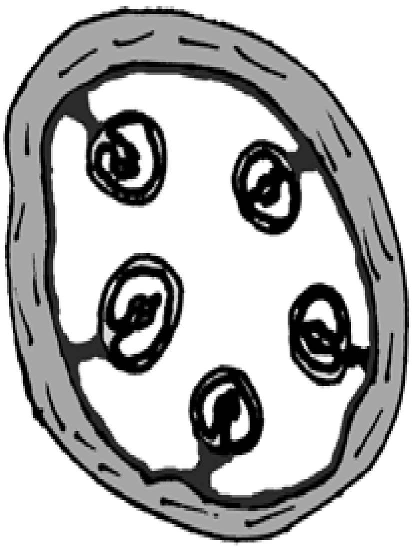

**Fig.14: A Larval form of Cyclophyllidean Cestodes** *(e.g. Taenia Multiceps)*

**Fig. 15: A Larval form of Cyclophyllidean Cestodes** *(e.g. Echinococcus Granulosus). - Hydiatid Cyst*

## 4.0 Conclusion

In this unit, you learnt that the body plan of adult cestode is divided into scolex, neck and strobila. The scolices of the order Caryophyllidea (parasites of freshwater fish) have no special attachment organs while the Pseudophyllidea have weakly muscular grooves which are armed with bothria. The Cyclophyllidea have four acetabulate suckers. In addition to these are glandular areas, protrusible suckers and rostellum depending on the species of the cyclophillidean. The strobila is made up of proglottids containing the male and the female reproductive organs. The larvae of cestodes vary with species with some being ciliated and as such are free swimming. Some however, have operculum with thin shell wall. Others have thick shell wall with 6 hooks.

## 5.0 Summary

The body plan of adult cestode is divided into scolex, neck and strobila. The scolices of the order Caryophyllidea (parasites of freshwater fish) have no special attachment organs while the Pseudophyllidea have weakly muscular grooves which are armed with bothria. The Cyclophyllidea have four acetabulate suckers. In addition to these are glandular areas, protrusible suckers and rostellum depending on the species of the cyclophillidean. The strobila is made up of proglottids containing the male and the female reproductive organs. The larvae of cestodes vary with species with some being ciliated and as such are free swimming. Some however, have operculum with thin shell wall. Others have thick shell wall with 6 hooks.

## 6.0 Self-Assessment Exercise

Activity

Answer the following questions:

1. Describe the four main types of scolex (LO1).
2. Differentiate between the larvae of psedophyllidean and cyclophyllidean (LO2).
3. Give a concise description of the various larval forms of cestodes (LO2).

## 7.0 References/Further Reading

Ukoli, F.M.A. (1990). *Introduction of Parasitology in Tropical Africa.* John Wiley and Sons Ltd., Chichester.

# Unit 2 Tapeworms and Examples

## 1.0 Introduction

Cestodes or tapeworms are the most specialised of the Platyhelminthe parasites. All cestodes have at least one, and sometimes more than one, secondary or intermediate host as well as their primary host. While the intermediate hosts are often invertebrates of some sort, the primary host is normally a vertebrate. However, in some cases both hosts are vertebrates, as in the common Beef Tapeworm (Taenia saginatus), and in a few species there may be only a single host. A number of tapeworms include mankind in their life cycles but infection is not normally a serious health problem and can be cured. There are more than 1,000 species of tapeworms known to science, and nearly every species of vertebrate is liable to infection from at least one species of tapeworm.

## 2.0 Objectives

At the end of this unit, you should be able to:

- describe the morphology and life cycle of a named cestode
- dxplain the epidemiology and control of these parasites.

## 3.0 Main Content

### 3.1 Diphyllobothrium Latum (The Broad Fish Tapeworm)

Diphyllobothrium latum is the fish tapeworm of man. It has a fairly cosmopolitan distribution, but is particularly common in the Baltic region, Russia and the Great Lakes region of the U.S.A.

**Morphology of the Adult Tapeworm**
The adult parasites are typically between 2 and 12 m in length by up to 2 cm in width, but may grow even longer in some cases. The anterior organ of attachment is a bothria, a pair of shallow, elongated muscular grooves, typical of tapeworms of the order Pseudophyllidea. The body is divided into proglottids, as is the case of all pseudophyllidean tapeworms. These proglottids are broader than they are long, except at the terminal end, where they are approximately square in shape.

Internally the proglottids are typical of pseudophyllidean tapeworms, with numerous testes and vitellaria arranged on the lateral margins of the proglottid, with a central bilobed ovary. An important difference between this parasite and the other tapeworms of man is that the uterus open to the exterior (cyclophyllidean tapeworms have closed uteruses). Eggs are therefore actively deposited by the parasite, in contrast to the disintegration of the proglottids seen in the other human tapeworms.

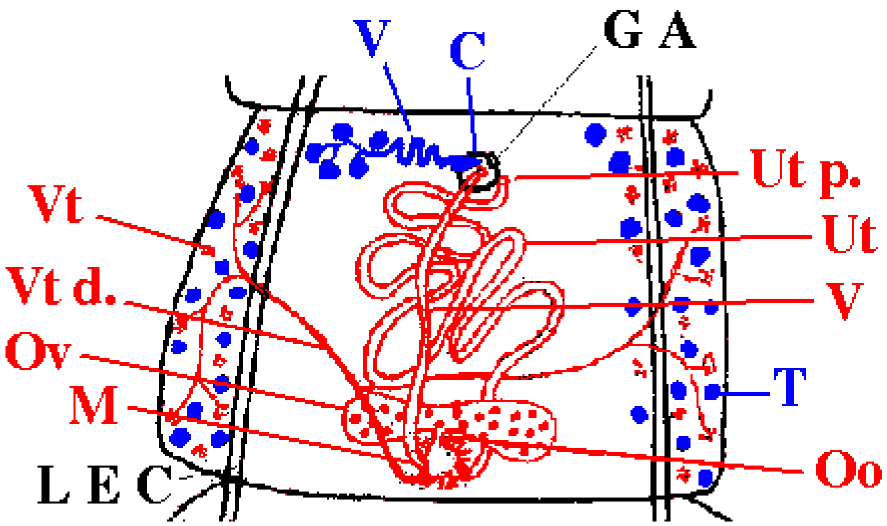


**Fig.1: The Female Reproductive System the Male Reproductive System of D. Latum**

Key - Ov - Ovary (bilobed in D. latum.) ;Oo - Ootype (where the egg is formed); Ut - Uterus (In the pseudophyllideans this opens to the outside, via the uterine pore); Ut p. - Uterine pore (not present in the cyclophyllideans); V - Vagina (a long straight tube); Vt - Vitelline glands (secreting substances that make up the egg yolk and shell);Vt d. - The Vitelline duct (connecting the vitelline gland, which are diffuse and are situated lateraly in D. latum ;M - The Mehlis gland (A cluster of unicellular shell glands, absent in some species) T - Testes (dorso-lateral in D. latum ;V - Vas deferens; C - Cirrus (a protrusible muscular organ, opening anterior to the vagina in a common genital atrium); G A - Genital Atrium (a cup shaped sinus, where the cirrus and vagina have common openings); L E C – The Lateral Excretory Canal

**Life Cycle and Transmission**

Diphylobothrium latum has a typical Pseudophyllidean tapeworm lifecycle. In addition to the adult parasites in the definitive host, (i.e. man), there are two intermediate hosts containing larval stages. Eggs are passed from man in the faeces and hatch in water to release a small motile embryonic parasite, the coracidium. This is internally similar to the hexacanth larvae of the cyclophyllidean tapeworms, being equipped with 6 hooks, but this hexacanth larva is covered in a ciliated embryophore. The coracidium is a free swimming stage, but cannot survive long. For further development, it must be ingested by the first intermediate host, a copepod.

On ingestion the embryonic larvae penetrates the arthropods gut wall, entering the haemocoel to develop into the first larval stage, the procercoid, measuring 50µm in length. This larva, (as well as the next larval stage, the plerocercoid described above) is very different from the cyclophyllidean parasite larvae in that they have elongated and solid bodies. In addition, the procercoid bears the embryonic hooklets on a posterior bulb like rounded growth, the cercomer.

To continue the lifecycle, the copepod must be ingested by the next intermediate host, a fish. The procercoid penetrates the gut wall of the fish, and develops into the next larval stage, the plerocercoid (sparganum), measuring 4 - 5 mm in length, in the viscera or musculature of the fish. These plerocercoids have again elongated solid bodied parasites, but differ from the procercoids in the absence of the cercomer and hooklets, and at the anterior end having a developed attachment organ, the bothridium, similar to the adult parasite. A number of different species of fish may act as intermediate hosts for the plerocercoids of D. latum, but the highest densities of plerocercoids are found in carnivorous fish such as the pike. These high parasite loads are because, in addition to infection by ingestion of the copepod plus procercoid, if another infected fish is eaten the plerocercoids within the body tissues of this predated fish are released in the intestine of the carnivorous fish. These then migrate through the intestinal wall, to invade the new host, which is then acting as a Paratenic host for these secondary plerocercoids.

The plerocercoids are, in addition, very long lived, and may achieve very high parasite densities. Man is infected by ingestion of raw or undercooked fish, the plerocercoids emerging in the intestine to grow into the adult parasite. In addition to man a number of other fish eating mammals may also be infected, including cats, dogs, pigs, bears. Therefore D. latum in addition to being a parasite of man also causes zoonotic infection. In man multiple infections may occur, sometimes of very high numbers (up to 143 worms have been reported from a single individual). In these cases the parasites length is considerably reduced.

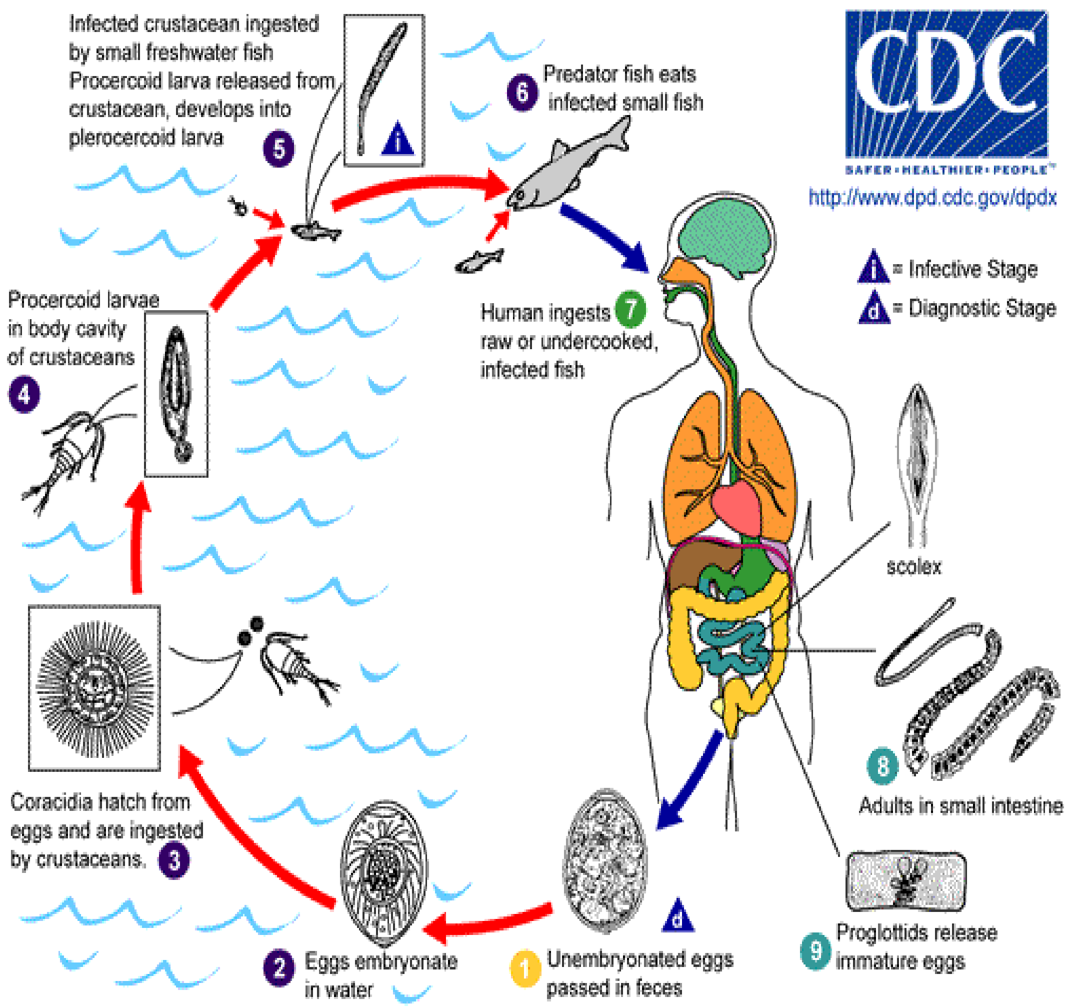


**Fig. 2: Life Cycle of D. Latum ( source**: http://www.dpd.cdc.gov/dpdx)

**Pathology of Infection**

Infection, as is often the case with adult tapeworms, presents a variable range of pathology, but again is not commonly the cause of serious disease in man. Symptoms, when they occur, include a variety of non-specific abdominal signs, including abdominal pain and loss of weight, and are often very similar to the symptoms displayed during infection with adult Taenia. However, D. latum differs from Taenia in absorbing much more vitamin B12, (between ten and fifty times more) than other tapeworms. Infection may therefore result in a macrocytic hypochromic anaemia in some cases, vitamin B12 having an important role in formation of blood cells. This feature of the disease is much more common in the Baltic region, particularly in Finland. This tapeworm derived anaemia may be due to host derived genetic factors. It is also more commonly seen when the tapeworm is situated higher in the intestine.

**Epidemiology and Control**

Infection occurs by consuming raw or undercooked fish harbouring sparganum. Therefore to avoid infection in man, fish should be properly cooked, killing the infective plerocercoids.

## 3.2 Dipylidium Caninum - (The Dog Tapeworm)

This Tapeworm is primarily a parasite of the Dog and the Cat. However man, and in particular children, may also be infected.

**Lifecycle**

Similar to Taenia saginata, the proglottids of this tapeworm are actively motile, and are able to crawl out of the anus of the definitive host as well as being passed in the faeces. The eggs of this species of tapeworm are contained in egg-capsules, each containing up to twenty eggs. These eggs are ingested by the parasite's intermediate host, in this case an invertebrate arthropod such as fleas (only the larval flea can be infected) or the dog louse Trichodectes canis. The onchosphere larvae is released in the arthropods gut and penetrates through the gut wall, developing into a cysticercoid, similar to the hymenolepid larval tapeworms.

Infection of the Definitive host, whether dog, cat or man, occurs on ingestion of the larval parasite, either when the intermediate host is ingested, or ingestion of the crushed bodies of these hosts. For example, if the dog licks the face of the child just after it has bitten a flea or louse. On ingestion the cysticercoid larvae develops into the adult parasite in the small intestine in about twenty days.

**Morphology**

Larvae - The larvae are roughly pear-shaped, and follow the typical cysticercoids body pattern. Adults - These are relatively short tapeworms, measuring between 15 and 17cm in length and consisting of up to 170 proglottids. These are elongated in form, the gravid proglottids, measuring approximately 12 x 3m and packed full of eggcapsules, having the appearance of grains of rice. The scolex, by which the parasite attaches to the wall of the small intestine, has four large acetabulate suckers, a retractile rostellum and six rows of 30 to 150 rose-thorn shaped hooks. The eggs which are typical cyclophyllidean tapeworm eggs, are round in shape and measure up to 60µm, and are held within egg-capsules.

**Pathology of Infection**

The infection appears to be asymptomatic and generally non-pathogenic, although there may be some degree of mild pruritis, or itching, around the perineum due to the presence of emerging proglottids.

## 3.3 Tapeworms of the Genus Hymenolepis

There are a number of species in this genus, two of which are common parasites of man.

**H. Nana - The Dwarf Tapeworm**

This tapeworm is relatively small, growing up to 4cm in length, the size of the parasite being inversely proportional to the number of worms present in the infection. Infections, which are more commonly seen in children in warmer climates, are characterised by the presence of numerous parasites (both cysticercoid larvae and adults) in the small intestine. Infection is by ingestion of soil contaminated with faeces containing eggs and may give rise to abdominal discomfort.

**H. Diminuta - The Rat Tapeworm**

This tapeworm is much longer than H. nana, growing up to 60cm or more in length. This is primarily a parasite of the rat, humans only being infected by accidental ingestion of the insect intermediate host. This species is of more importance as a research model for the study of the biochemistry, physiology, chemotherapy and immunology of tapeworm infections. In addition there are a number of species found in animals, including;

- H. Carioca - A common non-pathogenic parasite of fowl in the USA.
- H. Microstoma - A parasite of rodents.
- H. Lanceolata - A pathogenic parasite of ducks, geese and other anseriform domestic fowl.
- H. Coronula- A parasite of anseriform domestic fowl.
- H. Cantaniana - A parasite of chickens and other galliform domestic fowl.

**Morphology**

Apart from their relative sizes, these two parasites of man are very similar, H.nana being up to 4cm in size, the strobila consisting of up to 200 proglottids, whilst H. diminuta grows up to 60cm or more in length and the strobila consists of up to 1000 proglottids. These proglottids are trapezoidal in shape, and are approximately four times as wide as they are long. Each proglottid contains three round testes, a bi-lobed ovary, a compact vitelline gland and a large uterus opening to a lateral genital pore (as does the cirrus). The scolex in both parasites have four suckers and a retractile rostellum which in H. nana is equipped with 20 - 30 hooks (the rostellum is unarmed in H. diminuta).

Finally the eggs of the two species both have the characteristic thickened walls of all cestode eggs, but may easily be differentiated. Those of the yellowish brown H. diminuta eggs are much rounder than colourless H. nana eggs and are larger with 60 - 80µm in diameter.

In H. Nana the eggs are oval in shape, measuring ~ 40 by 50µm and contains an oncosphere equipped with 3 pairs of embryonic hooks (i.e. a "hexacanth" larvae) and long wavy filaments (absent in H. diminuta) which lie in the space between the larvae and the egg shell wall.

The two species infecting man have rather different lifecycles which will be considered separately here.

**H. Nana**

This parasite has rats and mice as well as man as the definitive host, and differs from H. diminuta and almost all other tapeworm in that an intermediate host is not required, although fleas and beetles may be used. The embryonated eggs are passed in the faeces where they contaminate soil. If the eggs are ingested by the definitive host the oncosphere is activated and breaks out of the egg and penetrates the gut villus. Here it develops as a cysticoid larvae in about 4 days before rupturing into the gut lumen.

Once ruptured, the scolex attaches to the gut mucosa and the parasite develops into the adult tapeworm after about 15 to 20 days. If the insect intermediate hosts are utilised the lifecycle is similar to that of H. diminuta below. In heavy infections eggs liberated by adult worms in the intestine may hatch here rather than passing out of the body, to give autoinfection.

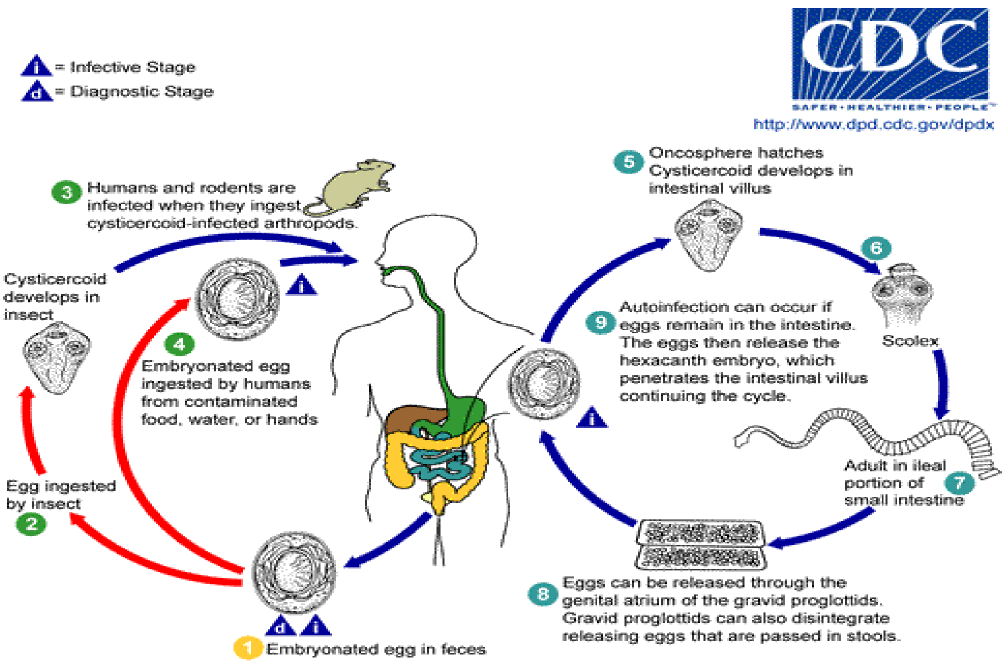


**Fig. 3: Life Cycle of H. Nana (Source: Http://www.dpd.cdc.gov/dpdx)**

**H. Diminuta**

This parasite as in most tapeworms does require an intermediate host. Embryonated eggs pass out of the body of the definitive host in the faeces and are ingested by the insect intermediate hosts. Many insects may act as intermediate hosts for this parasite, the most common being fleas and beetles such as the flour beetle. When ingested by the intermediate host the oncosphere larvae become activated, break out of the egg shell and penetrate into the insect's body cavity where they develop into a cysticercoid larvae. For completion of the lifecycle, the infected intermediate host must be eaten by the definitive host. On ingestion, the cysticercoid larva becomes activated, the scolex becomes attached to the gut mucosal wall, and the parasite develops into the adult tapeworm. An interesting feature of Hymenolepis tapeworms is that they undergo a diurnal migration within the gut, which is associated with the feeding patterns of the host. From about 4pm to 4am few parasites are seen in the lower part of the small intestine, whilst from about 4am to 4pm many parasites are seen in the upper part of the small intestine. This was first observed in H. diminuta and subsequently in other species, and is indicative of a nocturnal feeding pattern by the parasite.

**Pathology of Infection**

These parasites are not very pathogenic, usually with asymptomatic infections. In man infected with H. nana there may be a slight irritation of the gut mucosa and slight abdominal pain, and with very heavy infections (>2000 worms) there may also be some diarrhoea. In the bird species there may be enteritis and intestinal obstruction with some species.

## 4.0 Conclusion

In this unit, you learnt that D. latum 'a psedophyllidean' infects fish which in turn infects man when fed on raw or undercooked fish. Rats and mice as well as man are the definitive hosts of H. nana, and therefore difers from H. diminuta and almost all other tapeworm in that an intermediate host is not required, although fleas and beetles may be used. Dipylidium caninum are dog tapeworms that can as well infect human expecially children.

## 5.0 Summary

D. latum 'a psedophyllidean' infects fish which in turn infects man when fed on raw or undercooked fish. Rats and mice as well as man are the definitive hosts of H. nana, and therefore difers from H. diminuta and almost all other tapeworm in that an intermediate host is not required, although fleas and beetles may be used. Dipylidium caninum are dog tapeworms that can as well infect human expecially children.

## 6.0 Self-Assessment Exercise

Activity

Conduct a physical examination of different types of tapeworm and report your findings in the log book.

Answer the following questions:

1. What are the striking features of cestodes ?(LO1).
2. Explain the transmission cycle of D. latum (LO2).
3. What are morphological differences between the mature proglottids of Dipylidium caninum and Hymenolepis spp? (LO2).
4. Describe the life cycle of D. latum (LO2).

## 7.0 Reference/ Further Reading

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# Unit 3 Tapeworms of Man and Other Human's Cestodes

## 1.0 Introduction

Two species from the genus Taenia are common parasites of man, these being Taenia solium (the Pork tapeworm) and Taenia saginata (the Beef tapeworm). Taenia saginata has a cosmopolitan distribution, with estimates of approximately 50 million cases of infection world-wide annually. As with T. saginata and T. solium this parasite has a cosmopolitan distribution, with estimates of approximately 50 million cases of infection world-wide annually.

However, the incidence of infection may vary considerably, and may be influenced by a number of factors such as religious inhibitions on eating pork, as in many Islamic countries, or in other countries by high degrees of sanitation, limiting exposure of the intermediate hosts to human faeces. This parasite has pigs as the main intermediate host, but man may also act as an intermediate host for this parasite as well as being infected with the adult tapeworms. This aspect of the parasites lifecycle has important implications for the pathology associated with infection with this parasite. Echinococcus granulosus is one of the three species of Echinococcus that is generally accepted as parasites of man. It is the causative agent of Hydatid disease in man and many other mammals. It occurs in Europe and Artic region of North America.

## 2.0 Objectives

- discuss the epidemiology and control of human tapeworms
- describe the morphology of taenia spp
- explain the pathology infection of taenia spp.

## 3.0 Main Content

### 3.1 Taenia Spp

**Life Cycle of Taenia Spp**

This parasite has cattle or related animals as its main intermediate hosts, although other animals such as camels, llamas and some antelopes may also occasionally be infected. The larval form in these animals is a cysticercus in the muscles and heart. These are infected by ingestion of the eggs of the tapeworm; shed from the faeces of the carnivorous definitive host, in this case man. Once ingested the eggs hatch to release the hexacanth larvae, which migrate through the intestinal wall to reach the blood or lymphatic systems, from where it is carried to the tissues, particularly the heart and other muscles to develop into the cysticercus. Man is infected by ngestion of undercooked or raw meat, the bladder wall of the cysticercus being digested in the intestine to release the scolex of the parasite. This attaches to the intestinal wall and grows into the mature adult tapeworm.

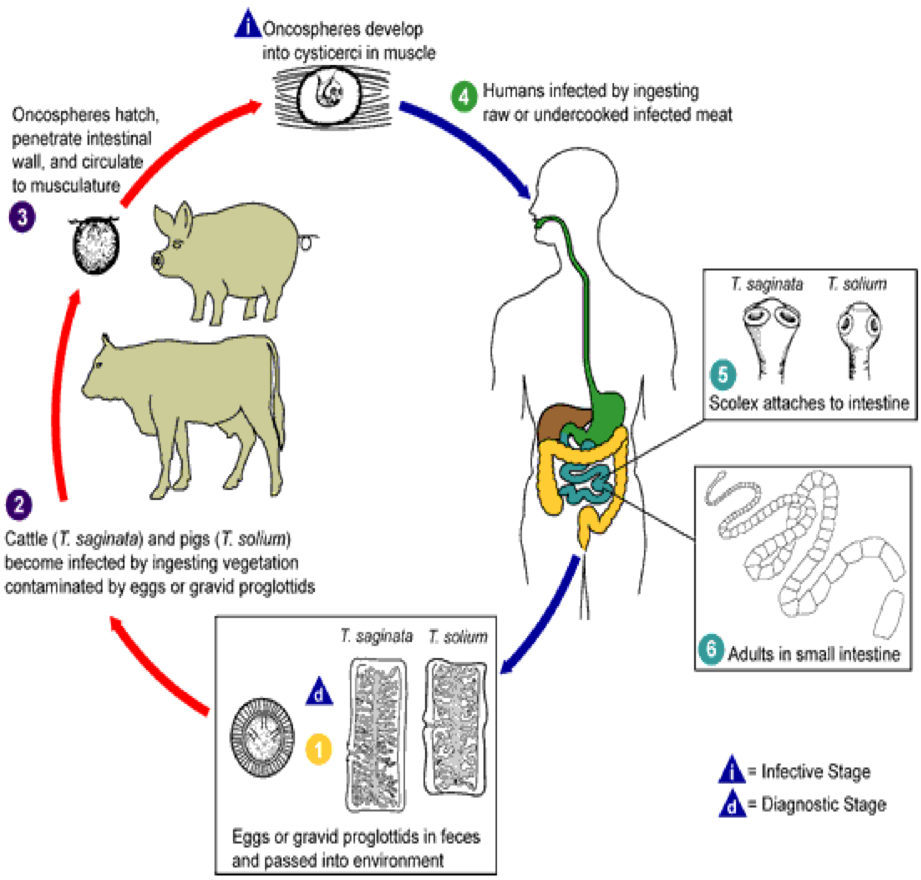


**Fig.1: Life cycle of T. saginata and T. Solium**

## Morphology

Taenia Saginata Larvae - These cysticerci are approximately 7.5-10mm wide by 4-6mm in length.

Adults - The adult tapeworms have an average length of about 5 meters, consisting of approximately 1000 proglottids, but may grow up to 17 metres in length occasionally, and are therefore longer than the adult forms of Taenia solium. The mature proglottids have approximately double the number of testes that T. saginata has and are larger. The gravid proglottids are also larger, measuring approximately 20mm long by 6mm wide with a uterus with more lateral branches than T. solium.

These gravid proglottids when detached from the strobila may be very active, not only crawling away from the faeces when passed, but often actively emerging from the anus to deposit eggs from the ruptured uterus around the perianal region. The scolex in this tapeworm may also be differentiated from T. solium as it is slightly larger, at approximately 2mm in diameter and is unarmed, without any hooks, although the 4 acetabular suckers are still present.

## Taenia Solium

Larvae - These small cysticerci (refered to as Cysticercus cellulosae) are approximately 6-18mm wide by 4 - 6mm in length when found in the muscles or subcutaneous tissues (the normal sites for the larva of this parasite). The cysticerci may however be found in other tissues such as those of the central nervous system where they may grow much larger, up to several centimetres in diameter.

Adults - The adult tapeworms have an average length of about 3 meters, but may grow up to 8 metres in length occasionally, and follow the typical morphology of cestode tapeworms. The strobila consists of between 800 and 1000 proglottids. There is only half the number of testes that T. Saginata has. The gravid proglottids, measuring approximately 12mm long by 6mm wide, have a uterus with between 8 to 12 lateral branches, less than T. Saginata The scolex in this tapeworm may also be differentiated from T. saginata as it is equipped with a low rostellum with a double crown of approximately 30 hooks.

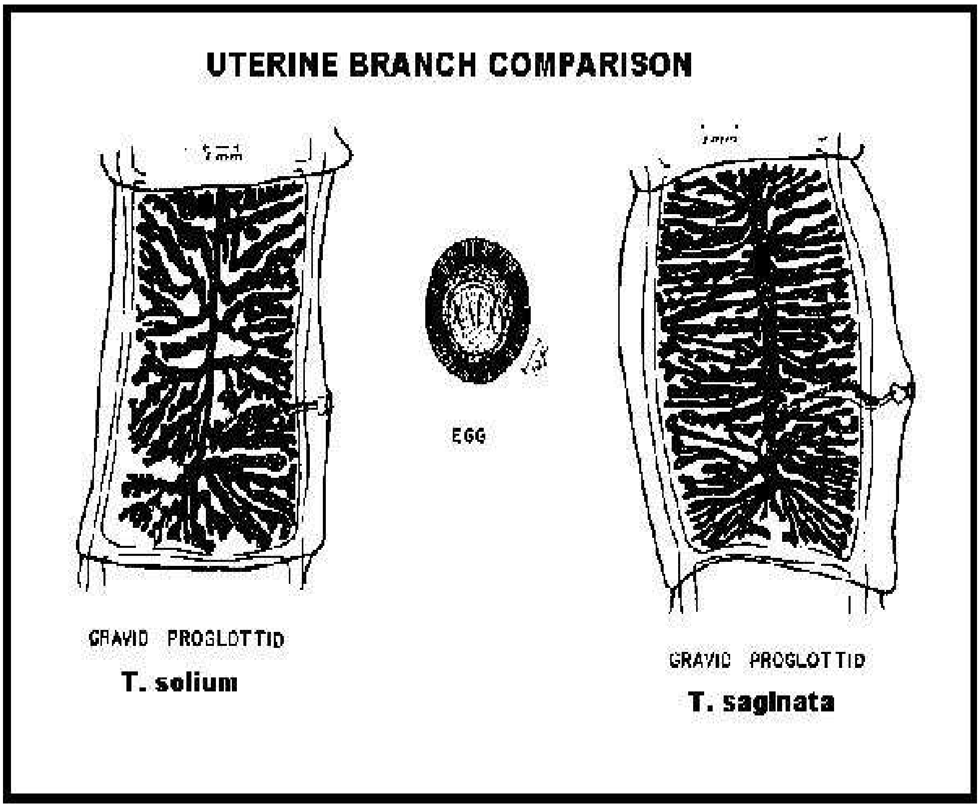


*Fig. 2: Showing the Distinctions between the Proglottid of T. Solium and T. Saginata*

Major Differences between T. Saginata and T. Solium

| Features | T. saginata | T. solium |
|---|---|---|
| Size | 3-7m(sometimes Upto 25m) long | 2-3m(sometimes up to 10m) long |
| No. of proglottids | 1000-2000 (sheds 3-10 daily) | 800-1000 (sheds 8-10 daily) |
| No. of eggs per proglottid | 100000 | 40000 |

| | | |
|---|---|---|
| Scolex | Cuboidal, up to 2.0mm In diameter | Spheroid, about 1.0mm in diameter |
| Rostellum | Absent | Present, armed with two circlets of 22-32 hooks |
| No. of testes | 800-1200 | 300-500 |
| Shape of overy | Bilobed | Trilobed |
| Gravid uterus | 15-25 lateral branches on each side | 7-13 lateral branches on each side |
| Vaginal sphincter | Present | Absent |
| Gravid proglottid | When detached, active and creep out through anus and craw about individually | When detached, passive |

**Pathology of Infection**

**T. Saginata**
Larvae - Unlike T. solium, T. saginata does not utilise man as an intermediate host, and therefore pathology due to the larval form is not a feature in human disease. In cattle the cysticercus, refered to as Cysticercus bovis (named before the parasite life cycle had been determined, and the connection between the two forms had been established) is completely asymptomatic.

Adults - The pathology of infection with adult T. saginata is highly variable. Often infections are completely asymptomatic, but in other cases some degree of pathology may be seen, most seriously intestinal blockage. In some cases vitamin deficiency may be the result of excessive absorption of nutrients by the parasite, although this aspect of tapeworm pathology is more a feature of infection with the fish tapeworm D. latum. In addition infection may be accompanied by a broad range of non-specific symptoms, including more commonly, (if seen at all), abdominal pain, digestive disturbances, excessive appetite or loss of appetite, weakness and weight loss.

**T. Solium**
Larvae - Infection with the larval form of T. solium cysticercus cellulosae, (Called "Cysticercosis") may have severe consequences, the annual world-wide mortality due to cysticercosis having been estimated at approximately 50 000 cases. In man the cysticerci mainly develop in the subcutaneous tissues, but infections in both the Central Nervous System (C.N.S.) and ocular tissues are also very common. Infection of the C.N.S. may cause severe pain, paralysis, optical and/or psychic disturbances and epileptic convulsions, mainly due to mechanical pressure as the larvae develop. Later there may be loss of consciousness and even death. infections involving the eye may give rise to discomfort, and can cause detachment of the retina.

Adults - Usually only a single adult specimen is present, which may cause a slight degree of mucosal inflammation. The actual effects on the host may vary considerably, often there are few symptoms, but in some cases a variety of nonspecific symptoms such as constipation, epigastric pain and diarrhoea, are present. Very rarely there may be perforation of the intestinal wall, with subsequent peritonitis. However, more seriously, as detailed above, the presence of adult worms carries the risk of autoinfection due to reverse-peristalsis resulting in cysticercosis, it being estimated that approximately 25% of cases of Cysticercus cellulosae infections in man being acquired by this route.

**Diagnosis of Infection by Taenia spp**

1. Demonstration of scolex and proglottids in the faeces. However, scolex are rarely excreted in faeces
2. The eggs of T. saginata and T. solium are similar. However, most laboratory diagnosis is through the observation of Taenia spp eggs in faecal sample.
3. Examination of gravid uterus shows 15-25 lateral branches in T. Saginata and 7-13 lateral branches (counted from the main stem) in T. Solium when short chains of 5-8 proglottids passed out in faeces are pressed through glass slides.
4. The scolex of T. saginata is easily distinguished from that of T. solium in that it has only 4 suckers but no hooks.
5. Radiological examination of the intestinal tract may reveal tapeworm infection.

**Epidemiology and Control**

The prevalence of Taenia infection is on the increase due to the following factors;

- Intensification of animal production
- Development of meat industries in several developing countries
- Consumption of undercooked beef and pork by tourist visiting highly endemic areas
- Consumption of semi-cooked meat in manufactured food products like hamburgers, etc.
- Accelerating urbanisation with decreased efficiency of sewage systems
- Sewage farming

In view of the above listed epidemiological factors that favour transmission, the following measures can be taken to reduce prevalence;

1. Proper meat inspection services before usage in meat industries. Diseased meat should be condemned and destroyed.
2. Lightly infected beef with cysticerci can be rendered safe for consumption by freezing at -10oC for at least 10 days.
3. Cooking of meat well before eating
4. High standards of sanitation will reduce transmission.
5. Immunisation against bivine cysticercosis.

## 3.2 Other Taenia Cestodes

**Infection by Adult Tapeworms**

Taenia taeniformis - This parasite has a cosmopolitan distribution, the adult parasites are normally found in cats and related carnivores, but it has been reported from an Argentinean child. The adult tapeworms are about 60cm long, and are unusual in that they lack a neck. The scolex is large and equipped with two rows of hooks, whilst the posterior gravid proglottids have a characteristic bell shape. The larvae, which are found in wild rodents, are a strobilocercus, a development of a cysticercus where the scolex has evaginated, but is still attached to the bladder of the cysticercus by a short segmented strobila.

Taenia bremneri (Syn. T. confusa) - reported from man in Africa, Japan and the United State of America. This parasite may be a synonym of T. saginata. Taenia africanus - reported a few times in East Africa. This tapeworm has broad segments and an unarmed scolex with a small apical sucker.

**Infection by Larvae (Metacestode Infections)**

Taenia multiceps - The adult tapeworms of this species are found in dogs and related canids. The larva is a fluid containing cyst 5cm or more in diameter, containing several hundred protoscolices, and is called a coenurus. It is normally found in the brain or spinal cord of sheep and goats where it is an important pathogen. In these animals, it causes a condition known as 'gid' or 'staggers' as the coenurus develops along with an associated destruction of nervous tissue. The larval form may rarely infect man, where it causes a condition called coenurus cerebralis, on accidental ingestion of tapeworm eggs from the faeces of dogs.

Taenia Serialis - A similar parasite to T. multiceps, the coenurus larvae, measuring 4cm in diameter or larger, is usually found in the subcutaneous and intramuscular tissues of lagomorphs. The adult tapeworms are found in dogs and foxes with a cosmopolitan distribution. They measure about 70 cm in length and have a scolex with two rows of about 30 hooks. The larvae have been reported very rarely in man.

Taenia Glomerulatus - The larvae normally infect rodents, but the coenurus larvae have also been reported as rarely infecting man in Africa.

## 3.3 Echinococcus spp

Three species of Echinococcus have been generally accepted as parasites of man Echinococcus granulosus. There are causative agent of Hydatid disease in man and many other mammals. The dog acts as the definitive host for this species. A number of sub-species of this parasite have also been described, the most universally accepted being E. g. granulosus (thought to be the original species found in Europe, although now more widespread) and E. g. canadensis (the indigenous species of the Arctic region of North America, for more details see below). In addition there is considerable strain variation within this parasite, with differing preferences for intermediate hosts. For example in Ireland a strain exists whose larvae only infect the horse, man being resistant to infection.

**Life Cycle**

Dogs and other canids are parasitised by the adult tapeworm. When shed by the tapeworm, the gravid proglottids disintegrate in the dogs intestine, and eggs which are passed in the faeces, are highly resistant, being able to survive freezing and drying on the ground for up to a year. Many mammals apart from man may act as intermediate hosts, in particular sheep and horses. The situation is highly complex as at least 9 sub-species have been identified, all with different host specificity;

E.g. granulosus - Adult form in most canids apart from the red fox, hydatids in sheep, pigs, cattle, man and many wild ruminants.

E.g. equinus - Adults in canids, hydatids in horses and other equidae, but probably not man

E.g. canadensis - Adults in canids, hydatids in caribou, reindeer and man

E.g. borealis - Adults in canids, hydatids in many cervids and man. In addition, in parts of Kenya there is a strain or sub-species that is particularly adapted to transmission between man and domesticated dogs.

The egg enters the host by ingestion, either from contaminated grass (as is the case in infections of herbivorous ruminants), or in the case of man, by contamination, (for example by the dog licking face after it has been cleaning itself) or other examples of bad hygiene, followed by transfer to the mouth. The egg then hatches in the intestine, penetrates the gut wall, and travels via the lymphatic or blood system throughout the body, from where they lodge within the body tissues. The cysts may develop anywhere within its intermediate hosts body, but as the circulatory blood stream passes from the mesenteric blood vessels to the liver; it is in the liver that the majority of the cysts (in about 65% of cases) are found. Next in frequency of infection are the lungs (about 20%), brain (1%), peritoneal cavity (8%), kidneys (3%) and bone marrow or other organs. Development of the cysts to produce infective protoscolices takes approximately 1 to 2 years.

On the death of the intermediate host, either directly by predation on the part of the dog, or by the scavenging of the dead cadaver, (the protosocialises are also highly resistant, being able to survive in carrion for several weeks), the cyst is ingested along with the offal. The cyst wall is then digested, liberating the protoscolices which quickly evaginate, penetrating deeply into the crypts of Lieberkuhn, and developing to adult worms in approximately 7 to 9 weeks. Due to the presence of many protoscolices in each hydatid cyst, dogs may be infected with many E. granulosus (tapeworms).

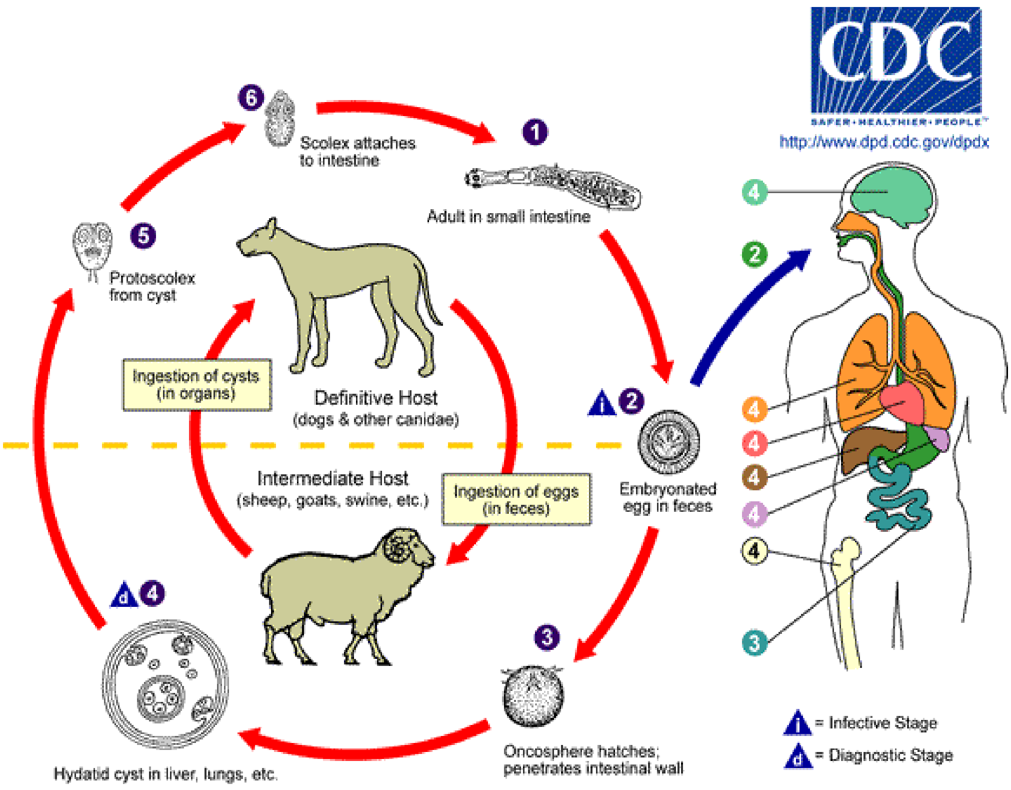


**Fig. 3: Life Cycle of E. Granulosus** *(source: http://www.dpd.cdc.gov/dpdx)*

**Morphology**

Larvae - These Metacestodes (called 'Hydatids') are large, roughly spherical, fluid filled hollow bladders, containing numerous protoscolices (forming the so-called hydatid sand), brood capsules, and daughter cysts which are identical in form to their parent cyst. The cyst wall itself consists of an outer laminated hyaline wall, supporting the whole cyst. Beneath this there is a nucleated germinal layer, studded with developing brood capsules, which may eventually break off to float freely in the fluid filled cyst. The protoscolices are formed within the brood capsules, which may rupture to give the free protoscolices in the hydatid fluid. They vary considerably in size depending on where in the body they form, which may be almost any organ of the body. Those found in the liver (the most common organ affected) may be approximately 20cm in diameter, but those found in the peritoneal cavity may sometimes be very much larger, containing several litres of fluid. For example one case has been reported of a cyst 50cm in diameter, containing 16 litre of fluid.

Adults - The adult parasites in the dog represent one of the smallest of the tapeworms. They measure between 3 and 9mm in length, and usually consist of only 3 proglottids, an immature, a mature, and a gravid proglottid. The scolex is globular in shape, and has a prominent rostellum, armed with a double row of between 30 and 36 hooks. The eggs are very similar to those of the genus Taenia, and measure between 30 and 40µm in diameter

**Pathology of Infection**

Larvae - In domesticated animals clinical signs appear to be uncommon, whilst in man they will vary in their seriousness depending on where in the body the hydatid develops, and how large it grows. Sometimes, the infection is asymptomatic, the only evidence of infection being the presence of calcified cysts on autopsy after death due to an unrelated cause. The major pathology is due to the size of the cyst, giving rise to pressure related injury. A complication may arise if the cyst is ruptured, possibly due to blows to the body, muscular strain, or during operations.

In this case the contents of the hydatid are released into the body's circulatory system and the liberated protoscolices may give rise to numerous secondary cysts throughout the body. In addition, the hydatid cyst fluid is highly allergenic and cyst rupture may result in anaphylactic shock and rapid death.

Adults - The adult tapeworm is usually non-pathogenic to its canine hosts, although sometimes in very heavy infections there may be some inflammation of the intestinal wall.

**Echinococcus Multilocularis**
It is the causative agent of highly pathogenic Alveolar Hydatid disease in man and other mammals. The fox is the most important definitive host, although dogs, and occasionally cats, may also be infected with the adult parasite. Again, there appears to be a number of sub-species of this organism, E. m. multilocularis in Europe and E. m. sibiricencis in North America. This is very similar to that of E. granulosus, but with more adaptations for colder climates. For example, the eggs are highly resistant to cold temperatures, being able to survive at -20° for more than 2 weeks. In addition, the pre patent period in the definitive host is much shorter, usually between 4 to 5 weeks.

**Morphology**
Larvae - The larval E. multilocularis is very different from that of E. granulosus. In this case the 'cyst' grows invasively by external budding, forming a diffuse growth through the infected organ, replacing that organ's tissues. The growth itself, (it cannot truly be called a cyst as there is no real cyst wall), is composed of numerous cavities containing a gelatinous matrix within which protoscolices and numerous brood capsules are produced, and which in its behaviour, most closely resembles a malignant neoplasm. In contrast to E. granulosus this growth is also very rapid, infective protoscolesces being present after only 2 to 3 months, as compared to the 1 to 2 years in the related metacestode.

Adults - The adult parasite is very similar to E. granulosus, being slightly smaller, with a maximum length of approximately 4mm, and consisting of 4 to 5 proglottids.

**Pathology of Infection**
Larvae - The multilocular cyst is highly pathogenic due to its fast growth rate and invasive nature, in extreme cases completely replacing liver tissue. As the cyst lacks the tough laminated layer seen in E. granulosus, and by its nature grows by budding, metastases of growth may also be seen, colonising other body organs. Due to this aspect of the parasite, it may also be transferred by transplantation. This parasite must be considered one of the most pathogenic of the parasitic helminths.

Adults - As with E. granulolsus the adult tapeworm is usually non-pathogenic to its canine hosts.

## 4.0 Conclusion

In this unit, we have discussed about tape worms and their effect on humans, how they occur in humans.

## 5.0 Summary

In this unit, you have learnt about the two major tape worms infecting man; Taenia saginata (beef tape worms) and T. solium (pork tape worm). Infections by these tapeworms often occur following the consumption of raw or undercooked beef and pork. Others Taenia spp which have man as accidental host are T. taeniformis, T. bremneri, T.multiceps, T. serialis and T. glomerulatus.

Dog and other canids are the definitive hosts of Echinococcus granulosus with the hydatid cyst of the parasite causing the pathological effects seen in man. Proper cooking of beef and pork could prevent infection due to T. saginata and T. solium while good sanitary condition can as well prevent infection by E. granulosus.

## 6.0 Self-Assessment Exercise

Activity: Conduct a physical examination of the various types of taenia spp and report your findings in the log book.

Answer the following questions:

1. Briefly discuss the epidemiology and control of human tapeworms (LO1)
2. Highlight the pathology control measures of Echinococcus granulosus (LO3)
3. Describe the morphology of describe the morphology of Taenia saginata, Taenia solium, T. solium (LO2)

## 7.0 References/ Further Reading

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