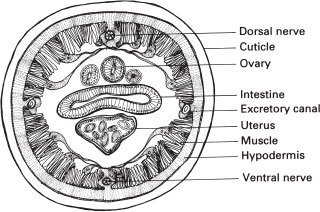
Bottom of Form

**Parasite taxonomy and morphology**

*Trichostrongylus, Ostertagia, Dictyocaulus,*  *Haemonchus* etc. Buccal capsule small. Life cycle **direct**; infection by L3 **Strongyloidea**  *Strongylus, Syngamus* etc. Buccal capsule well developed; leaf crowns and teeth usually present. Life cycle **direct**; infection by L3 **Ancylostomatoidea***Ancylostoma, Uncinaria* etc. **Metastrongyloidea**  *Metastrongylus, Muellerius,  Protostrongylus* etc. Buccal capsule small. Life cycle **indirect**; infection by L3 in intermediate host **Non-bursate nematodes**   **Rhabditoidea**  *Strongyloides, Rhabditis* etc. Very small worms; buccal capsule small. Free-living and parasitic generations. Life cycle **direct**; infection by L3   **Ascaridoidea**  *Ascaris, Toxocara, Parascaris* etc. Large white worms. Life cycle **direct**; infection by L2 in egg   **Oxyuroidea**  *Oxyuris, Skrjabinema* etc. Female has long, pointed tail. Life cycle **direct**; infection by L3 in egg   **Spiruroidea**  *Spirocerca, Habronema, Thelazia* etc. Spiral tail in male. Life cycle **indirect**; infection by L3 from insect   **Filarioidea**  *Dirofilaria, Onchocerca, Parafilaria* etc. Long thin worms. Life cycle **indirect**; infection by L3 from insect   **Trichuroidea**  *Trichuris, Capillaria, Trichinella* etc. Whip-like or hair-like worms. Life cycle **direct** or **indirect**; infection by L1   **Dioctophymatoidea**  *Dioctophyma* etc. Very large worms. Life cycle **indirect**; infection by L3 in aquatic annelids

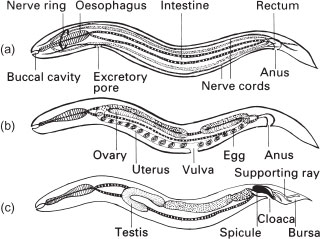
[**Fig. 1.1**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_1) Transverse section of a generalised female nematode.



The **digestive system** is tubular ([Fig. 1.2a](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_2)). The mouth of many nematodes is a simple opening, which may be surrounded by two or three lips, and leads directly into the oesophagus. In others, such as the strongyloids, it is large, and opens into a **buccal capsule**, which may contain teeth. Such parasites, when feeding, draw a plug of mucosa into the buccal capsule, where it is broken down by the action of enzymes, which are secreted into the capsule from adjacent glands. Some of these worms may also secrete anticoagulant, and small vessels, ruptured in the digestion of the mucosal plug, may continue to bleed for some minutes after the worm has moved to a fresh site.

Those with very small buccal capsules, like the trichostrongyloids, or simple oral openings, like the ascaridoids, generally feed on mucosal fluid, products of host digestion and cell debris, while others, such as the oxyuroids, appear to scavenge on the contents of the lower gut. Worms living in the bloodstream or tissue spaces, such as the filarioids, feed exclusively on body fluids.

[**Fig. 1.2**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_2) Longitudinal sections of a generalised nematode. (a) Digestive, excretory and nervous system. (b) Reproductive system of a female nematode. (c) Reproductive system of a male nematode.



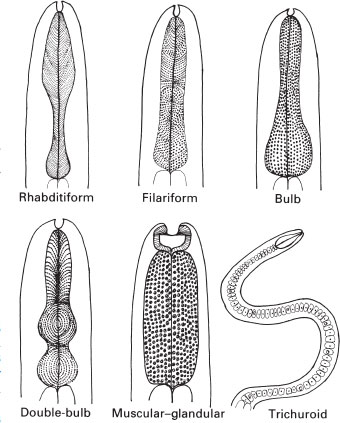
The **oesophagus** is usually muscular and pumps food into the intestine. It is of variable form ([Fig. 1.3](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_3)), and is a useful preliminary identification character for groups of worms. It may be **filariform**, simple and slightly thickened posteriorly, as in the bursate nematodes; **bulb-shaped**, with a large posterior swelling, as in the ascaridoids; or **double bulb-shaped**, as in the oxyuroids. In some groups this wholly muscular form does not occur: the filarioids and spiruroids have a **muscular–glandular** oesophagus which is muscular anteriorly, the posterior part being glandular; the **trichuroid** oesophagus has a capillary form, passing through a single column of cells, the whole being known as a stichosome. A **rhabditiform** oesophagus, with slight anterior and posterior swellings, is present in the preparasitic larvae of many nematodes, and in adult free-living nematodes.

The **intestine** is a tube whose lumen is enclosed by a single layer of cells or by a syncytium. The luminal surfaces possess microvilli, which increase the absorptive capacity of the cells. In female worms the intestine terminates in an anus, while in males there is a cloaca which functions as an anus, and into which opens the vas deferens and through which the copulatory spicules may be extruded.

The so-called ‘**excretory system**’ is very primitive, consisting of a canal within each lateral cord joining at the excretory pore in the oesophageal region.

The **reproductive systems** consist of filamentous tubes. The **female organs** comprise ovary, oviduct and uterus, which may be paired, ending in a common short vagina, which opens at the vulva ([Fig. 1.2b](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_2)). At the junction of uterus and vagina in some species there is a short muscular organ, the ovejector, which assists in egg laying. A vulval flap may also be present.

[**Fig. 1.3**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_3) The basic forms of oesophagus found in nematodes.

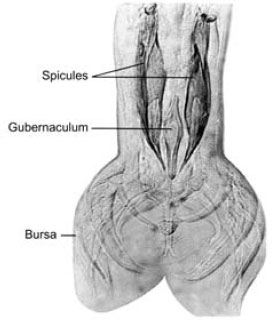


The **male organs** consist of a single continuous testis and a vas deferens terminating in an ejaculatory duct into the cloaca ([Fig. 1.2c](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_2)). Accessory male organs are sometimes important in identification, especially of the trichostrongyloids, the two most important being the spicules and gubernaculum ([Fig. 1.4](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_4)). The **spicules** are chitinous organs, usually paired, which are inserted in the female genital opening during copulation. The **gubernaculum**, also chitinous, is a small structure, which acts as a guide for the spicules. With the two sexes in close apposition the amoeboid sperm are transferred from the cloaca of the male into the uterus of the female.

The **cuticle** may be modified to form various structures (Figs [1.5a](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_5) and [1.5b](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_5)), the more important of which are:

**Leaf crowns** consisting of rows of papillae occurring as fringes round the rim of the buccal capsule (external leaf crowns) or just inside the rim (internal leaf crowns). They are especially prominent in certain nematodes of horses. Their function is not known, but it is suggested that they may be used to pin a patch of mucosa in position during feeding, or that they may prevent the entry of foreign matter into the buccal capsule when the worm has detached from the mucosa.

[**Fig. 1.4**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_4) Male trichostrongylid nematode bursa showing spicules and bursa.



**Cervical papillae** occur anteriorly in the oesophageal region, and **caudal papillae** posteriorly at the tail. They are spine-like or finger-like processes, and are usually diametrically placed. Their function may be sensory or supportive.

**Cervical** and **caudal alae** are flattened wing-like expansions of the cuticle in the oesophageal and tail regions.

**Cephalic** and **cervical vesicles** are inflations of the cuticle around the mouth opening and in the oesophageal region.

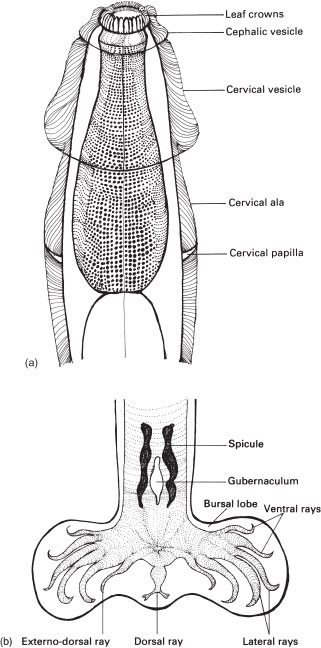
The **copulatory bursa**, which embraces the female during copulation, is important in the identification of certain male nematodes and is derived from much expanded caudal alae, which are supported by elongated caudal papillae called **bursal rays**. It consists of two lateral lobes and a single small dorsal lobe.

**Plaques** and **cordons** are plate-like and cord-like ornamentations present on the cuticle of many nematodes of the superfamily Spiruroidea.

***BASIC NEMATODE LIFE CYCLE***

In the Nematoda, the sexes are separate and the males are generally smaller than the females, which lay eggs or larvae. During development, a nematode moults at intervals, shedding its cuticle. In the complete life cycle there are four moults, the successive larval stages being designated L1, L2, L3, L4 and finally L5, which is the immature adult.

[**Fig. 1.5**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_5) Cuticular modifications of a generalised nematode. (a) Anterior region. (b) Posterior region of a male.



One feature of the basic nematode life cycle is that immediate transfer of infection from one **final host** to another rarely occurs. Some development usually takes place either in the faecal pat or in a different species of animal, the **intermediate host**, before infection can take place.

In the common form of **direct** life cycle, the free-living larvae undergo two moults after hatching and infection is by ingestion of the free L3. There are some important exceptions however, infection sometimes being by larval penetration of the skin or by ingestion of the egg containing a larva.

In **indirect** life cycles, the first two moults usually take place in an intermediate host and infection of the final host is either by ingestion of the intermediate host or by inoculation of the L3 when the intermediate host, such as a blood-sucking insect, feeds.

After infection, two further moults take place to produce the L5 or immature adult parasite. Following copulation a further life cycle is initiated.

In the case of gastrointestinal parasites, development may take place entirely in the gut lumen or with only limited movement into the mucosa.

However, in many species, the larvae travel considerable distances through the body before settling in their final (predilection) site and this is the migratory form of life cycle. One of the most common routes is the **hepatic–tracheal**. This takes developing stages from the **gut** via the portal system to the **liver** then via the hepatic vein and posterior vena cava to the **heart** and from there via the pulmonary artery to the **lungs**. Larvae then travel via the bronchi, trachea and oesophagus to the **gut**. It should be emphasised that the above is a basic description of nematode life cycles and that there are many variations.

***DEVELOPMENT OF THE PARASITE***

***EGG***

Nematode eggs differ greatly in size and shape, and the shell is of variable thickness, usually consisting of three layers.

The inner membrane, which is thin, has lipid characteristics and is impermeable. A middle layer, which is tough and chitinous gives rigidity and, when thick, imparts a yellowish colour to the egg. In many species this layer is interrupted at one or both ends with an operculum (lid) or plug. The third outer layer consists of protein, which is very thick and sticky in the ascaridoids and is important in the epidemiology of this superfamily.

In contrast, in some species the eggshell is very thin and may be merely present as a sheath around the larva.

The survival potential of the egg outside the body varies, but appears to be connected with the thickness of the shell, which protects the larva from desiccation. Thus parasites whose infective form is the larvated egg usually have very thick-shelled eggs which can survive for years on the ground.

***HATCHING***

Depending on the species, eggs may hatch outside the body or after ingestion.

Outside the body, hatching is controlled partly by factors such as temperature and moisture and partly by the larva itself. In the process of hatching, the inner impermeable shell membrane is broken down by enzymes secreted by the larva and by its own movement. The larva is then able to take up water from the environment and enlarges to rupture the remaining layers and escape.

When the larvated egg is the infective form, the host initiates hatching after ingestion by providing stimuli for the larva, which then completes the process. It is important for each nematode species that hatching should occur in appropriate regions of the gut and hence the stimuli will differ, although it appears that dissolved carbon dioxide is a constant essential.

***LARVAL DEVELOPMENT AND SURVIVAL***

Three of the important superfamilies, the trichostrongyloids, the strongyloids and the rhabditoids, have a completely free-living preparasitic phase. The first two larval stages usually feed on bacteria, but the L3, sealed off from the environment by the retained cuticle of the L2, cannot feed and must survive on the stored nutrients acquired in the early stages. Growth of the larva is interrupted during moulting by periods of lethargus in which it neither feeds nor moves.

The cuticle of the L2 is retained as a sheath around the L3; this is important in larval survival with a protective role analogous to that of the eggshell in egg-infective groups.

The two most important components of the external environment are temperature and humidity. The optimal temperature for the development of the maximum number of larvae in the shortest feasible time is generally in the range 18–26°C. At higher temperatures, development is faster and the larvae are hyperactive, thus depleting their lipid reserves. The mortality rate then rises, so that few will survive to L3. As the temperature falls the process slows, and below 10°C the development from egg to L3 usually cannot take place. Below 5°C movement and metabolism of L3 is minimal, which in many species favours survival.

The optimal humidity is 100%, although some development can occur down to 80% relative humidity. It should be noted that even in dry weather where the ambient humidity is low, the microclimate in faeces or at the soil surface may be sufficiently humid to permit continuing larval development.

In the trichostrongyloids and strongyloids, the embryonated egg and the ensheathed L3 are best equipped to survive in adverse conditions such as freezing or desiccation; in contrast, the L1 and L2 are particularly vulnerable. Although desiccation is generally considered to be the most lethal influence in larval survival, there is increasing evidence that by entering a state of anhydrobiosis, certain larvae can survive severe desiccation.

On the ground most larvae are active; although they require a film of water for movement and are stimulated by light and temperature, it is now thought that larval movement is mostly random and encounter with grass blades accidental.

***INFECTION***

As noted previously, infection may be by ingestion of the free-living L3, and this occurs in the majority of trichostrongyloid and strongyloid nematodes. In these, the L3 sheds the retained sheath of the L2 within the alimentary tract of the host, the stimulus for exsheathment being provided by the host in a manner similar to the hatching stimulus required by egg-infective nematodes. In response to this stimulus the larva releases its own exsheathing fluid, containing an enzyme leucine aminopeptidase, which dissolves the sheath from within, either at a narrow collar anteriorly so that a cap detaches, or by splitting the sheath longitudinally. The larva can then wriggle free of the sheath.

As in the preparasitic stage, growth of the larva during parasitic development is interrupted by two moults, each of these occurring during a short period of lethargus.

The time taken for development from infection until mature adult parasites are producing eggs or larvae is known as the **prepatent period** and this is of known duration for each nematode species.

***METABOLISM***

The main food reserve of preparasitic nematode larvae, whether inside the egg shell or free-living, is lipid, which may be seen as droplets in the lumen of the intestine. The infectivity of these stages is often related to the amount present; larvae which have depleted their reserves are not as infective as those which still retain quantities of lipid.

Apart from these reserves the free-living first and second stage larvae of most nematodes feed on bacteria. However, once they reach the infective third stage, they are sealed in the retained cuticle of the second stage, cannot feed and are completely dependent on their stored reserves.

In contrast, the adult parasite stores its energy as glycogen, mainly in the lateral cords and muscles, and this may constitute 20% of the dry weight of the worm.

Free-living and developing stages of nematodes usually have an aerobic metabolism, whereas adult nematodes can metabolise carbohydrate by both glycolysis (anaerobic) and oxidative decarboxylation (aerobic). However, in the latter, pathways may operate which are not present in the host and it is at this level that some antiparasitic drugs operate.

The oxidation of carbohydrates requires the presence of an electron transport system, which in most nematodes can operate aerobically down to oxygen tensions of 5.0 mmHg or less. Since the oxygen tension at the mucosal surface of the intestine is around 20 mmHg, nematodes in close proximity to the mucosa normally have sufficient oxygen for aerobic metabolism. Otherwise, if the nematode is temporarily or permanently some distance from the mucosal surface, energy metabolism is probably largely anaerobic.

As well as the conventional cytochrome and flavoprotein electron transport system, many nematodes have ‘haemoglobin’ in their body fluids which gives them a red pigmentation. This nematode haemoglobin is chemically similar to myoglobin and has the highest affinity for oxygen of any known animal haemoglobin. The main function of nematode haemoglobin is thought to be to transport oxygen, acquired by diffusion through the cuticle or gut, into the tissues; blood-sucking worms presumably ingest a considerable amount of oxygenated nutrients in their diet.

The end products of the metabolism of carbohydrates, fats or proteins are excreted through the anus or cloaca, or by diffusion through the body wall. Ammonia, the terminal product of protein metabolism, must be excreted rapidly and diluted to nontoxic levels in the surrounding fluids. During periods of anaerobic carbohydrate metabolism, the worms may also excrete pyruvic acid rather than retaining it for future oxidation when aerobic metabolism is possible.

The ‘excretory system’ terminating in the excretory pore is almost certainly not concerned with excretion, but rather with osmoregulation and salt balance.

Two phenomena which affect the normal parasitic life cycle of nematodes and which are of considerable biological and epidemiological importance are **arrested** **larval development** and the **periparturient rise** in faecal egg counts.

***ARRESTED LARVAL DEVELOPMENT***

(synonyms: inhibited larval development, hypobiosis) This phenomenon may be defined as the temporary cessation in development of a nematode at a precise point in its parasitic development. It is usually a facultative characteristic and affects only a proportion of the worm population. Some strains of nematodes have a high propensity for arrested development while in others this is low.

Conclusive evidence for the occurrence of arrested larval development can only be obtained by examination of the worm population in the host. It is usually recognised by the presence of large numbers of larvae at the same stage of development in animals withheld from infection for a period longer than that required to reach that particular larval stage.

The nature of the stimulus for arrested development and for the subsequent maturation of the larvae is still a matter of debate. Although there are apparently different circumstances which initiate arrested larval development, most commonly the stimulus is an environmental one received by the free-living infective stages prior to ingestion by the host. It may be seen as a ruse by the parasite to avoid adverse climatic conditions for its progeny by remaining sexually immature in the host until more favourable conditions return. The name commonly applied to this seasonal arrestment is **hypobiosis**. Thus the accumulation of arrested larvae often coincides with the onset of cold autumn/winter conditions in the northern hemisphere, or very dry conditions in the subtropics or tropics. In contrast, the maturation of these larvae coincides with the return of environmental conditions suitable to their free-living development, although it is not clear what triggers the signal to mature and how it is transmitted.

The degree of adaptation to these seasonal stimuli and therefore the proportion of larvae which do become arrested seems to be a heritable trait and is affected by various factors, including grazing systems and the degree of adversity in the environment. For example, in Canada where the winters are severe, most trichostrongyloid larvae ingested in late autumn or winter become arrested, whereas in southern Britain with moderate winters, about 50–60% are arrested. In the humid tropics where free-living larval development is possible all the year round, relatively few become arrested.

However, arrested development may also occur as a result of both acquired and age immunity in the host and, although the proportions of larvae arrested are not usually so high as in hypobiosis, they can play an important part in the epidemiology of nematode infections. Maturation of these arrested larvae seems to be linked with the breeding cycle of the host and occurs at or around parturition.

The epidemiological importance of arrested larval development from whatever cause is that, first, it ensures the survival of the nematode during periods of adversity; secondly, the subsequent maturation of arrested larvae increases the contamination of the environment and can sometimes result in clinical disease.

***PERIPARTURIENT RISE (PPR) IN FAECAL EGG COUNTS***

(Synonyms: post-parturient rise, spring rise.)

This refers to an increase in the numbers of nematode eggs in the faeces of animals around parturition.

This phenomenon is most marked in ewes, goats and sows and recent data supports the hypothesis that there is competition between the immune system, the rapidly growing fetus in late pregnancy and the udder during lactation, for nutrients, particularly metabolisable protein. This relaxation of immunity can be largely restored by supplementation with rumen-undegradable protein and is also influenced by the body protein status of the ewe.

The source of the PPR is three-fold:

(1) Maturation of larvae arrested due to host immunity.

(2) An increased establishment of infections acquired from the pastures and a reduced turnover of existing adult infections.

(3) An increased fecundity of existing adult worm populations.

Contemporaneously, but not associated with the relaxation of host immunity, the PPR may be augmented by the maturation of hypobiotic larvae.

The importance of the PPR is that it occurs at a time when the numbers of new susceptible hosts are increasing and so ensures the survival and propagation of the worm species. Depending on the magnitude of infection, it may also cause a loss of production in lactating animals and, by contamination of the environment, lead to clinical disease in susceptible young stock.

**NEMATODE SUPERFAMILIES**

**Superfamily TRICHOSTRONGYLOIDEA**

The trichostrongyloids are small, often hair-like, worms in the bursate group, which, with the exception of the lungworm *Dictyocaulus*, parasitise the alimentary tract of animals and birds. Structurally they have few cuticular appendages and the buccal capsule is vestigial. The males have a well developed bursa and two spicules, the configuration of which is used for species differentiation. The life cycle is direct and usually non-migratory and the ensheathed L3 is the infective stage.

The trichostrongyloids, including *Dictyocaulus*, are responsible for considerable mortality and widespread morbidity, especially in ruminants. The most important alimentary genera are *Ostertagia, Teladorsagia, Haemonchus, Trichostrongylus, Cooperia, Nematodirus, Hyostrongylus, Marshallagia* and *Mecistocirrus*. Other genera of lesser importance are *Amidostomum, Ollulanus, Ornithostrongylus* and *Impalaia*.

**Superfamily STRONGYLOIDEA**

There are several important parasites of domestic mammals and birds in this superfamily of bursate nematodes.

Most are characterised by a large buccal capsule, which often contains teeth or cutting plates, and in some there are prominent leaf crowns surrounding the mouth opening. The adults occur on mucosal surfaces of the gastrointestinal and respiratory tracts and feeding is generally by the ingestion of plugs of mucosa.

With the exception of three genera, *Syngamus, Mammomonogamus* and *Cyathostoma*, which are parasitic in the trachea and major bronchi, and *Stephanurus* found in the peri-renal area, all other genera of veterinary importance in this superfamily are found in the intestine and can be conveniently divided into two groups, the **strongyles** and **hookworms**.

The strongyles are parasitic in the large intestine and the important genera are *Strongylus, Triodontophorus, Chabertia* and *Oesophagostomum*. The cyathostomins (cyathostomes or trichonemes) of horses include the genera *Cyathostomum, Cylicocyclus, Cylicodontophorus* and *Cylicostephanus*.

*Syngamus* and *Cyathostoma* are important parasites of the respiratory tract of birds. *Mammomonogamus* are parasites of the respiratory tract of cattle, sheep and goats.

**Superfamily ANCYLOSTOMATOIDEA**

Hookworms are parasites of the small intestine and the genera of veterinary importance are *Ancylostoma, Uncinaria, Bunostomum* and to a lesser extent, *Gaigeria* and *Agriostomum*.

In humans important hookworm genera are *Ancylostoma* and *Necator*.

**Superfamily METASTRONGYLOIDEA**

Most worms in this superfamily inhabit the lungs or the blood vessels adjacent to the lungs. The typical life cycle is indirect, and the intermediate host is usually a mollusc.

They may be conveniently divided into three groups according to host: those occurring in pigs (*Metastrongylus*), in sheep and goats (*Muellerius, Protostrongylus, Cystocaulus, Spiculocaulus* and *Neostrongylus*), and in the domestic and wild carnivores (*Oslerus, Filaroides, Aelurostrongylus, Angiostrongylus, Crenosoma, Anafilaroides, Metathelazia* and *Gurltia*).

*Elaphostrongylus* occurs in deer in Europe; *Parelaphostrongylus* occurs in deer and camelids in North America.

**Superfamily RHABDITOIDEA**

This is a primitive group of nematodes which are mostly free-living, or parasitic in lower vertebrates and invertebrates. Although a few normally free-living genera such as *Halicephalobus* (*Micronema*) and *Rhabditis* occasionally cause problems in animals, the only important genus from the veterinary point of view is *Strongyloides*.

**Superfamily ASCARIDOIDEA**

The ascaridoids are among the largest nematodes and occur in most domestic animals, both larval and adult stages being of veterinary importance. While the adults in the intestine may cause unthriftiness in young animals, and occasional obstruction, an important feature of the group is the pathological consequences of the migratory behaviour of the larval stages.

With a few exceptions the genera have the following characters in common. They are large, white opaque worms, which inhabit the small intestine. There is no buccal capsule, the mouth consisting simply of a small opening surrounded by three lips. The common mode of infection is by ingestion of the thick-shelled egg containing the L2. However, the cycle may involve transport and paratenic hosts.

Genera of veterinary interest are *Ascaris, Toxocara, Toxascaris, Parascaris, Ascaridia, Heterakis* and to a lesser extent the anisakids (*Anisakis, Contracaecum, Hysterothylacium, Pseudoterranova, Angusticaecum*).

**Superfamily OXYUROIDEA**

Adult oxyuroids of animals inhabit the large intestine and are commonly called pinworms because of the pointed tail of the female parasite. They have a double bulb oesophagus and a direct life cycle. The genera of veterinary interest are *Oxyuris* and *Probstmayria*, both parasitic in the horse; *Skrjabinema*, which is a parasite of ruminants; *Paraspidodera* in guinea pigs; and *Subulura* (Subuluroidea) which are parasites of poultry. Oxyurids include the common human pinworm, *Enterobius*.

**Superfamily SPIRUROIDEA**

The precise classification of a number of genera currently assigned to this superfamily is controversial, but there are some of significance in veterinary medicine: *Spirocerca, Habronema, Draschia, Parabronema, Thelazia, Gnathostoma, Gongylonema* and to a lesser extent *Ascarops, Physocephalus, Simondsia, Physaloptera, Spirura, Echinuria, Dispharynx, Tetrameres, Streptocara, Cheilospirura, Histiocephalus, Hartertia* and *Oxyspirura*. A major characteristic of this group is the tight spirally coiled tail of the male. The life cycles are indirect involving arthropod intermediate hosts.

Members of the genus *Thelazia* are principally found in or around the eyes of animals and can be responsible for keratitis. Unlike most spiruroids, the L1 stage is not ingested from the faeces, but by flies feeding on ocular secretions.

The genus *Gongylonema* is unusual among the spiruroids in having a very wide final host range, which includes all the domesticated animals, though it is most prevalent in ruminants. Like most spiruroids the favoured location of the adults is in the upper alimentary tract, in the oesophagus, and in the forestomachs and stomach of mammals and the crop of birds.

**Superfamily FILARIOIDEA**

This superfamily is closely related to the Spiruroidea and, as in the latter, all its genera have indirect life cycles. None of them inhabits the alimentary tract, and they depend upon insect vectors for transmission.

Within the superfamily, differences in biological behaviour are seen, the more primitive forms laying eggs, which are available to the vectors in dermal exudates, and the more highly evolved forms laying larvae, termed microfilariae. The latter, which may be enclosed in a flexible, sheath-like ‘egg shell’ are taken up by parasitic insects feeding on blood and tissue fluids. In some species, the microfilariae only appear in the peripheral blood and tissues at regular intervals, some appearing in the daytime and others at night; this behaviour is termed diurnal or nocturnal periodicity.

Genera of interest in veterinary medicine include *Parafiliaria, Stephanofilaria, Dirofilaria, Dipetalonema, Onchocerca, Setaria, Elaeophora, Ornithofilaria* and *Pelecitus*. Of greater importance in human medicine are the genera *Onchocera, Brugia, Loa, Wuchereria* and *Mansonella*.

***FILARIOSIS IN MAN***

Though they are probably the most important group of helminth infections in humans, filarioid nematodes are of only marginal concern to the veterinarian, since domestic animals are of little significance in their epidemiology. The following are the most important species in man:

1. *Onchocerca volvulus*. Human onchocercosis due to *O. volvulus* occurs around the world in the equatorial zone, and is transmitted by *Simulium* spp (black flies). The adult worms live in subcutaneous nodules, and almost the entire pathogenic effect is caused by the microfilariae; dermatitis and elephantiasis are common, but the most important effect is ocular onchocercosis (‘river blindness’), so-called because of its distribution along the habitats of *Simulium* spp. Dying microfilariae cause a sclerosing keratinitis in the cornea that leads to corneal opacification and retinochorioiditis. It has been estimated that in Africa there are about 20 million people affected by onchocercosis. The only other animals to which it is transmissible are the higher primates, chimpanzee and gorilla. Ivermectin is effective in reducing skin microfilarial counts in *O. volvulus* infection and repeated treatment should help reduce transmission. The onchocercosis associated pathology in the eye and skin has also been shown to be reduced with ivermectin treatment.

2. *Brugia* spp are carried by many species of mosquito and occur in Southeast Asia, notably in Malaysia, causing elephantiasis. The most important species, *B. malayi*, is also infective for monkeys and domestic and wild carnivores, and has been transmitted experimentally to the cat and dog. The lesser species occurring in man, *B. pahangi*, has a reservoir in many species of domestic and wild animals, including the dog and cat. Adult parasites inhabit lymph nodes and afferent lymphatic vessels.

3. *Wuchereria bancrofti* is also mosquito borne and affects the lymphatic system causing elephantiasis in Africa, Asia and South America. It is exclusive to man. As with *Brugia* spp, the main pathogenic effects are associated with adult worms rather than with microfilariae.

4. *Loa loa* is transmitted by *Chrysops* spp (tabanid flies), and occurs in west, central and east Africa, where it causes the transient subcutaneous enlargements known as ‘Calabar swellings’. It is confined to man, apes and monkeys. Longevity can be up to 20 years.

5. *Mansonella ozzardi*, carried by *Culicoides* spp and *Simulium* spp, occurs in the Caribbean, and in Central and South America. It lives in the fat and on the mesentery or pleural cavity, and is usually considered to be non-pathogenic, though recently it has been associated with allergic signs. The prevalence is extremely high in endemic areas, where parasites closely resembling *M. ozzardi* are commonly found in monkeys and in horses and cattle. There is, however, reluctance to presume that these animals may be reservoir hosts until positive identification is made.

**Superfamily TRICHUROIDEA**

The members of this superfamily are found in a wide variety of domestic animals. A common morphological feature is the ‘stichosome’ oesophagus that is composed of a capillary-like tube surrounded by a single column of cells.

There are three genera of interest. The first, *Trichuris*, is found in the caecum and colon of mammals; the second, *Capillaria*, is most commonly present in the alimentary or respiratory tract of mammals or birds. Both lay eggs with plugs at both poles. The adults of the third genus, *Trichinella*, are found in the small intestine of mammals and produce larvae, which immediately invade the tissues of the same host.

**Superfamily DIOCTOPHYMATOIDEA**

Species of veterinary interest in this superfamily are the ‘kidney worm’, *Dioctophyma renale; Hystrichis* and *Eustrongylides* occur in aquatic fowl.

**Superfamily DRACUNCULOIDEA**

Members of this superfamily are parasites of the subcutaneous tissues. The two genera of veterinary significance are *Dracunculus* and *Avioserpens*. The life cycle involves development in a species of *Cyclops* before becoming infective to the final host.

**Phylum ACANTHOCEPHALA**

This is a separate class, closely related to the Nematoda, which contains a few genera of veterinary importance. They are generally referred to as ‘thornyheaded worms’ due to the presence of a hook-covered proboscis anteriorly, and most are parasites of the alimentary tract of vertebrates. The hollow proboscis armed with recurved hooks, which aid in attachment, is retractable and lies in a sac. There is no alimentary canal, with absorption taking place through the thick cuticle, which is often folded and invaginated to increase the absorptive surface. The sexes are separate, males being much smaller than females. Posteriorly, the male has a muscular bursa and penis and, after copulation, eggs, discharged by ovaries into the body cavity of the female, are fertilised and taken up by a complex structure called the uterine bell, which only allows mature eggs to pass out. These are spindleshaped, thick-shelled and contain a larva which has an anterior circlet of hooks and spines on its surface and is called an **acanthor**. The life cycle is indirect, involving either an aquatic or terrestrial arthropod intermediate host. On ingestion by the intermediate host, the egg hatches and the acanthor migrates to the haemocoel of the arthropod where it develops to become a **cystacanth** after 1–3 months. The definitive host is infected by ingestion of the arthropod intermediate host, and the cystacanth, which is really a young adult, attaches and grows to maturity in the alimentary canal. The prepatent period varies from 5–12 weeks.

**Family OLIGACANTHORHYNCHIDAE**

The major genus of veterinary significance is *Macracanthorhynchus*, which is found in pigs.

**Family POLYMORPHIDAE**

A few genera are parasites of rodents (*Moniliformis*) aquatic birds (*Polymorphus, Filicollis*) and fishes (*Echinorhynchus, Acanthocephalus*).

**Phylum PLATYHELMINTHES**

This phylum contains the two classes of parasitic flatworms, the **Trematoda** and the **Cestoda**.

**Class TREMATODA**

The class Trematoda falls into two main subclasses, the **Monogenea**, which have a direct life cycle, and the **Digenea**, which require an intermediate host. The former are found mainly as external parasites of fish, while the latter are found exclusively in vertebrates and are of considerable veterinary importance.

The adult digenetic trematodes, commonly called ‘flukes’, occur primarily in the bile ducts, alimentary tract and vascular system. Most flukes are flattened dorsoventrally, have a blind alimentary tract, suckers for attachment and are hermaphrodite. Depending on the predilection site, the eggs pass out of the final host, usually in faeces or urine, and the larval stages develop in a molluscan intermediate host. For a few species, a second intermediate host is involved, but the mollusc is essential for all members of the group.

There are many families in the class Trematoda, and those which include parasites of major veterinary importance are the Fasciolidae, Dicrocoeliidae, Paramphistomidae and Schistosomatidae. Of lesser importance are the Troglotrematidae and Opisthorchiidae. The most important group by far are the Fasciolidae and the discussion below of structure, function, and life cycle is largely orientated towards this group.

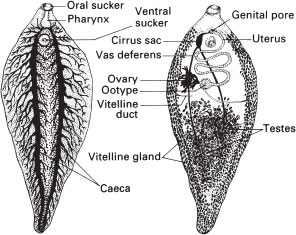
**Subclass DIGENEA**

***STRUCTURE AND FUNCTION OF DIGENETIC TREMATODES***

The adult possesses two muscular suckers for attachment. The oral sucker at the anterior end surrounds the mouth, and the ventral sucker, as the name indicates, is on that surface. The body surface is a tegument, which is absorptive and is often covered with spines. The muscles lie immediately below the tegument. There is no body cavity and the organs are packed in a parenchyma ([Fig. 1.6](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_6)).

The digestive system is simple, the oral opening leading into a pharynx, oesophagus and a pair of branched intestinal caeca, which end blindly. Undigested material is presumably regurgitated. The excretory system consists of a large number of ciliated flame cells, which impel waste metabolic products along a system of tubules, which ultimately join and open to the exterior. The nervous system is simple, consisting of a pair of longitudinal trunks connecting anteriorly with two ganglia.

[**Fig. 1.6**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_6) Internal structure of a generalised digenetic trematode.



The trematodes are usually hermaphrodite and both cross- and self-fertilisation may occur. The male reproductive system consists of a pair of testes each leading into a vas deferens; these join to enter the cirrus sac containing a seminal vesicle and the cirrus, a primitive penis which terminates at the common genital opening ([Fig. 1.6](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_6)). The female system has a single ovary leading into an oviduct, which is expanded distally to form the ootype. There the ovum acquires a yolk from the secretion of the vitelline glands and ultimately a shell. As the egg passes along the uterus, the shell becomes hardened and toughened and is finally extruded through the genital opening adjacent to the ventral sucker. The mature egg is usually yellow because of the tanned protein shell and most species have an operculum.

Food, generally blood or tissue debris, is ingested and passed into the caeca where it is digested and absorbed. Metabolism appears to be primarily anaerobic.

***LIFE CYCLE OF DIGENETIC TREMATODES***

The essential point of the life cycle is that whereas one nematode egg can develop into only one adult, one trematode egg may eventually develop into hundreds of adults. This is due to the phenomenon of asexual multiplication, **parthenogony**, in the molluscan intermediate host, i.e. the production of new individuals by single larval forms.

The adult flukes are always oviparous and lay eggs with an operculum or lid at one pole. In the egg the embryo develops into a pyriform (pear-shaped), ciliated larva called a **miracidium**. Under the stimulus of light, the miracidium releases an enzyme, which attacks the proteinaceous cement holding the operculum in place. The latter springs open like a hinged lid and the miracidium emerges within a few minutes.

The miracidium, propelled through the water by its cilia, does not feed and must, for its further development, find a suitable snail within a few hours. It is believed to use chemotactic responses to ‘home’ in on the snail and, on contact, it adheres by suction to the snail and penetrates its soft tissues aided by a cytolytic enzyme. The entire process of penetration takes about 30 minutes, after which the cilia are lost and the miracidium develops into an elongated sac, the **sporocyst**, containing a number of germinal cells. These cells develop into **rediae**, which migrate to the hepato-pancreas of the snail; rediae are also larval forms possessing an oral sucker, some flame cells and a simple gut. From the germinal cells of the rediae arise the final stages, the **cercariae**, although if environmental conditions for the snail are unsuitable, a second or daughter generation of rediae is often produced instead. The cercariae, in essence young flukes with long tails, emerge actively from the snail, usually in considerable numbers. The actual stimulus for emergence depends on the species, but is most commonly a change in temperature or light intensity. Once a snail is infected, cercariae continue to be produced indefinitely, although the majority of infected snails die prematurely from gross destruction of the hepato-pancreas.

Typically the cercariae swim for some time, utilising even a film of water, and within an hour or so attach themselves to vegetation, shed their tails and encyst. This stage is called a **metacercaria**.

Encysted metacercariae have great potential for survival extending to months. Once ingested, the outer cyst wall is removed mechanically during mastication. Rupture of the inner cyst occurs in the intestine and depends on a hatching mechanism, enzymatic in origin, triggered by a suitable oxidation-reduction potential and a carbon dioxide system provided by the intestinal environment. The emergent juvenile fluke then penetrates the intestine and migrates to the predilection site where it becomes adult after several weeks.

**Family FASCIOLIDAE**

These are large leaf-shaped flukes. The anterior end is usually prolonged into the shape of a cone and the anterior sucker is located at the end of the cone. The ventral sucker is placed at the level of the ‘shoulders’ of the fluke. The internal organs are branched while the cuticle is covered in spines. There are three important genera: *Fasciola, Fascioloides* and *Fasciolopsis*.

**Family DICROCOELIIDAE**

These trematodes are small, lancet-like flukes occurring in the biliary and pancreatic ducts of vertebrates. Miracidia are present in the eggs when they are passed in the faeces; there is no redial stage during development in the snail and two to three intermediate hosts may be involved in the life cycle. Members of this family are found in ruminants (*Dicrocoelium, Eurytrema*), and cats (*Platynosomum*).

**Family PARAMPHISTOMATIDAE**

Adult paramphistomes are mainly parasitic in the forestomachs of ruminants, although a few species occur in the intestine of ruminants, pigs and horses. Their shape is not typical of the trematodes, being conical rather than flat. All require a water snail as an intermediate host. There are several genera: *Paramphistomum, Cotylophoron, Bothriophoron, Orthocoelium* (syn *Ceylonocotyle*), *Gastrodiscus, Homologaster* and *Explanatum* (syn *Gigantocotyle*), of which *Paramphistomum* is the most common and widespread.

**Family TROGLOTREMATIDAE**

Several genera are of local veterinary interest. *Paragonimus*, commonly referred to as the ‘lung fluke’, is found in cats, dogs and other carnivores and in man in North America and Asia. The cycle involves a water snail and a crayfish or fresh water crab. Pulmonary signs are comparatively rare in cats or dogs and the veterinary interest is in the potential reservoir of infection for man.

The genus *Nanophyetus* is a fluke found mainly in the small intestine of dogs, mink and other fish-eating mammals. It occurs in the northwest United States and parts of Siberia and is of importance because the flukes are vectors of the rickettsial, *Neorickettsia helminthoeca*, which causes a severe haemorrhagic enteritis of dogs, the so-called ‘salmon poisoning’. This name is derived from the cycle of the fluke, which involves a water snail and a fish that is often one of the salmonid type.

The genus *Collyriclum* are parasites occurring within subcutaneous cysts in chickens, turkeys and wild birds. Intermediate hosts are snails and dragonflies.

**Family CYCLOCOELIDAE**

These are medium-sized to large fluke, parasites of aquatic birds in the body cavity, air sacs or nasal cavities. Genera include *Typhlocoelum* in the respiratory tract of ducks, and *Hyptiasmus* in the nasal and orbital sinuses of ducks and geese.

**Family OPISTHORCHIIDAE**

The members of this family require two intermediate hosts, the first being water snails and the second a wide variety of fish, in which the metacercariae are encysted. The final hosts are fish-eating mammals in which they inhabit the bile ducts.

*Opisthorchis* (syn *Clonorchis*) is by far the most important genus, with *Metorchis, Parametorchis* and *Pseudamphistomum* being of lesser importance.

**Family SCHISTOSOMATIDAE**

This family is primarily parasitic in the blood vessels of the alimentary tract and bladder. In man, schistosomes are often responsible for severe and debilitating disease and veterinary interest lies in the fact that they can cause a similar disease in animals, some of which may act as reservoirs of infection for man. The schistosomes differ from other flukes in that the sexes are separate, the small adult female lying permanently in a groove, the gynaecophoric canal, in the body of the male (see [Fig. 2.12](https://veteriankey.com/parasite-taxonomy-and-morphology/Chapter02.xhtml#fig2_12)). The most important genus is *Schistosoma* with *Bilharziella, Trichobilharzia, Orientobilharzia, Ornithobilharzia, Heterobilharzia* and *Austrobilharzia* other genera of lesser importance.

**Family DIPLOSTOMATIDAE**

The family Diplostomatidae includes the genera *Alaria* and *Diplostomum*. The life cycle involves two intermediate hosts, namely freshwater snails and frogs. The definitive host is infected through eating frogs containing encysted metacercariae (mesocercariae).

**Family ECHINOSTOMATIDAE**

The family Echinostomatidae includes the genera *Echinostoma, Echinoparyphium* and *Hypoderaeum*, which are parasites of birds, and *Echinochasmus* and *Euparyphium*, which are parasites of fish-eating mammals. The life cycle involves two intermediate hosts, namely freshwater snails and fish or frogs. The definitive host is infected through eating the second intermediate host containing encysted metacercariae (mesocercariae).

**Family NOTOCOTYLIDAE**

The family Notocotylidae includes the genera *Notocotylus, Paramonostomum* and *Catatropis*, which are parasites of birds, and *Cymbiforma*, which occur in sheep, goats and cattle. The small eggs are characterised by long filaments at the poles. The intermediate hosts are snails.

**Family BRACHYLAEMIDAE**

Members of this family are parasites of birds (*Brachylaemus*) or sheep (*Skrjabinotrema*). The intermediate hosts are snails.

**Family PLAGIORCHIIDAE**

*Plagiorchis* are parasites of birds. The life cycle involves two intermediate hosts, namely freshwater snails and larvae of dragonflies. The definitive host is infected through eating the dragonflies or their nymphs containing encysted metacercariae.

**Family PROSTHOGONIMIDAE**

*Prosthogonimus* are also parasites of birds with life cycles similar to *Plagiorchis*.

**Family HETEROPHYIDAE**

These are small trematodes found in the intestines of mammals and birds. The life cycle generally involves two intermediate hosts, namely freshwater snails and fishes or frogs. Genera of veterinary interest are *Heterophyes* found in dogs, cats, foxes and man; *Metagonimus* in the small intestines of dogs, cats, pigs and man; and *Rossicotrema* in cats, dogs, foxes and seals.

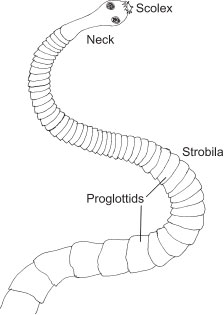
**Family STRIGEIDAE**

These worms are characterised by a constriction dividing the body into an anterior flattened adhesive organ and a posterior cylindrical part. They are parasites of the alimentary tract of birds. The life cycle involves two intermediate hosts, freshwater snails and a second host that may be a fish or leech. Genera include *Apatemon* and *Cotylurus* in the intestine of pigeons and ducks; and *Parastrigea* in ducks.

**Class CESTODA**

This class differs from the Trematoda in having a tape-like body with no alimentary canal. The body is segmented, each segment containing one and sometimes two sets of male and female reproductive organs. Almost all the tapeworms of veterinary importance are in the order Cyclophyllidea, the two exceptions being in the order Pseudophyllidea.

[**Fig. 1.7**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_7) Structure of a typical cyclophyllidean cestode.



**Order CYCLOPHYLLIDEA**

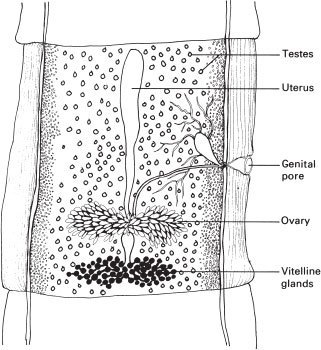
***STRUCTURE AND FUNCTION***

The adult cestode ([Fig. 1.7](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_7)) consists of a head or **scolex** bearing attachment organs, a short unsegmented neck and a chain of segments. The chain is known as a **strobila** and each segment as a **proglottid**.

The organs of attachment are four suckers on the sides of the scolex and these may bear hooks. The scolex usually bears anteriorly a mobile protrusible cone or rostellum and in some species this may be also armed with one or more concentric rows of hooks, which aid in attachment.

The proglottids are continuously budded from the neck region and become sexually mature as they pass down the strobila. Each proglottid is hermaphrodite with one or two sets of reproductive organs, the genital pores usually opening on the lateral margin or margins of the segment ([Fig. 1.8](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_8)); both self-fertilisation and cross-fertilisation between proglottids may occur. The structure of the genital system is generally similar to that of the trematodes. As the segment matures, its internal structure largely disappears and the fully ripe or gravid proglottid eventually contains only remnants of the branched uterus packed with eggs. The gravid segments are usually shed intact from the strobila and pass out with the faeces. Outside the body the eggs are liberated by disintegration of the segment or are shed through the genital pore.

[**Fig. 1.8**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_8) Mature segment illustrating the reproductive organs.



The fully embryonated egg consists of:

(1) The hexacanth (six-hooked) embryo or **oncosphere**.

(2) A thick, dark, radially striated ‘shell’ called the **embryophore**.

(3) A true shell, which is a delicate membrane and is often lost while still in the uterus.

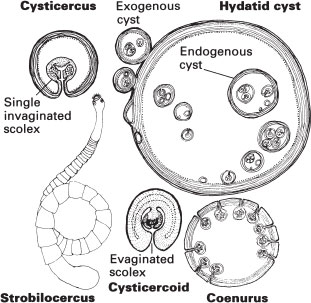
The tegument of the adult tapeworm is highly absorptive, the worm deriving all its nourishment through this structure. Below the tegument are muscle cells and the parenchyma, the latter a syncytium of cells, which fills the space between the organs. The nervous system consists of ganglia in the scolex from which nerves enter the strobila. The excretory system, as in the Trematoda, is composed of flame cells leading to efferent canals, which run through the strobila to discharge at the terminal segment.

***LIFE CYCLE***

The typical life cycle of these cestodes is indirect with one or more intermediate hosts. With few exceptions, the adult tapeworm is found in the small intestine of the final host, the segments and eggs reaching the exterior in the faeces.

When the egg is ingested by the intermediate host, the gastric and intestinal secretions digest the embryophore and activate the oncosphere. Using its hooks, it tears through the mucosa to reach the blood or lymph stream or, in the case of invertebrates, the body cavity. Once in its predilection site the oncosphere loses its hooks and develops, depending on the species, into one of the following larval stages, often known as **metacestodes** ([Fig. 1.9](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_9)):

[**Fig. 1.9**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_9) Larval stages of cyclophyllidean cestodes.



* **Cysticercus:** Fluid-filled cyst containing an attached single invaginated scolex, sometimes called a protoscolex.
* **Coenurus:** Similar to a cysticercus, but with numerous invaginated scolices.
* **Strobilocercus:** The scolex is evaginated and is connected to the cyst by a chain of asexual proglottids. The latter are digested away after ingestion by the final host, leaving only the scolex.
* **Hydatid:** This is a large fluid-filled cyst lined with germinal epithelium from which are produced invaginated scolices which lie free or in bunches, surrounded by germinal epithelium (brood capsules). The contents of the cysts other than the fluid, i.e. scolices and brood capsules, are frequently described as ‘hydatid sand’. Occasionally also, daughter cysts complete with cuticle and germinal layer are formed endogenously or, if the cyst wall ruptures, exogenously.
* **Cysticercoid:** A single evaginated scolex embedded in a small solid cyst. Typically found in very small intermediate hosts such as arthropods.
* **Tetrathyridium:** Worm-like larva with an invaginated scolex; found only in Mesocestoididae.

When the metacestode is ingested by the final host the scolex attaches to the mucosa, the remainder of the structure is digested off, and a chain of proglottids begins to grow from the base of the scolex.

The seven main families of veterinary interest in the order Cyclophyllidea are the *Taeniidae, Anoplocephalidae, Dilepididae, Davaineidae, Hymenolepididae, Mesocestoididae* and *Thysanosomidae*.

**Family TAENIIDAE**

The adults are found in domestic carnivores and man. The scolex has an armed rostellum with a concentric double row of hooks (the important exception is *Taenia saginata* whose scolex is unarmed). The gravid segments are longer than they are wide.

The intermediate stage is a cysticercus, strobilocercus, coenurus or hydatid cyst and these occur only in mammals.

Genera of importance are *Taenia* (syn *Multiceps*) and *Echinococcus*.

**Family ANOPLOCEPHALIDAE**

These are essentially tapeworms of horses (*Anoplocephala, Paranoplocephala*) and ruminants (*Moniezia*). The scolex has neither rostellum nor hooks and the gravid segments are wider than they are long. The intermediate stage is a cysticercoid present in forage mites of the family Oribatidae.

**Family DILEPIDIDAE**

These are tapeworms of the dog, cat (*Dipylidium*), and the fowl (*Amoebotaenia, Choanotaenia, Metroliasthes*). The scolex usually has an armed rostellum with several rows of hooks. The intermediate stage is a cysticercoid.

**Family DAVAINEIDAE**

These are mainly parasites of birds (*Davainea, Raillietina, Cotugnia*). These tapeworms usually have rows of hooks on both rostellum and suckers. The intermediate stage is a cysticercoid.

**Family HYMENOLEPIDIDAE**

These parasites are of minor veterinary importance. Members of this family, which have a characteristically slender strobila, infect birds, man and rodents (*Hymenolepis, Rodentolepis, Fimbriaria*). The intermediate stage is a cysticercoid present in an arthropod host.

**Family MESOCESTOIDIDAE**

Also of minor veterinary importance, these cestodes of carnivorous animals and birds have two metacestode stages. The first is a cysticercoid in an insect or mite, and the second a solid larval form, a tetrathyridium, in a vertebrate. Genera include *Mesocestoides* found in dogs, cats and wild mammals, and *Dithyridium* in chickens, turkeys and wild birds.

**Family THYSANOSOMIDAE**

Closely related to the Anoplocephalidae, this family contains several tapeworms of veterinary importance found mainly in sheep and other ruminants (*Stilesia, Thysanosoma, Thysaniezia* and *Avitellina*).

The intermediate stage is a cysticercoid present in forage mites of the family Oribatidae.

**Order PSEUDOPHYLLIDEA**

The morphology of the Pseudophyllidea is generally similar to that of the Cyclophyllidea, but there are two distinct features. First, the scolex has no suckers and instead has two longitudinal grooves or **bothria**, which become flattened to form organs of attachment. Secondly, the egg shell is thick, brown and operculate, and the **coracidium**, which emerges after hatching, is an oncosphere with an embryophore which is ciliated for mobility in water.

The pseudophyllidean life cycle utilises two intermediate hosts. The coracidium must first be ingested by a crustacean in whose body cavity a larval **procercoid** develops. Subsequently, if the crustacean is eaten by a freshwater fish, the procercoid is liberated, and in the muscles of the new host develops into a second larval stage, a **plerocercoid**, which possesses the characteristic scolex; it is only this stage which is infective to the final host.

This order contains only two genera of veterinary importance, *Diphyllobothrium* and *Spirometra*.

**Family DIPHYLLOBOTHRIIDAE**

The genus *Diphyllobothrium* is an important cestode of humans and fish-eating mammals. They are long tapeworms with an unarmed scolex, with two muscular bothria.

*Spirometra* are tapeworms of dogs, cats and wild carnivores and an occasional human zoonosis (sparganosis).

**ENTOMOLOGY**

Veterinary entomology, in its literal sense, means a study of insects of veterinary importance. This term, however, is commonly used to describe the wider study of all arthropods parasitic on animals, including arachnids such as ticks and mites.

**Phylum ARTHROPODA**

The phylum Arthropoda contains over 80% of all known animal species and consists of invertebrates whose major characteristics are a hard chitinous exoskeleton, a segmented body and jointed limbs.

***CLASSIFICATION***

There are two major classes of arthropods of veterinary importance, namely the Insecta and Arachnida, and the important orders in these classes are shown in Figs [1.10](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_10) and [1.11](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig1_11).

The two major classes can be differentiated by the following general characteristics:

**Insecta:** These have three pairs of legs, the head, thorax and abdomen are distinct, and they have a single pair of antennae.

**Arachnida:** The adults have four pairs of legs, the body is divided into the gnathosoma (mouthparts) and idiosoma (fused cephalo-thorax and abdomen); there are no antennae.

[**Fig. 1.10**](https://veteriankey.com/parasite-taxonomy-and-morphology/#fig_1_10) A flea (Siphonaptera) (a), louse (Phthiraptera) (b) and adult fly (Diptera) (c), showing the general morphological features of insect ectoparasites.

