**Flatworm**

**flatworm**, also called **platyhelminth**, any of the phylum Platyhelminthes, a group of soft-bodied, usually much flattened invertebrates. A number of flatworm species are free-living, but about 80 percent of all flatworms are parasitic—i.e., living on or in another organism and securing nourishment from it. They are bilaterally symmetrical (i.e., the right and left sides are similar) and lack specialized respiratory, skeletal, and circulatory systems; no body cavity (coelom) is present. The body is not segmented; spongy [connective tissue](https://www.britannica.com/science/connective-tissue) (mesenchyme) [constitutes](https://www.merriam-webster.com/dictionary/constitutes) the so-called parenchyma and fills the space between organs. Flatworms are generally hermaphroditic—functional reproductive organs of both sexes occurring in one individual. Like other advanced multicellular animals, they possess three embryonic layers—endoderm, mesoderm, and ectoderm—and have a head region that contains concentrated sense organs and nervous tissue (brain). Most evidence, however, indicates that flatworms are very primitive compared with other invertebrates (such as the arthropods and annelids). Some modern evidence suggests that at least some flatworm species may be secondarily simplified from more complex ancestors.

The phylum consists of four classes: **Trematoda (**[**flukes**](https://www.britannica.com/animal/fluke-flatworm)**), Cestoda (**[**tapeworms**](https://www.britannica.com/animal/tapeworm)**),**[**Turbellaria**](https://www.britannica.com/animal/turbellarian)**(planarians), and [Monogenea](https://www.britannica.com/animal/Monogenea)**.

It should be noted that some authorities consider Monogenea, which contains the order Aspidogastrea, to be a subclass within the class Trematoda. Members of all classes except Turbellaria are [parasitic](https://www.britannica.com/science/parasitism) during all or part of the [life cycle](https://www.britannica.com/dictionary/life%20cycle). Most turbellarians are exclusively free-living forms. More than 20,000 flatworm species have been described.

**General features**

**Importance**

Although some platyhelminths (flatworms) are free-living and nondestructive, many other species (particularly the flukes and tapeworms) parasitize humans, domestic animals, or both. In Europe, Australia, and North and South America, [tapeworm infestations](https://www.britannica.com/science/cestodiasis) of humans have been greatly reduced as a consequence of routine [meat](https://www.britannica.com/topic/meat) inspection. But where sanitation is poor and meat eaten undercooked, the incidence of tapeworm infestations is high. In the Baltic countries much of the population is infested with the broad tapeworm (*Diphyllobothrium latum*); in parts of the southern United States a small proportion of the population may be infested with the dwarf tapeworm (*Hymenolepis nana*). In Europe and the United States the beef tapeworm (*Taenia saginata*) is common because of the habit of eating undercooked steaks or other beef products.

Parasites in immature stages (larvae) can cause serious damage to the host. A larval stage of the gid parasite of [sheep](https://www.britannica.com/animal/domesticated-sheep) (*Multiceps multiceps*) usually lodges in the sheep [brain](https://www.britannica.com/science/brain). Fluid-filled [hydatid](https://www.britannica.com/science/echinococcosis) cysts (i.e., sacs containing many cells capable of developing into new individuals) of *Echinococcus* may occur almost anywhere in the body of sheep. In humans, hydatids of the liver, brain, or [lung](https://www.britannica.com/science/lung) are often fatal. Infestation occurs only where people live in close association with dogs that have access to infested sheep for food.

Thirty-six or more fluke species have been reported as parasitic in humans. [Endemic](https://www.merriam-webster.com/dictionary/Endemic) (local) centres of infection occur in virtually all countries, but widespread infections occur in the Far East, Africa, and tropical America. Many species are ingested as cysts, called metacercariae, in uncooked food—e.g., the lung fluke *Paragonimus westermani* found in crayfish and crabs, the intestinal flukes *Heterophyes heterophyes* and *Metagonimus yokogawai* and the liver fluke *Opisthorchis sinensis* in [fish](https://www.britannica.com/animal/fish), and the intestinal fluke *Fasciolopsis buski* on plants. Free-swimming [larvae](https://www.britannica.com/science/larva) (called cercariae) of [blood](https://www.britannica.com/science/blood-biochemistry) flukes penetrate the [human skin](https://www.britannica.com/science/human-skin) directly. In humans these parasites and others listed below cause much misery and death. Control of certain flukes through the eradication of their [mollusk](https://www.britannica.com/animal/mollusk) hosts has been attempted but without much success.

[Schistosomiasis](https://www.britannica.com/science/schistosomiasis) (bilharziasis) is a major [human disease](https://www.britannica.com/science/human-disease) caused by three species of the [genus](https://www.britannica.com/science/genus-taxon) *Schistosoma*, known collectively as blood flukes. Africa and western Asia (e.g., Iran, Iraq) are endemic centres for *S. haematobium*; *S. mansoni* also is found in these areas, as well as in the [West Indies](https://www.britannica.com/place/West-Indies-island-group-Atlantic-Ocean) and [South America](https://www.britannica.com/place/South-America). In the Far East, *S. japonicum* is the important blood [fluke](https://www.britannica.com/animal/fluke-flatworm).

Among domestic animals, the sheep [liver fluke](https://www.britannica.com/animal/liver-fluke-Fasciola-hepatica) (*Fasciola hepatica*) may cause debilitating and fatal [epidemics](https://www.merriam-webster.com/dictionary/epidemics) (liver rot) in sheep. These animals become infected by eating metacercariae encysted on grass. Monogenea are common pests on fish in hatcheries and home aquariums.

**Size range**

Most turbellarians are less than five millimetres (0.2 inch) long, and many are microscopic in size. The largest of this class are the [planarians](https://www.britannica.com/animal/planarian), which may reach 0.5 metre (about 20 inches) in length. Trematodes are mostly between about one and 10 millimetres (0.04 to 0.4 inch) long; members of some species, however, may grow to several centimetres. The smallest cestodes are about one millimetre (0.04 inch) long, but members of a few species exceed 15 metres (50 feet) in length. The Monogenea range in length from 0.5 to 30 millimetres (0.02 to 1.2 inches). Aspidogastrea are from a few millimetres to 100 millimetres in length.

**Distribution and abundance**

In general, free-living flatworms (the turbellarians) can occur wherever there is moisture. Except for the temnocephalids, flatworms are [cosmopolitan](https://www.merriam-webster.com/dictionary/cosmopolitan) in distribution. They occur in both fresh water and [salt water](https://www.britannica.com/science/seawater) and occasionally in moist terrestrial habitats, especially in tropical and subtropical regions. The temnocephalids, which are parasitic on freshwater crustaceans, occur primarily in Central and South America, Madagascar, [New Zealand](https://www.britannica.com/place/New-Zealand), Australia, and islands of the South Pacific.

Some flatworm species occupy a very wide range of habitats. One of the most cosmopolitan and most tolerant of different ecological conditions is the turbellarian *Gyratrix hermaphroditus*, which occurs in fresh water at elevations from [sea level](https://www.britannica.com/science/sea-level) to 2,000 metres (6,500 feet) as well as in saltwater pools. Adult forms of parasitic flatworms are [confined](https://www.britannica.com/dictionary/confined) almost entirely to specific [vertebrate](https://www.britannica.com/animal/vertebrate) hosts; the larval forms, however, occur in vertebrates and in invertebrates, especially in mollusks, arthropods (e.g., crabs), and annelids (e.g., marine polychaetes). They are cosmopolitan in distribution, but their occurrence is closely related to that of the intermediate host or hosts.

**Natural history**

**Life cycle**

**Reproduction**

With very few exceptions, platyhelminthes are [hermaphroditic](https://www.britannica.com/science/hermaphroditism), and their reproductive systems are generally complex. Numerous testes but only one or two ovaries are usually present in these flatworms. The female system is unusual in that it is separated into two structures: the ovaries and the vitellaria, often known as the vitelline glands or [yolk](https://www.britannica.com/science/yolk) glands. The cells of the vitellaria form yolk and eggshell components. In some groups, particularly those that live primarily in water or have an aqueous phase in the [life cycle](https://www.britannica.com/dictionary/life%20cycle), the eggshell consists of a hardened [protein](https://www.britannica.com/science/protein) known as [sclerotin](https://www.britannica.com/science/sclerotin), or tanned protein. Most of this protein comes from the vitellaria. In other groups, especially those that are primarily terrestrial or have a terrestrial phase in their life cycle, the eggshells are composed of another protein, keratin, a tougher material that is more resistant to adverse environmental conditions.

In the tapeworms, the tapelike body is generally divided into a series of segments, or proglottids, each of which develops a complete set of male and female genitalia. A rather complex copulatory apparatus consists of an evertible (capable of turning outward) penis, or cirrus, in the male and a canal, or vagina, in the female. Near its opening the female canal may [differentiate](https://www.merriam-webster.com/dictionary/differentiate) into a variety of tubular organs. Fertilized [eggs](https://www.britannica.com/science/egg-biology) are often stored in a saclike uterus, which may become greatly distended; in tapeworms, it may fill a whole segment.

Each male and female reproductive system may have its own external opening, or gonopore, or the terminal regions of each system may join to form a common genital atrium, or passage, and a genital pore.

Either [cross-fertilization](https://www.britannica.com/science/cross-fertilization) (i.e., involving two individuals) or [self-fertilization](https://www.britannica.com/science/self-fertilization) may occur; self-fertilization is probably more common. Some free-living flatworms perform a type of copulation known as hypodermic impregnation, whereby the penis of one [animal](https://www.britannica.com/animal/animal) pierces the epidermis of another and injects sperm into the tissues. Some forms reproduce asexually through [budding](https://www.britannica.com/science/budding-reproduction).

**Development**

The [life cycles](https://www.britannica.com/dictionary/life%20cycles) of the free-living forms are relatively simple. Fertilized eggs are laid singly or in batches. Frequently they are attached to some object or surface by an adhesive secretion. After a period of embryonic development, free-swimming [larvae](https://www.britannica.com/science/larva) or minute worms emerge.

In contrast, parasitic platyhelminths undergo very complex life cycles, often involving several larval stages in other animals—the intermediate hosts; these hosts may be [invertebrate](https://www.britannica.com/animal/invertebrate) or [vertebrate](https://www.britannica.com/animal/vertebrate).

The simplest cycle in parasitic platyhelminths occurs in the [Monogenea](https://www.britannica.com/animal/Monogenea), which have no intermediate hosts. The majority of the Monogenea are [ectoparasitic](https://www.britannica.com/science/ectoparasitism) (externally parasitic) on fish. The eggs hatch in water. The larva, known as an oncomiracidium, is heavily ciliated (has actively moving hairlike projections) and bears numerous [posterior](https://www.britannica.com/dictionary/posterior) hooks. It must attach to a host before it can grow and mature. In some species (e.g., *Polystoma integerrimum*) parasitic in frogs, maturation of the genitalia is synchronized with maturation of the host and apparently is controlled by the [endocrine system](https://www.britannica.com/science/endocrine-system) of the latter.

In the life cycle of [trematode](https://www.britannica.com/animal/fluke-flatworm) flukes of the subclass [Digenea](https://www.britannica.com/animal/Digenea), [mollusks](https://www.britannica.com/animal/mollusk) (mostly snails) serve as the intermediate host. Fertilized eggs usually hatch in water. The first larval stage, the miracidium, generally is free-swimming and penetrates a freshwater or marine [snail](https://www.britannica.com/animal/snail), unless it has already been ingested by one. Within this intermediate host, the [parasite](https://www.britannica.com/dictionary/parasite) passes through a series of further stages known as sporocysts, rediae, and [cercariae](https://www.britannica.com/science/cercaria). Through a complex process of asexual replication, each miracidium larva gives rise to dozens, or even hundreds, of cercariae. The cercariae exit the snail and swim for a number of hours in the surrounding water. The cercariae must locate a vertebrate host to complete the life cycle. In addition, many species must first invade another intermediate host, typically a fish or amphibian. The trematode life cycle is completed only if the final, or definitive, host (such as a bird, sheep, or cow) eventually eats the intermediate host. In some species the trematode modifies the behaviour or appearance of the second intermediate host in ways that increase the likelihood that it will be eaten by the proper definitive host.

Tapeworms of the subclass Eucestoda are generally [transmitted](https://www.britannica.com/dictionary/transmitted) from host to host by direct ingestion of eggs; by ingestion of intermediate hosts containing larval stages; and, very rarely, by passage of a larva from an intermediate host through a skin wound into another intermediate host.

Transmission to a human host through a skin wound is most likely to occur in Asia, where frogs infested with [tapeworm](https://www.britannica.com/animal/tapeworm) larvae are sometimes used to treat wounds. The tapeworm, *Hymenolepis nana*, parasitic in rodents and humans, can complete its life cycle without an intermediate host.

[**Regeneration**](https://www.britannica.com/science/regeneration-biology)

The ability to undergo tissue regeneration, beyond simple wound healing, occurs in two classes of Platyhelminthes: Turbellaria and Cestoda.

**Turbellaria**

Turbellarians, [planaria](https://www.britannica.com/animal/planarian) particularly, have been commonly used in regeneration research. The greatest regenerative powers exist in species capable of asexual reproduction. Pieces from almost any part of the turbellarian *Stenostomum*, for example, can develop into completely new worms. In some cases regeneration of very small pieces may result in the formation of imperfect (e.g., headless) organisms.

In other Turbellaria, regeneration of the head is limited to pieces from the anterior region or to tissues containing the [cerebral](https://www.merriam-webster.com/dictionary/cerebral) ganglion (brain). The region anterior to this ganglion is incapable of regeneration, but if cuts are made posterior to it, many species can replace the entire posterior region, including the [pharynx](https://www.britannica.com/science/pharynx) and the reproductive system. In the cut pieces, [polarity](https://www.britannica.com/science/polarity-biology) is retained; i.e., the anterior zone of the cut piece regenerates the head and the posterior region regenerates the tail. If a region in front of the pharynx is transplanted into the posterior region of another individual, it influences that region to form a pharyngeal zone that eventually [differentiates](https://www.merriam-webster.com/dictionary/differentiates) a pharynx. This new pharyngeal zone is now said to be determined and, if removed, will regenerate again into a new pharynx.

There is evidence that a special type of [cell](https://www.britannica.com/science/cell-biology), a [neoblast](https://www.britannica.com/science/neoblast), is involved in [planarian](https://www.britannica.com/animal/planarian) regeneration. Neoblasts, rich in [ribonucleic acid](https://www.britannica.com/science/RNA) (RNA), which plays an essential role in [cell division](https://www.britannica.com/science/cell-division), appear in great numbers during regeneration. Similar cells, apparently inactive, occur in the tissues of whole organisms (see also [regeneration: Biological regeneration](https://www.britannica.com/science/regeneration-biology)).

**Cestoda**

Regeneration, although rare in the parasitic worms in general, does occur in the cestodes. Most tapeworms can regenerate from the head (scolex) and neck region. This property often makes it difficult to treat people for tapeworm infections; [treatment](https://www.britannica.com/dictionary/treatment) may eliminate only the body, or strobila, leaving the scolex still attached to the intestinal wall of the host and thus capable of producing a new strobila, which reestablishes the infestation. Cestode larvae from several species can regenerate themselves from cut regions. A branched larval form of *Sparganum prolifer*, a human parasite, may undergo both asexual multiplication and regeneration.

**Ecology**

Turbellaria are [adapted](https://www.britannica.com/science/adaptation-biology-and-physiology) to a wide range of [environments](https://www.merriam-webster.com/dictionary/environments), and many species are resistant to extreme environmental conditions. Some occur in coastal marine habitats—in sand, on or under rocks, and in or on other animals or plants. Some marine species occur at relatively great depths in the sea; others are pelagic (i.e., living in the open sea). Freshwater species are found in ponds, lakes, rapidly flowing rivers, and streams. Temporary freshwater pools may contain adult forms that survive periods of dryness in an encysted state. Some aquatic species exhibit considerable tolerance to osmotic changes—i.e., to differences in salt concentrations of the water; a marine species (*Coelogynopora biarmata*), for example, has also been found in freshwater springs.

[Terrestrial](https://www.britannica.com/dictionary/Terrestrial) turbellarian species occur in soil, moist sand, leaf litter, mud, under rocks, and on vegetation. Some have been found in pools in the desert and in caves. Cave-dwelling species tend to show loss of eyes and pigment.

Some species are able to stand considerable [temperatures](https://www.britannica.com/science/temperature). For example, *Crenobia alpina*, which occurs in alpine streams, apparently can survive temperatures of -40 to -50 °C (-40 to -58 °F). Remarkable heat tolerance is exhibited by *Macrostomum thermale* and *Microstomum lineare*, which are found in hot springs at 40–47 °C (104–117 °F). *M. lineare* can also tolerate temperatures as low as 3 °C (37 °F).

Many turbellarians live in association with plants and animals. Marine algae, for example, frequently harbour many turbellarian species, often in large numbers. Turbellarians most commonly associate with animals such as echinoderms (e.g., sea stars), crustaceans (e.g., crabs), and mollusks. Less commonly, associations occur with [sipunculid](https://www.britannica.com/animal/peanut-worm) worms, [polychaete](https://www.britannica.com/animal/polychaete) worms, arachnids (e.g., spiders), cnidarians (e.g., jellyfish), other turbellarians, and lower vertebrates. An interesting feature of these associations is that species within a turbellarian family tend to associate with one type of organism; for example, almost all members of the family Umagillidae associate with echinoderms.

In a few cases, the association is parasitic; i.e., the turbellarians obtain all of their nourishment from the host. Most of these species belong to the order Neorhabdocoela, in which the [alimentary canal](https://www.britannica.com/science/gastrointestinal-tract) is either [absent](https://www.britannica.com/dictionary/absent) or reduced.

Among the turbellaria that are parasitic or commensal (i.e., living in close association with but not harmful to another organism) the Temnocephalida are best adapted for attachment to other organisms. They have a large saucer-shaped posterior adhesive [organ](https://www.britannica.com/science/organ-biology) and anterior tentacles that are also used for adhesion. All temnocephalids occur on freshwater hosts, mainly crustaceans but also mollusks, turtles, and [jellyfish](https://www.britannica.com/animal/jellyfish).

The tendency to associate with other animals apparently represents a definite [evolutionary](https://www.britannica.com/science/evolution-scientific-theory) trend among the platyhelminths; permanent associations essential to the survival of a species could develop from loose associations, which may then have given rise to parasitic forms, including the trematodes and cestodes. The free-living larval stages that frequently occur in these groups play a major role in [disseminating](https://www.merriam-webster.com/dictionary/disseminating) the species.

The ecology of the parasitic groups (i.e., [Cestoda](https://www.britannica.com/animal/tapeworm) and Trematoda) is particularly complex, because as many as four hosts may be involved in the life cycle. In the case of the broad tapeworm, for example, humans serve as the final (or definitive) hosts, various species of fish as one intermediate host, and species of a small water [crustacean](https://www.britannica.com/animal/crustacean) (*Cyclops*) as another intermediate host. It is clear that the broad tapeworm (*Diphyllobothrium latum*) can occur only where an [intimate](https://www.merriam-webster.com/dictionary/intimate) ecological association exists among the three host groups.

In addition to adapting to the general external [environment](https://www.merriam-webster.com/dictionary/environment), parasites at each stage of the life cycle must adapt to the microenvironment inside the host. [Adaptations](https://www.merriam-webster.com/dictionary/Adaptations) include not only obvious features, such as suckers or hooks for attachment, but also those associated with the biochemical, physiological, and immunological conditions imposed by the host. Parasites frequently utilize the physiological and biochemical properties of a new host, especially those that differ markedly from the external environment, in order to trigger the next developmental stage—e.g., several species of cestodes are stimulated to mature sexually by the high body temperature (40 °C) of their bird host, which contrasts sharply with the low body temperature of the cold-blooded fish host of the larval stage. The unusually intimate association of certain [flukes](https://www.britannica.com/animal/fluke-flatworm) (subclass Digenea) with mollusks suggests that [flukes](https://www.britannica.com/dictionary/flukes) were originally parasites of mollusks and that they later developed an association with other hosts.

Knowledge of a platyhelminth parasite’s ecology and of that of its intermediate host(s) is essential if control measures against the pest are to be effective. Humans have sometimes inadvertently modified the environment in ways that have increased the spread of infection. The [Aswan High Dam](https://www.britannica.com/topic/Aswan-High-Dam) in Egypt, for example, has produced conditions especially favourable for the breeding of the [snail](https://www.britannica.com/animal/snail) that serves as the required intermediate host of the [blood fluke](https://www.britannica.com/animal/blood-fluke) (*Schistosoma mansoni*). In this case, as with many [trematode](https://www.britannica.com/animal/fluke-flatworm) infestations, people exposed themselves to the disease by bathing in water containing infective [larvae](https://www.britannica.com/science/larva) (cercariae) released from infested snails; the cercariae enter directly through the skin. Certain other human diseases of platyhelminth origin—such as hydatid (cyst) disease, caused by the tapeworm *Echinococcus granulosus*—owe their survival and dissemination to man’s close ecological association with dogs.

In the parasitic platyhelminth species (e.g., those in the Monogenea) that do not normally [utilize](https://www.britannica.com/dictionary/utilize) intermediate hosts, there is a close ecological association between egg release and production of young of both the parasite and its host; infection of the next generation of host could not otherwise occur.

Many platyhelminths show highly specific adaptations to internal host environments. Many monogeneans, for example, show a marked preference for a particular [gill arch](https://www.britannica.com/science/branchial-arch) in a fish. The scolex (head) of certain tapeworms of elasmobranch fishes (e.g., sharks, skates, and rays) is highly specialized and can satisfactorily attach only to the gut of a fish possessing a complementary structure.

**Form and function**

**External features**

Some turbellarians are gray, brown, or black, with mottled or striped patterns. Others, which contain symbiotic algae in the mesenchyme, are green or brown. Parasitic flatworms usually have no pigment, but cestodes may be coloured by food (e.g., bile, blood) in their gut. Some parasitic forms may show masses of dark eggs through a translucent, creamy, or whitish tissue.

The typical flatworm body is flattened and leaflike or tapelike. The head may be set off from the body or grade imperceptibly into it. The anterior (head) end can usually be distinguished from the posterior end in free-living forms by the presence of two pigment spots, which are primitive eyes. In the case of the tapeworm, the scolex is usually [conspicuous](https://www.merriam-webster.com/dictionary/conspicuous) for its breadth, while the strobila (body) typically consists of numerous [proglottids](https://www.britannica.com/science/proglottid), each of which is usually a self-sufficient reproducing unit with all of the sexual organs necessary to reproduce. The number of proglottids may vary from three in some species to several hundreds in others. Organs of attachment on the scolex may, in addition to suckers, consist of hooks, spines, or various combinations of these.

The structure and function of the body covering, or [tegument](https://www.britannica.com/science/integument), differs markedly between free-living and parasitic forms. In free-living forms, the body covering is typically an epidermis consisting of one layer of ciliated cells—i.e., cells with hairlike structures—the cilia being [confined](https://www.britannica.com/dictionary/confined) to specific regions in some species. In the parasitic groups—flukes, tapeworms, and monogeneans—the tegument shows striking modifications associated with the parasitic way of life. It once was thought that the tegument is a nonliving secreted layer; it is now known, however, that the tegument of parasites is metabolically active and consists of cells not separated from one another by [cell](https://www.britannica.com/science/cell-biology) walls (i.e., a syncytium). The tegument itself consists of cytoplasmic extensions of tegumental cells, the main bodies of which lie in what may be described as the “subcuticular” zone, although a true cuticle is not present. A [membrane](https://www.britannica.com/science/membrane-biology) separates the inner zone of the tegumental cells, the so-called perinuclear cytoplasm, from the surface syncytium, or distal cytoplasm.

The surface of tapeworms and monogeneans is drawn out into spinelike structures called microtriches, or [microvilli](https://www.britannica.com/science/microvilli). The microtriches probably help to attach the [parasite](https://www.britannica.com/dictionary/parasite) to the gut of the host, absorb nutritive materials, and secrete various substances. In the flukes, microtriches are lacking, but spines are frequently present.

Embedded in the epidermis of turbellarians are ovoid or rod-shaped bodies (rhabdoids) of several sorts; of uncertain function, the bodies frequently are concentrated dorsally or may be clustered anteriorly as rod tracts opening at the apex. Rhabdoids are absent in flukes and tapeworms.

**Internal features**

Beneath the epidermis of turbellarians is a [homogeneous](https://www.merriam-webster.com/dictionary/homogeneous) or lamellated basal [membrane](https://www.britannica.com/science/membrane-biology). Club-shaped mesenchymal gland cells, opening externally, generally are present in all flatworms. In turbellarians two major types of mesenchymal glands occur: one produces a slimy material upon which the organisms creep; the other secretes an adhesive substance for capture of prey, for adhesion, and for cementing egg capsules to a suitable surface. The [larvae](https://www.britannica.com/science/larva) of parasitic forms generally possess similar glands whose secretions are used for adhesion, for producing cyst walls around resting stages, and for penetrating hosts; some adult parasites have glands for adhesion and, in trematodes, for softening and digesting host tissues.

The mesenchyme consists of fixed and free cells as well as a fibrous matrix. A fluid occupies the minute open spaces and serves for distribution of nutrients and wastes. The mesenchymal cells in certain groups may [differentiate](https://www.merriam-webster.com/dictionary/differentiate) during growth to become sex cells or may function in asexual reproduction in repair or in regeneration.

Flatworms have no specialized respiratory system; gases simply diffuse across the body wall.

**Nervous system**

The main ganglia, or nerve centres, of the [nervous system](https://www.britannica.com/science/nervous-system) and the major sense organs are generally concentrated at the anterior end. Typically, the primitive [brain](https://www.britannica.com/science/brain) of the flatworm consists of a bilobed mass of tissue with lateral longitudinal nerve cords connected by transverse connectives, thus forming a rather ladderlike structure or grid running the greater length of the organism. Free-living forms commonly have two longitudinal cords, but some tapeworms have as many as 10. Sensory receptors occur in all groups.

**Musculature**

The well-developed muscular system present in flatworms is [comprised](https://www.merriam-webster.com/dictionary/comprised) of a subcuticular musculature consisting of layers of circular, longitudinal, and diagonal muscles close to the epidermis, and a mesenchymal musculature consisting of dorsoventral, transverse, and longitudinal fibres passing through the mesenchyme. In general, platyhelminths are capable of extensive body contraction and elongation.

[**Digestive**](https://www.britannica.com/science/invertebrate-digestive-system-anatomy)**and excretory systems**

The blind-ending intestine of trematodes consists of a simple sac with an anterior or midventral mouth or a two-branched gut with an anterior mouth; an [anus](https://www.britannica.com/science/anus) is usually lacking, but a few species have one or two anal pores. Between the mouth and the intestine are often a pharynx and an esophagus receiving secretions from glands therein. The intestine proper, lined with digestive and absorptive cells, is surrounded by a thin layer of muscles that effect peristalsis; i.e., they contract in a wavelike fashion, forcing material down the length of the intestine. In many larger flukes lateral intestinal branches, or diverticula, bring food close to all internal tissues. Undigested residue passes back out of the mouth.

Cestodes have no digestive tract; they absorb nutrients from the host across the body wall. Most other flatworms, however, have [conspicuous](https://www.merriam-webster.com/dictionary/conspicuous) digestive systems. The digestive system of turbellarians typically consists of mouth, pharynx, and intestine. In the order Acoela, however, only a mouth is present; food passes directly from the mouth into the parenchyma, to be absorbed by the mesenchymal cells.

The excretory system consists of protonephridia. These are branching canals ending in so-called flame cells—hollow cells with bundles of constantly moving cilia.

**Nutrition**

**Free-living forms**

Free-living platyhelminths (class Turbellaria), mostly carnivorous, are particularly adapted for the capture of prey. Their encounters with prey appear to be largely [fortuitous](https://www.merriam-webster.com/dictionary/fortuitous), except in some species that release ensnaring [mucus](https://www.britannica.com/science/mucus) threads. Because they have developed various complex [feeding](https://www.britannica.com/science/feeding-behaviour) mechanisms, most turbellarians are able to feed on organisms much larger than themselves, such as annelids, arthropods, mollusks, and tunicates (e.g., sea squirts). In general, the feeding mechanism involves the [pharynx](https://www.britannica.com/science/pharynx) which, in the most highly developed forms, is a powerful muscular [organ](https://www.britannica.com/science/organ-biology) that can be protruded through the mouth. Flatworms with a simple ciliated pharynx are restricted to feeding on small organisms such as protozoans and rotifers, but those with a muscular pharynx can turn it outward, thrust it through the tegument of annelids and crustaceans, and draw out their internal body organs and fluids. Turbellarians with a more advanced type of pharynx can extend it over the captured prey until the [animal](https://www.britannica.com/animal/animal) is completely [enveloped](https://www.britannica.com/dictionary/enveloped).

Digestion is both extracellular and intracellular. Digestive enzymes (biological catalysts), which mix with the food in the gut, reduce the size of the food particles. This partly digested material is then engulfed (phagocytized) by cells or absorbed; digestion is then completed within the gut cells.

**Parasitic forms**

In the parasitic groups with a gut (Trematoda and Monogenea), both extracellular and intracellular digestion occur. The extent to which these processes take place depends on the nature of the food. When fragments of the host’s food or tissues other than fluids or semifluids (e.g., [blood](https://www.britannica.com/science/blood-biochemistry) and mucus) are taken as nutrients by the parasite, digestion appears to be largely extracellular. In those that feed on blood, digestion is largely intracellular, often resulting in the [deposition](https://www.merriam-webster.com/dictionary/deposition) of hematin, an insoluble pigment formed from the breakdown of hemoglobin. This pigment is eventually extruded by disintegrating gut cells.

Despite the presence of a gut, trematodes seem able to absorb glucose and certain other materials through the metabolically active tegument covering the body surface. Tapeworms, which have no gut, absorb all nutrients through the tegument. Amino acids (the structural units of proteins) and small molecules of [carbohydrate](https://www.britannica.com/science/carbohydrate) (e.g., sugars) cross the tegument by a mechanism called active transport, in which molecules are taken up against a concentration [gradient](https://www.britannica.com/dictionary/gradient). This process, similar to that in the [vertebrate](https://www.britannica.com/animal/vertebrate) gut, requires the expenditure of energy. Cestodes may also be able to digest materials in contact with the tegument by means of so-called membrane digestion, a little-understood process.

**Metabolism**

Both free-living and parasitic platyhelminths utilize [oxygen](https://www.britannica.com/science/oxygen) when it is available. Most of the parasitic platyhelminths studied have a predominantly anaerobic [metabolism](https://www.britannica.com/science/metabolism) (i.e., not dependent upon oxygen). This is true even in species found in habitats—such as the bloodstream—where oxygen is normally available.

Parasitic platyhelminths are made up of the usual tissue constituents—protein, carbohydrates, and lipids—but, compared to other invertebrates, the proportions differ somewhat; i.e., the [carbohydrate](https://www.britannica.com/science/carbohydrate) content tends to be relatively high and the [protein](https://www.britannica.com/science/protein) content relatively low. In larval and adult cestodes, carbohydrate occurs chiefly as [animal](https://www.britannica.com/animal/animal) starch, or [glycogen](https://www.britannica.com/science/glycogen), which acts as the main source of energy for species in low oxygen habitats. The level of glycogen, like other chemical [constituents](https://www.merriam-webster.com/dictionary/constituents), can fluctuate considerably, depending on the diet or feeding habits of the host. In some species, more than 40 percent of the [worm’s](https://www.britannica.com/animal/worm) dried weight is glycogen.

Because carbohydrate metabolism is important in parasitic flatworms, a substantial amount of carbohydrate must be present in the host diet to assure normal growth of the parasite. Hence the growth rate of the rat [tapeworm](https://www.britannica.com/animal/tapeworm) (*Hymenolepis diminuta*) is a good indicator of the quantity of carbohydrate ingested by the rat. Experiments have shown that most parasitic worms have the capability of utilizing only certain types of carbohydrate. All tapeworms that have been studied thus far utilize the sugar glucose. Many tapeworms can also utilize galactose, but only a few can utilize maltose or sucrose.

An unusual [constituent](https://www.merriam-webster.com/dictionary/constituent) of both trematodes and cestodes is a round or oval structure called a calcareous corpuscle; large numbers of them occur in the tissues of both adults and [larvae](https://www.britannica.com/science/larva). Their function has not yet been established, but it is believed that they may act as reserves for such substances as calcium, magnesium, and phosphorus.

The chief proteins in cestodes and trematodes are keratin and sclerotin. Keratin forms the hooks and part of the protective layers of the cestode egg and the cyst wall of certain immature stages of trematodes. Sclerotin occurs in both cestode and [trematode](https://www.britannica.com/animal/fluke-flatworm) [eggshells](https://www.britannica.com/science/egg-biology), especially in those that have larval stages associated with aquatic [environments](https://www.merriam-webster.com/dictionary/environments).

Platyhelminth eggs hatch in response to a variety of different stimuli in different hosts. Most trematode eggs require oxygen in order to form the first larval stages and light in order to hatch. Light is thought to stimulate the release of an [enzyme](https://www.britannica.com/science/enzyme) that attacks a cement holding the lid (operculum) of the egg in place. A similar mechanism probably operates in cestodes (largely of the order Pseudophyllidea) whose life cycles involve aquatic intermediate hosts or definitive hosts, such as birds or fish.

In many cestodes, especially those belonging to the order Cyclophyllidea, the eggs hatch only when they are ingested by the host. When the host is an insect, hatching sometimes is apparently purely a mechanical process, the shell being broken by the insect’s mouthparts. In [vertebrate](https://www.britannica.com/animal/vertebrate) intermediate hosts, destruction of the shell depends largely on the action of the host’s enzymes. Activation of the embryo within the shell and its subsequent release depend on other factors, including the amount of [carbon dioxide](https://www.britannica.com/science/carbon-dioxide) present, in addition to the host’s enzymes. Factors involving a vertebrate host are also important in establishing trematode or cestode infections after encysted or [encapsulated](https://www.merriam-webster.com/dictionary/encapsulated) larval stages have been ingested. Under the influence of the same factors, tapeworm larvae are stimulated to evaginate their heads (i.e., turn them inside out, so to speak), a process that makes possible their attachment to the gut lining.

[**Evolution**](https://www.britannica.com/science/evolution-scientific-theory)

The origin of the platyhelminths and the evolution of the various classes remain unclear. There are, however, two main lines of thought. According to the more widely accepted view, the Turbellaria represent the ancestors of all other animals with three tissue layers. Other authorities have agreed, however, that flatworms may be secondarily simplified; that is, they may have [degenerated](https://www.britannica.com/dictionary/degenerated) from more-complex animals by an evolutionary loss or reduction of complexity.

It is generally believed that the parasitic groups are derived from the Turbellaria, many of which form close associations with other animals. These associations often show great host specificity, a characteristic of truly parasitic forms. There are a number of views regarding the evolutionary relationships among the various parasitic groups. One school of thought proposes that rhabdocoel turbellarians gave rise to monogeneans; these, in turn, gave rise to digeneans, from which the cestodes were derived. Another view is that the rhabdocoel ancestor gave rise to two lines; one gave rise to monogeneans, who gave rise to digeneans, and the other line gave rise to cestodes. A further modification of the latter view, based largely on the study of the larval forms, proposes that cestodes were derived from monogeneans.

In considering the evolution of the parasitic groups, the digeneans should be mentioned in particular. With very few exceptions, mollusks act as intermediate hosts in digenean life cycles. This condition has led to the widely accepted view that digeneans were originally commensals of mollusks that subsequently turned parasitic. Digeneans later formed an association with vertebrates; the vertebrates, in turn, became incorporated into the life cycle as definitive hosts.

**Classification**

**Distinguishing taxonomic features**

The flatworms are acoelomate triploblasts—i.e., they lack a body cavity and have three embryonic tissue layers: [endoderm](https://www.britannica.com/science/endoderm), mesoderm, and ectoderm. Also, they are unsegmented, and the bulk of their body is occupied by mesenchyme.

In the traditional [classification](https://www.britannica.com/science/classification-biology) of platyhelminths the principal [criteria](https://www.merriam-webster.com/dictionary/criteria) are: habitat of organism (i.e., free-living or parasitic); the characteristics of the body covering; the form and position of organs for attachment to host (when present); the presence or absence of segmentation; the form of the reproductive system, especially with respect to vitellaria (yolk glands) and the number of testes; the presence or absence of an alimentary canal; the characteristics of the [pharynx](https://www.britannica.com/science/pharynx) (when present); and the nature of protective egg membranes. Molecular and ultrastructural studies are rapidly altering traditional views of evolutionary relationships in this phylum.

**Annotated classification**

There is no unanimity concerning the [classification](https://www.britannica.com/science/classification-biology) of platyhelminths. The following [classification](https://www.britannica.com/dictionary/classification) should be considered provisional.

* **PHYLUM PLATYHELMINTHES**(flatworms)

Flat, unsegmented worms; gastrovascular cavity and respiratory, skeletal, and circulatory systems absent; excretion by means of flame-bulb protonephridia; mesenchyme fills all spaces between [organ](https://www.britannica.com/science/organ-biology) systems; a variable number of longitudinal nerve cords with transverse connectives; body structure triploblastic (i.e., 3 embryonic layers); reproductive system hermaphroditic and complex.

* + **Class**[**Turbellaria**](https://www.britannica.com/animal/turbellarian)

Epidermis usually ciliated at least in part, provided with rhabdoids (minute rodlike structures); body unsegmented; gut present except in order Acoela; life cycle simple; mostly free-living, some ectocommensal, endocommensal (i.e., living, respectively, outside or inside another organism without harming it), or parasitic; about 3,000 species.

* + - * + **Order Acoela**

Exclusively marine; mouth present; [pharynx](https://www.britannica.com/science/pharynx) simple or lacking; no intestine; without protonephridia, oviducts, yolk glands, or definitely delimited gonads; about 200 species.

* + - * + **Order Neorhabdocoela**

Saclike linear intestine; protonephridia and oviducts usually present; gonads few, mostly compact; [nervous system](https://www.britannica.com/science/nervous-system) generally with 2 [longitudinal](https://www.britannica.com/dictionary/longitudinal) trunks; about 600 species.

* + - * + **Order Catenulida**

Mostly freshwater; about 70 species.

* + - * + **Order Macrostomida**

Mostly inhabiting the areas between grains of sand; about 200 species.

* + - * + **Order Polycladida**

Pharynx simple, bulbose, or plicate (many ridges); intestine may have short diverticula, or pockets; protonephridia paired; testes usually numerous; penis papilla generally present; nervous system with 3–4 trunks; nearly 800 species.

* + **Class [Monogenea](https://www.britannica.com/animal/Monogenea)**

Oral sucker lacking or weakly developed; posterior end with large posterior adhesive disk (opisthaptor) usually provided with hooks; excretory pores paired, anterior and dorsal; parasites of the skin and other superficial locations, especially on the gills of fish; life cycle simple, no alternation of hosts; about 1,100 species.

* + **Class [Cestoda](https://www.britannica.com/animal/tapeworm)**([tapeworms](https://www.britannica.com/animal/tapeworm))

[Elongated](https://www.britannica.com/dictionary/Elongated) endoparasites with [alimentary canal](https://www.britannica.com/science/gastrointestinal-tract) lacking; epidermis modified for absorption and secretion; usually divided into segments (proglottids); adhesive organs limited to anterior end; except in Cestodaria, adult stages almost entirely parasites of vertebrates; life cycles complicated with 1 or more intermediate hosts; about 3,500 species.

* + - **Subclass Cestodaria**

Unsegmented tapeworms containing 1 set of genitalia; parasites of the body cavity or intestine of [annelid](https://www.britannica.com/animal/annelid) worms or fish; about 105 species.

* + - * + **Order Amphilinidea**

Uterus long and N-shaped; genital pores at or near posterior extremity; intestinal parasites of teleosts (bony fish); 105 species.

* + - * + **Order Caryophyllidea**

Uterus a coiled tube; genital pore well separated from [posterior](https://www.britannica.com/dictionary/posterior) extremity; intestinal parasites of teleosts, occasionally in annelids; about 85 species.

* + - * + **Order Gyrocotylidea**

Testes confined to anterior region; genital pores near anterior end; parasitic in intestine of fish of the [genus](https://www.britannica.com/science/genus-taxon) *Chimaera*; 105 species.

* + - **Subclass Eucestoda**

Polyzoic tapeworms with scolex (head) of varying structure; body usually with distinct external segmentation; parasitic in intestine of vertebrates. Known commonly as the “true” tapeworms; well more than 3,000 species.

* + - * + **Order Tetraphyllidea**

Scolex with 4 bothridia (leaflike muscular structure); vitellaria located in lateral margins of proglottids; genital pores lateral; parasites of elasmobranchs; about 200 species.

* + - * + **Order Lecanicephalidea**

Reproductive system similar to Tetraphyllidea, but scolex divided into an upper disklike or globular part and a lower collarlike part [bearing](https://www.britannica.com/dictionary/bearing) 4 suckers; mainly parasites of elasmobranchs; 5 species.

* + - * + **Order Proteocephalidea**

Scolex with 4 suckers, sometimes a 5th terminal one; vitellaria located in lateral margins; genital pores lateral; mainly parasites of cold-blooded vertebrates; about 185 species.

* + - * + **Order Diphyllidea**

Two bothridia, each sometimes bisected by a median longitudinal ridge; large rostellum (cone-shaped or cylindrical projection) armed with dorsal and ventral groups of large hooks; cephalic peduncle (fleshy stalk on head) with longitudinal rows of T-shaped hooks; genital pore median, parasitic in elasmobranchs; 1 genus, *Echinobothrium*, with 2 species.

* + - * + **Order Trypanorhyncha**

Scolex with 2 or 4 bothridia; vitellaria in continuous sleevelike distribution; parasites of elasmobranchs; about 115 species.

* + - * + **Order Pseudophyllidea**

Scolex with 2 elongated, shallow bothria, 1 dorsal and 1 ventral; genital pore [lateral](https://www.britannica.com/dictionary/lateral) or median. Vitellaria lateral or extending across proglottid and encircling other organs; parasites of teleosts and land vertebrates. Order includes the largest of all known tapeworms, *Polygonoporus giganticus*, which reaches lengths of 30 metres (100 feet) in sperm whales. About 315 species.

* + - * + **Order Nippotaeniidea**

Scolex bears 1 apical sucker; parasites of freshwater fish; 1 genus, *Nippotaenia*; 3 species.

* + - * + **Order Cyclophyllidea (Taenoidea)**

Scolex with 4 suckers; no uterine pores; 1 compact vitellarium behind ovary; mainly parasites of birds and mammals; probably more than 2,000 species.

* + - * + **Order Aporidea**

No sex ducts or genital openings; parasites of swans, ducks, and geese; 4 species.

* + - * + **Order Spathebothriidea**

Scolex without true bothria or suckers; strobila with internal segmentation but no external segmentation; [parasites](https://www.britannica.com/dictionary/parasites) of marine teleosts; 10 species.

* + **Class**[**Trematoda**](https://www.britannica.com/animal/fluke-flatworm)([flukes](https://www.britannica.com/animal/fluke-flatworm))

Ectoparasites or endoparasites; no ciliated epidermis; body undivided; adhesive organs well-developed; life cycles generally complex with 2 or more hosts; about 11,000 species.

* + - **Subclass Aspidogastrea**

Oral sucker absent; main adhesive organ occupying almost the entire ventral surface, consists of suckerlets arranged in rows; excretory pore single and posterior; endoparasites of vertebrates, mollusks, and crustaceans; about 35 species.

* + - **Subclass**[**Digenea**](https://www.britannica.com/animal/Digenea)

Oral and ventral suckers generally well-developed; development involves at least 1 intermediate host; usually endoparasites of vertebrates; about 9,000 species.

* + - * + **Order Strigeidida**

Cercaria (immature form) fork-tailed; penetration glands present; 1–2 pairs of protonephridia; about 1,350 species.

* + - * + **Order Echinostomida**

Cercaria with simple tail and many cyst-producing glands; life cycle with 3 hosts; about 1,360 species.

* + - * + **Order Plagiorchida**

Cercaria typically armed with a stylet; encystment in invertebrates, rarely vertebrates; excretory vessels not open to the exterior. Most representatives require 3 hosts to complete one life cycle. Many hundreds of species.

* + - * + **Order Opisthorchiida**

Cercaria never armed; excretory pores open on margins of tail; about 700 species.