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Common INTESTINAL HELMINTHS of Man

Life Cycle Charts

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I. Introduction

The primary purpose of the accompanying charts is to present to the students of parasitology, laboratory technicians, public health workers and practicing physicians, the fundamentals of the life cycles of the common intestinal helminths which parasitize man.

The authors have attempted to keep the charts relatively simple and uncluttered. Many details have been omitted purposely in order to stress the major steps in the life cycles. It is intended that they be used primarily by those who are studying parasitology for the first time or by those who desire a quick review of the subject and are not intended to take the place of textbook study. Pertinent details, alternative routes and the notable exceptions can be added by the individuals after receiving the additional information from their instructors or from the literature.

The following are a number of the principles which have been kept in mind in preparation of the charts:

1. Only the generally accepted scientific names have been used. All common names have been omitted.
2. The diagnostic and infective stages for man have been indicated and emphasized. Within groups of helminths, an attempt has been made to keep the sizes of the diagnostic stages relative from species to species. To a less degree, this also applies to adults within general groups.
3. With the exception of the diagnostic stages, details of morphology have been omitted.
4. Not all of the embryonic and larval stages have been indicated and, in general, only the usual routes in the life cycles are illustrated. For example, the number of generations of rediae and sporocysts are not recorded for the trematodes and the indirect cycle of *Hymenolepis nana* has been omitted.

Also see:

Brooke, M. M. and Melvin, D. M. 1964. Common Intestinal Protozoa of Man — Life Cycle Charts. PHS Publication 1140.

Melvin, D. M., Brooke, M. M., and Healy, G. R. 1965. Common Blood and Tissue Parasites of Man — Life Cycle Charts. PHS Publication 1234.

5. The times required for the various steps to be completed in the life cycle within hosts and the external environment have been omitted. The exact location and necessary environmental conditions for external development have not been recorded.
6. External environment has been labelled on the chart only for those helminths having no intermediate host.
7. In general, only broad groups of organisms have been indicated as invertebrate hosts. More specific names have been applied to mammalian hosts.
8. Reservoir hosts are not recorded on the charts but, in instances where man is primarily concerned as an accidental host, the common hosts are indicated.
9. No references have been listed since the material incorporated is general knowledge found in most parasitology textbooks.

II. Nematodes

The life cycles of the intestinal nematodes vary in complexity from the simple pattern of *Enterobius* to the more involved one of *Strongyloides* and have been arranged in this order.

The diagnostic stages have been drawn to scale. Other stages are not relative from species to species for obvious reasons of size variations.

The intestinal nematodes do not have an intermediate host in their life cycle but most require a developmental period outside of the human host to reach the infective stage. However, *Enterobius* sheds embryonated eggs which develop to the infective stage in about 6 hours and is usually considered immediately effective thus permitting an anus-to-mouth infection. Other species require longer periods, from 3 to 4 days in the case of *Strongyloides* to 3 weeks or more for *Trichuris*. Environmental factors such as temperature, moisture, and soil texture influence external development. Table 1 gives the usual developmental times within the host and in the external environment.

Table 1

USUAL TIME FOR COMPLETION OF LIFE CYCLES UNDER FAVORABLE CONDITIONS

Nematodes	Within Host	External Environment
Enterobius vermicularis	4 - 7 weeks	6 hours
Ascaris lumbricoides	8 weeks	10 - 15 days
Trichuris trichiura	10 - 12 weeks	21 days
Hookworm	4 - 7 weeks	5 - 6 days
Strongyloides stercoralis	4 weeks	3 - 4 days (Direct)

Ascaris and *Trichuris* are passed in the one-celled stage, ordinarily, and embryonate on the soil. Optimal development occurs in shady, moist soil, either loose loam or clay. Direct sunlight, excessive moisture, or drying will prevent development. *Ascaris* eggs are resistant to climatic conditions and may survive in soil for several months or longer. Subfreezing temperatures (above –30° C) do not affect their viability, although they are destroyed by temperatures over 40° C and by direct sunlight. *Trichuris* eggs are less resistant and are soon killed by freezing temperatures or drying. Human infection occurs by ingestion of contaminated food or water.

In addition to fertile eggs, *Ascaris* also produces unfertile eggs in the feces, not only in unisexual infections where males are absent but also in about two-fifths of all cases, especially when the worm burden is light. While they are of no importance in continuing the life cycle, these unfertile eggs are of diagnostic importance.

Two species of hookworms are parasitic in man: *Necator americanus*, the "New-World hookworm" and the most prevalent species in the Western hemisphere, and *Ancylostoma duodenale*, the "Old-World hookworm." The life histories are essentially the same and since species cannot be distinguished on the basis of the eggs, the term "hookworm" is generally used rather than the species name. Species identification is ordinarily made from adult morphology.

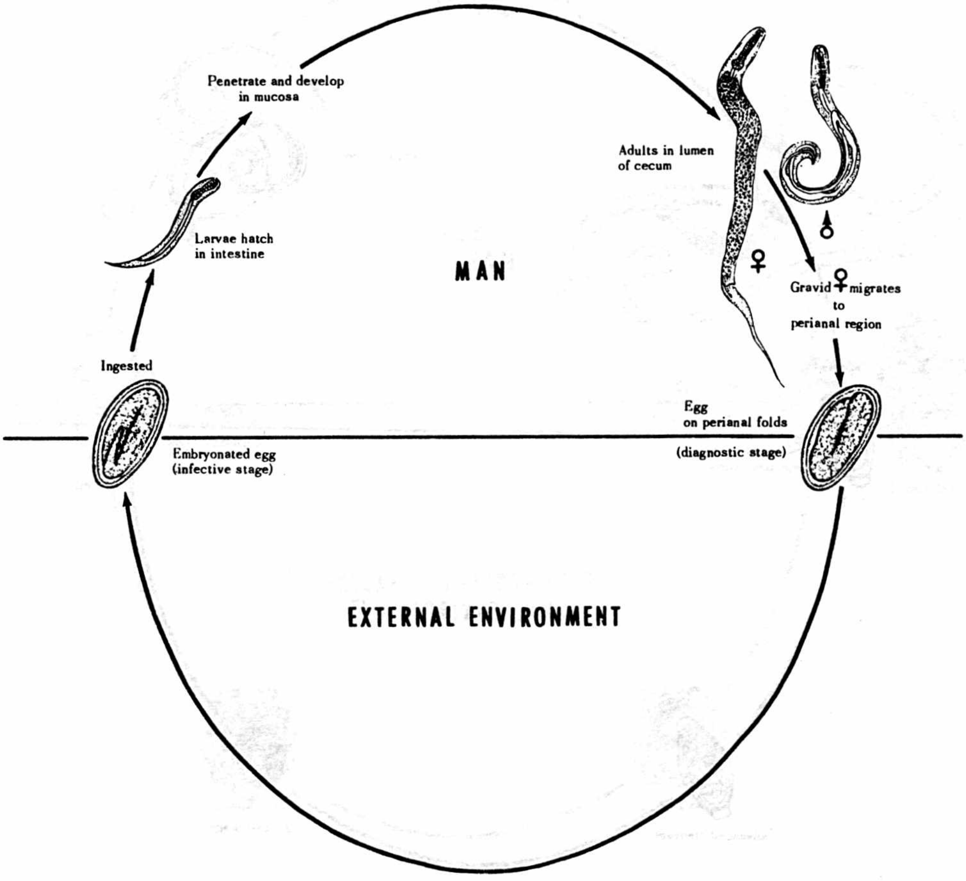
Hookworm eggs are usually passed in early cleavage and rapidly develop to the first larval stage, the rhabditiform larva. The larva hatches under optimum conditions in about 24 hours and reaches the infective third-stage filariform larva in about 5 to 7 days. Environmental factors such as aerated soil, moderate moisture, and temperatures ranging from 23° to 33° C are most favorable for development. In the absence of reinfestation, a given area of soil will remain infested up to about six weeks after initial contamination. Human infection occurs by penetration of the filariform larvae through the skin.

Strongyloides infections are diagnosed by finding rhabditiform larvae in feces or duodenal drainage. The adults live in the wall of the small intestine and the eggs embryonate and hatch before reaching the lumen of the intestine. Therefore, rhabditiform larvae rather than eggs are usually found in laboratory examinations. External development of *Strongyloides*, as indicated on the chart, may follow two routes, direct or indirect. It has been suggested that direct development takes place under unfavorable conditions (colder climate) and indirect development under favorable conditions (tropical climate). Development is influenced by the same climatic factors as are hookworm larvae. The larvae may live for several weeks on the soil. Human infection takes place by penetration of the larvae through skin.

Within the host, *Enterobius* and *Trichuris* mature directly in the intestine after a brief penetration in the mucosa. *Ascaris*, hookworm, and *Strongyloides*, however, undergo a lung-migration before maturing. Man is the only definitive host for *Enterobius* and probably the only important host for the other nematodes, although worms morphologically similar to these species have been recovered from lower animals.

LIFE CYCLE of—

Enterobius vermicularis



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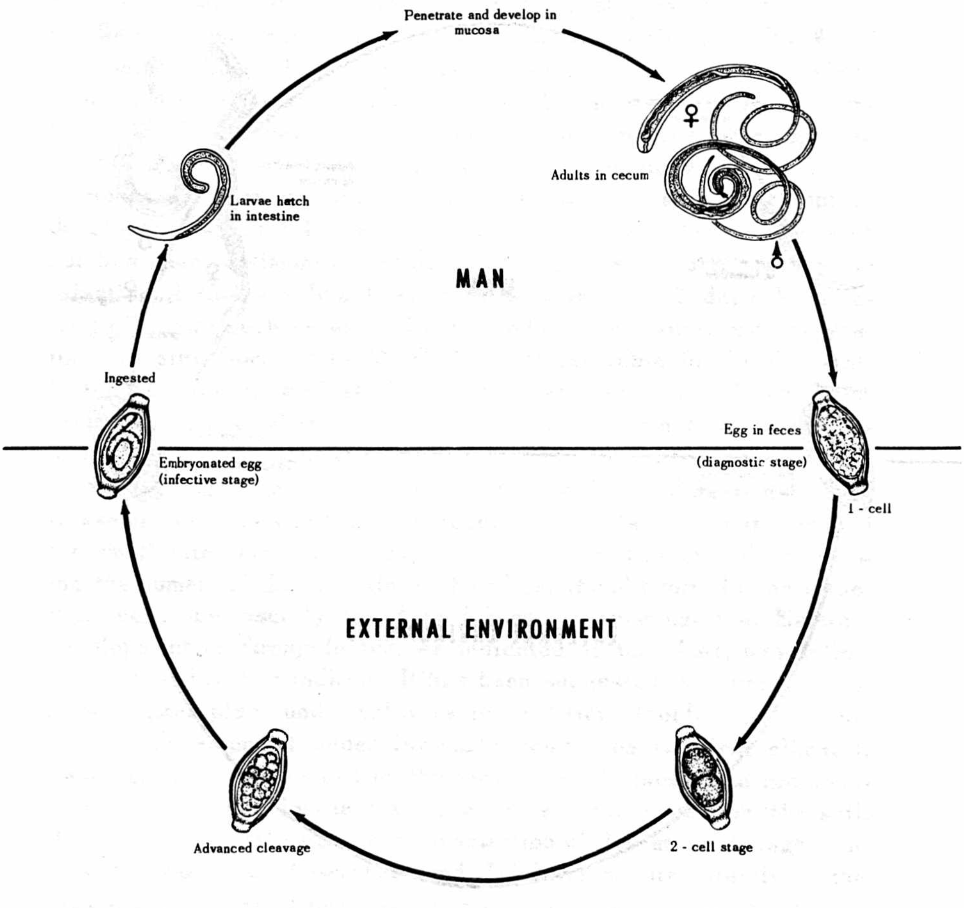
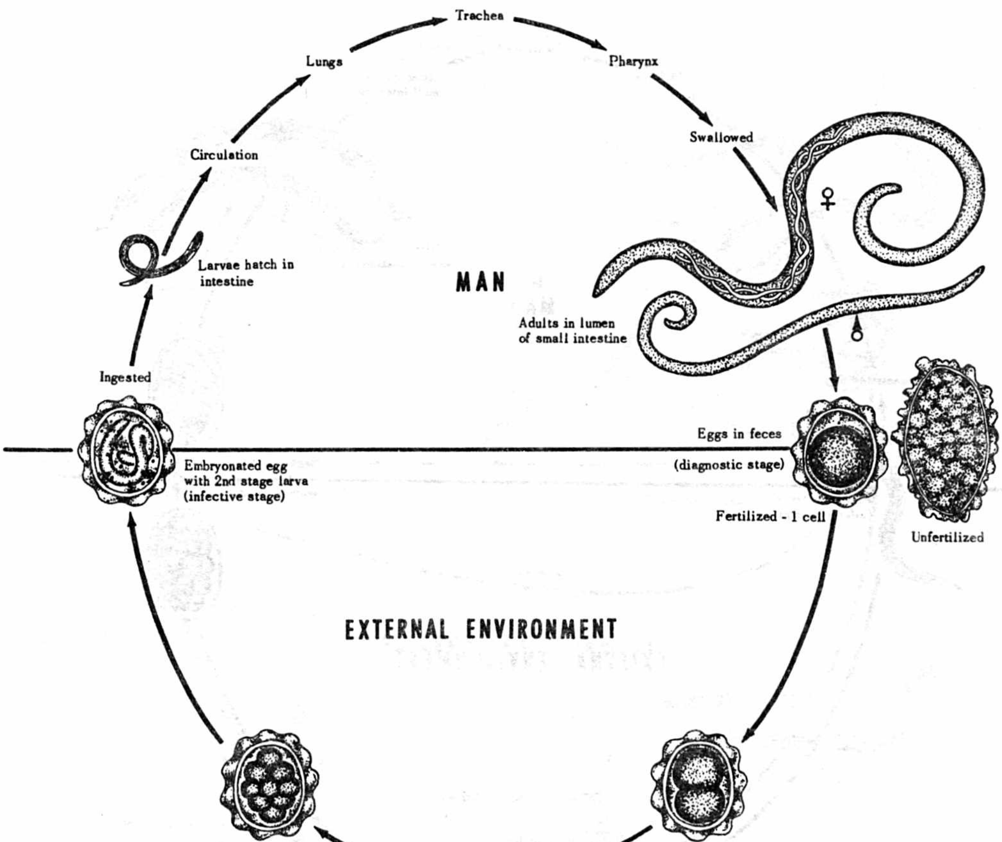
LIFE CYCLE of—

Trichuris trichiura



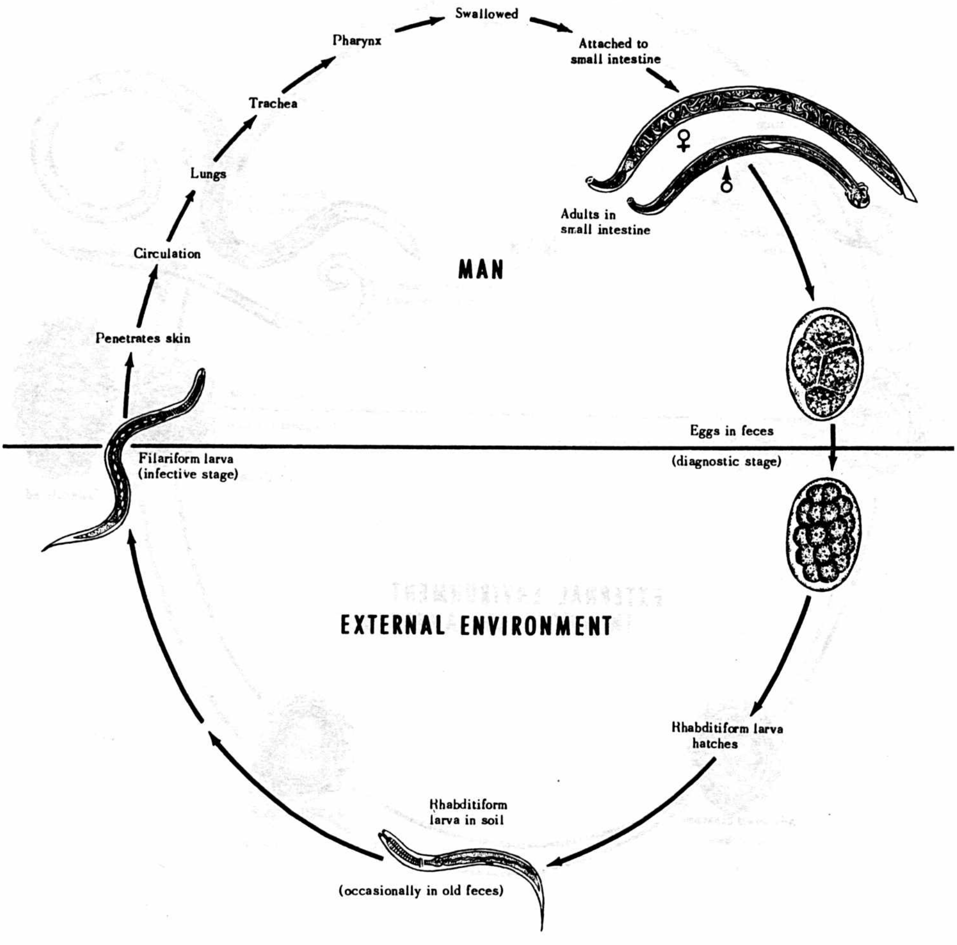
LIFE CYCLE of—

Ascaris lumbricoides



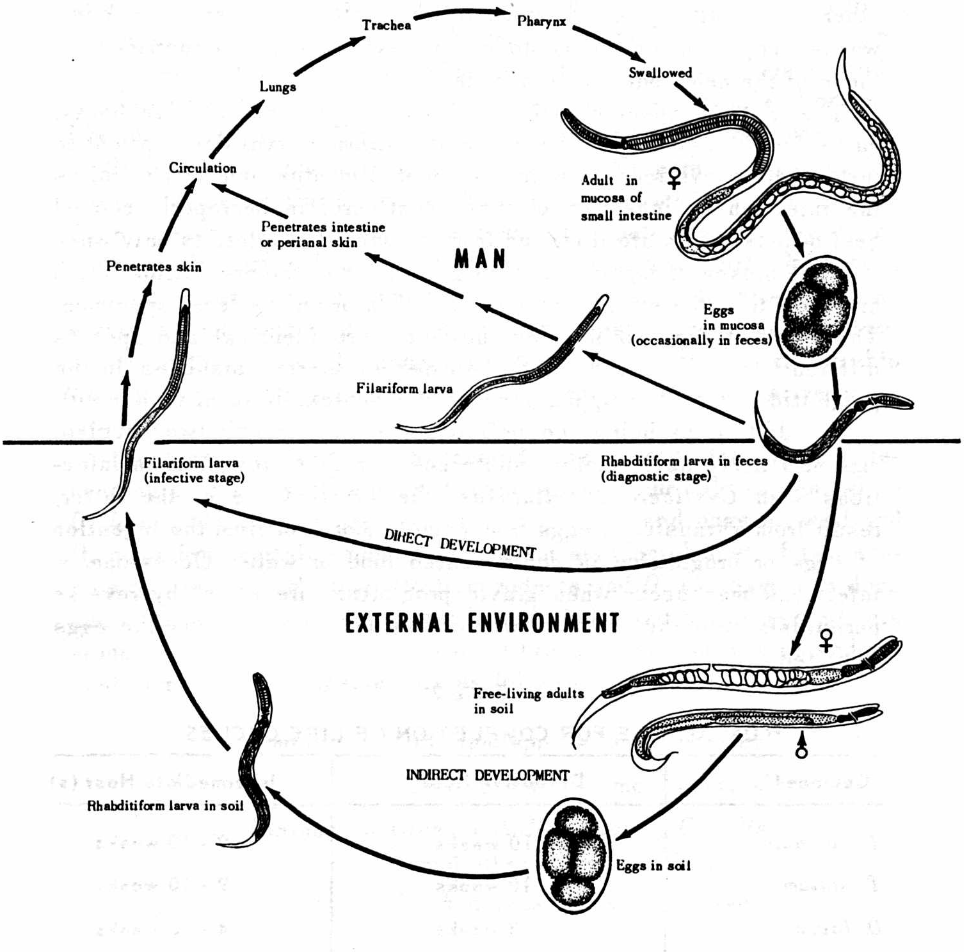
LIFE CYCLE of—

Hookworm



LIFE CYCLE of—

Strongyloides stercoralis



III. Cestodes

With one exception, *Hymenolepis nana*, the life cycles of the human cestodes involve two or more hosts: a definitive host in which the adult parasite lives and one or two intermediate hosts in which larval development occurs. Table 2 gives the usual developmental times in both intermediate and definitive hosts.

As with the diagnostic stages of nematodes, the proglottids and eggs of the cestodes have been drawn to scale, with relation to each other, but no attempt has been made to correlate the size of the adult worms. The eggs of the cestodes, however, are not proportional to those of the nematodes or trematodes.

The *Taenia* species utilize vertebrates as intermediate hosts, cattle for *T. saginata* and swine for *T. solium*. Larval development to the infective cysticercus requires about 2 months and man acquires the infection by ingestion of these cysticerci in improperly cooked beef or pork. Eggs are liberated from the gravid proglottids only when they are broken or ruptured and, in general, it is the proglottids which break off from the strobila that are found in or on the fecal specimen. The eggs of the two species, however, are identical and species differentiation is based on the number of uterine branches in the proglottid (or on the appearance of the scolex, if it is recovered).

In addition to being the definitive host for these two species, man may serve as the intermediate host for *T. solium*. Human infections with *Cysticercus cellulosae*, the larval stage of the latter, result from a transfer of eggs from anus to mouth or from the ingestion of eggs or proglottids in contaminated food or water. Occasionally, infections may occur when gravid proglottids are swept by reverse peristalsis into the stomach where they are digested and the eggs liberated.

Table 2

USUAL TIME FOR COMPLETION OF LIFE CYCLES

Cestodes	Definitive Host	Intermediate Host (s)
T. saginata	8 - 10 weeks	9 - 10 weeks
T. solium	8 - 10 weeks	9 - 10 weeks
D. latum	3 weeks	4 - 8 weeks
H. nana	4 weeks	- - - - - - - - -
H. diminuta	3 weeks	2 weeks
D. caninum	3 weeks	3 - 4 weeks

Diphyllobothrium latum also reaches its final infective stage in a vertebrate host but differs from other cestodes in having two intermediate hosts in its life cycle: first, an invertebrate, copepod, (*Cyclops* and *Diaptomus* species), and second, certain species of fresh water fish. In North America, the fish usually involved are pike, burbot, and carp. Unlike *Taenia* species, the eggs of *D. latum* are liberated from the gravid proglottids through a special uterine pore and are found in feces. Proglottids are found less frequently. The eggs are unembryonated when passed, in contrast to the embryonated eggs of other human cestode species, and require several days in water to embryonate and hatch. *D. latum* is the only human cestode which has a free-living stage since the eggs hatch and the larval form (the coracidium) is free-swimming before being ingested by a copepod. This cestode is also unique in that the plerocercoid larva can transfer from one fish to another, if the first fish host is ingested by a larger one.

Hymenolepis nana, the most common cestode parasite of man, has a direct cycle similar to that of *Enterobius vermicularis*. An intermediate host is not necessary, although the parasite can utilize an arthropod for larval development under certain conditions. Ordinarily, a direct anus-to-mouth transmission occurs and, in essence, man serves as both intermediate and definitive hosts. Larval development occurs in the villi of the upper part of the small intestine and in this way, the species has combined the intermediate and definitive hosts within a single animal.

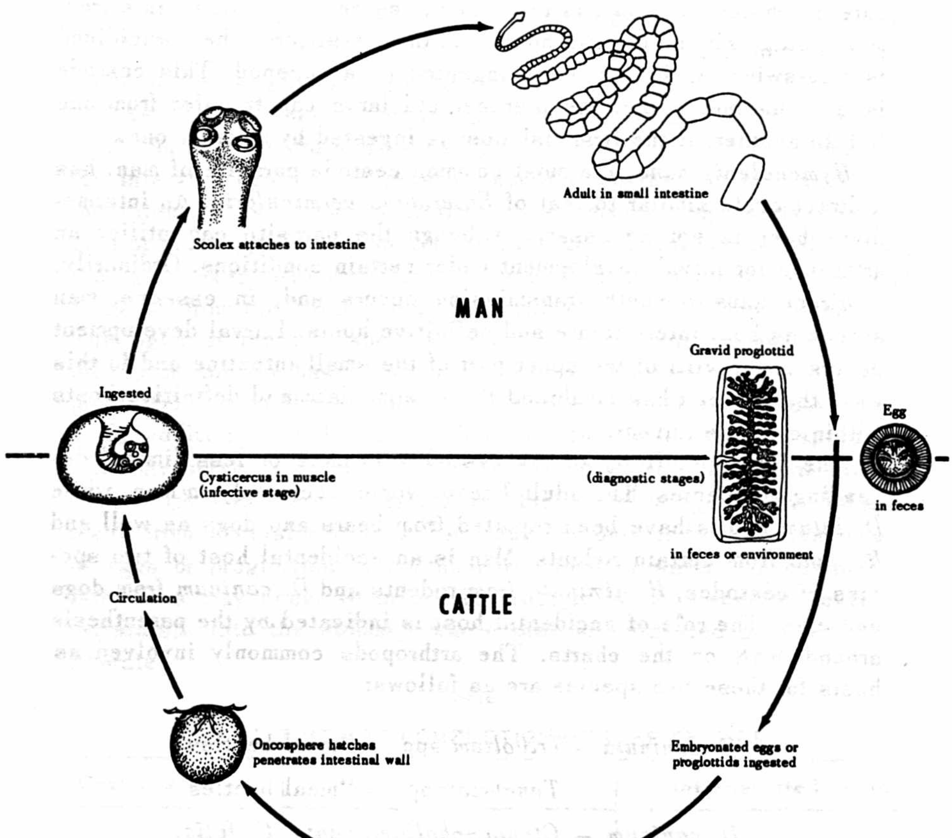
The host-specificity of the cestodes is more or less limited depending on species. The adult *Taenia* worms occur only in man, while *D. latum* adults have been reported from bears and dogs as well and *H. nana* from certain rodents. Man is an accidental host of two species of cestodes, *H. diminuta* from rodents and *D. caninum* from dogs and cats. The role of accidental host is indicated by the parenthesis around MAN on the charts. The arthropods commonly involved as hosts for these two species are as follows:

H. diminuta – *Tribolium* spp. – "meal beetles"
Tenebrio spp. – "meal beetles"

D. caninum – *Ctenocephalides canis*, *C. felis*, and other species of fleas.
Trichodectus canis, dog louse

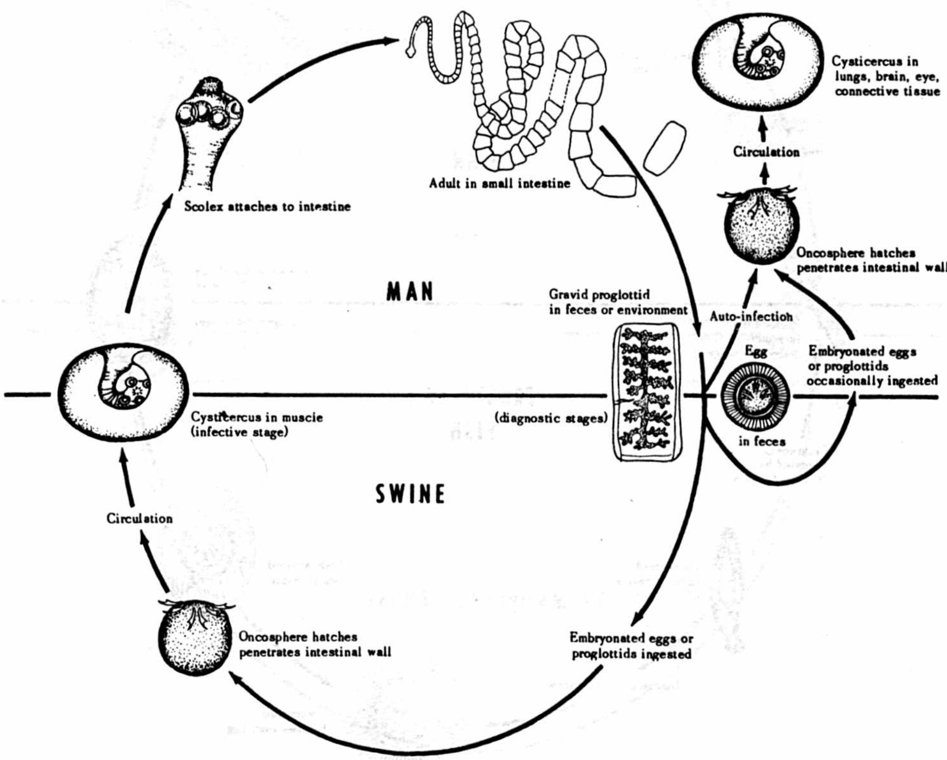
LIFE CYCLE of—

Taenia saginata



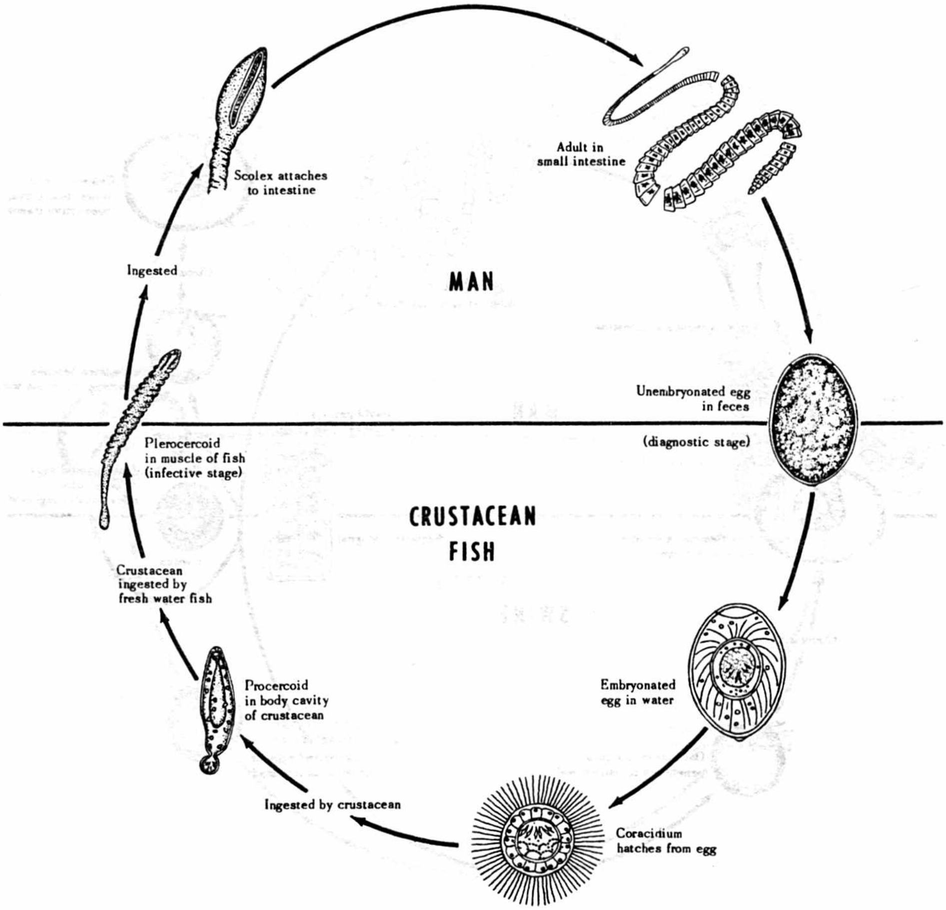
LIFE CYCLE of—

Taenia solium



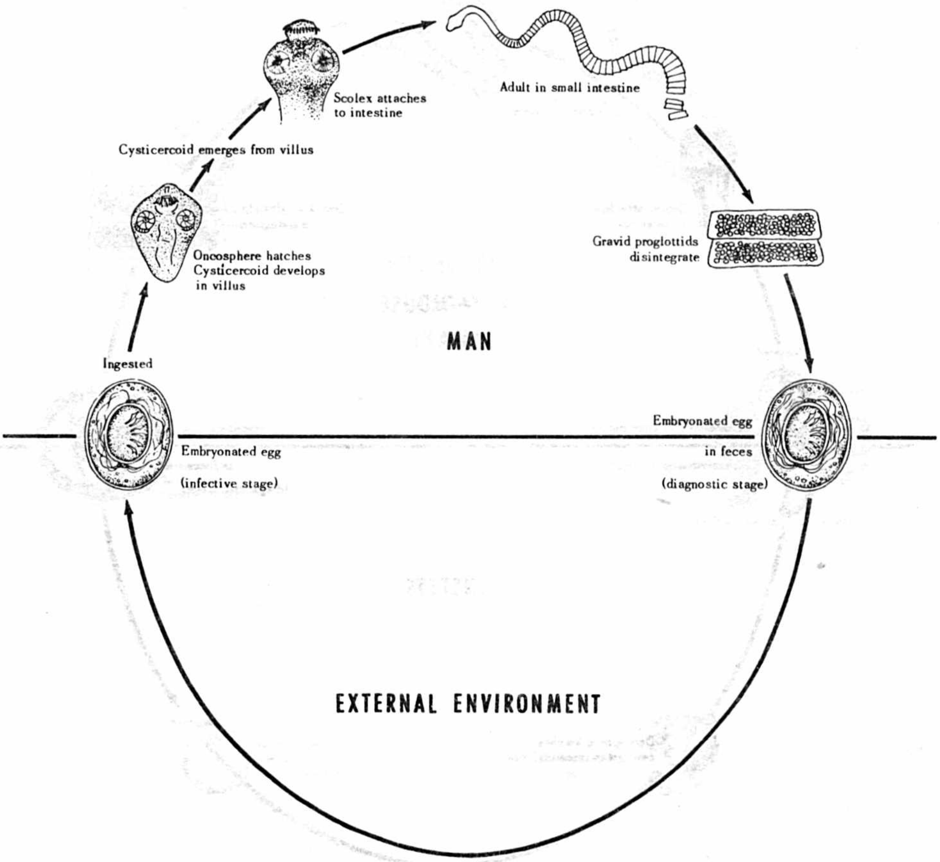
LIFE CYCLE of —

Diphyllobothrium latum



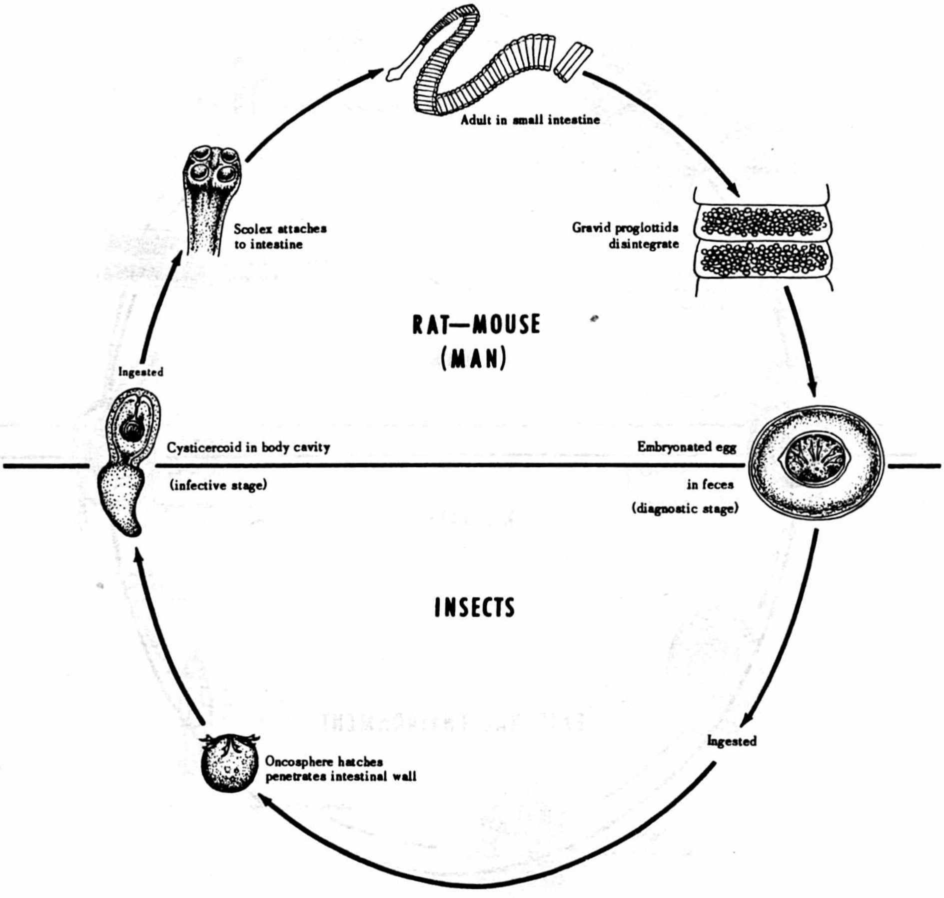
LIFE CYCLE of—

Hymenolepis nana



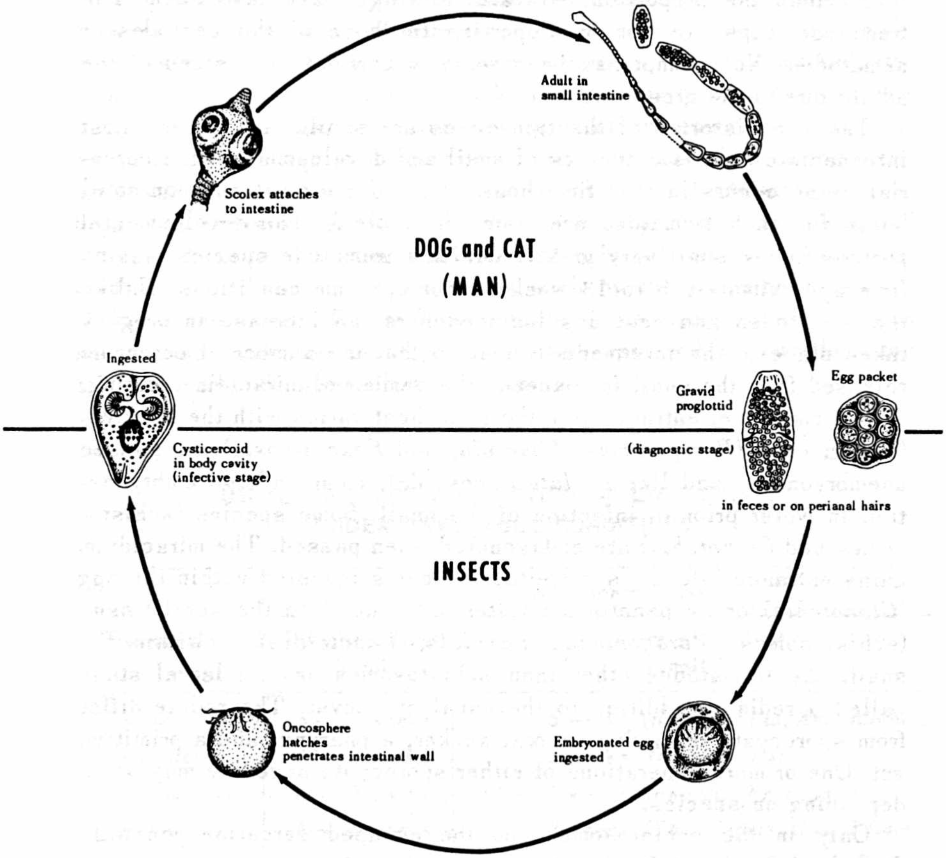
LIFE CYCLE of—

Hymenolepis diminuta



LIFE CYCLE of—

Dipylidium caninum



IV. Trematodes

The trematode life histories, in general, are more complex than those of the nematodes or cestodes and are somewhat more restricted in geographical distribution than the other helminths because of their rigid host specificities with regard to larval development.

As previously stated for nematodes and cestodes, the eggs of the various trematodes have been drawn to scale in relation to each other insofar as possible. Because of its very small size as compared to the other species, the egg of *Clonorchis sinensis* has been made larger than the proportionate scale drawing would have been. The trematode eggs are not in proportion to those of the cestodes or nematodes. No attempt has been made to correlate the sizes of the adults due to the great variations.

The life histories of the trematodes are similar in that the first intermediate host is a species of snail and development to the cercarial stage occurs in this first host. Some of the most common snail hosts for each trematode are listed in Table 3. The developmental periods in the snail vary greatly with the trematode species ranging from approximately 3 to 13 weeks under optimum conditions. Unlike the nematodes and cestodes included here, an increase in progeny takes place in the intermediate host so that the number of cercariae released from the snail far exceeds the number of miracidia entering.

The manner of entrance into the snail host varies with the species. Certain ones (*Paragonimus*, *Fasciola*, and *Fasciolopsis*) are passed unembryonated and like *D. latum* (cestode), must undergo embryonation in water prior to infection of the snail. Some species (schistosomes and *Clonorchis*) are embryonated when passed. The miracidium gains entrance into the snail either by being ingested within the egg (*Clonorchis*) or by penetration (after hatching) into the snail tissue (schistosomes, *Paragonimus*, *Fasciola*, *Fasciolopsis*). Within the snail, the trematodes other than schistosomes have a larval stage called a redia in addition to the usual sporocyst. The rediae differ from sporocysts in having an oral sucker, a pharynx, and a primitive gut. One or more generations of either sporocysts or rediae may occur depending on species.

Only in the schistosomes, do the escaped cercariae penetrate directly into the definitive host. Other species enter or adhere to a second intermediate host in or on which the cercariae lose the tail, spines, and lytic glands and encyst (metacercariae). The definitive host becomes infected by ingesting these encysted forms.

The free-swimming cercariae, such as those of the schistosomes, usually live only 1 to 3 or 4 days, but the encysted metacercariae are more resistant and survive for much longer periods, several weeks or months or even longer.

The patterns of the three species of schistosomes are similar and have been represented by a single chart. The specific locations of the adults in man have been indicated, as well as the usual body material (urine or feces) in which the specific eggs are normally found. By means of broken line arrows, the chart indicates that *S. haematobium* eggs may occasionally be found in feces although usually passed in urine, and that *S. japonicum* eggs may sometimes be found in urine as well as feces.

The schistosomes may occur naturally in mammals other than man: *S. mansoni*, in rodents and primates; *S. japonicum* in domestic animals such as dogs, cats, ruminants, hogs, equines, as well as rodents; *S. haematobium* in monkeys and rodents, but only rarely. *Paragonimus* occurs in cats, dogs, hogs, fur-bearing carnivora and rodents as well as man. *C. sinensis* is a parasite of man and other fish-eating mammals such as dogs and cats. In addition to man, *F. buski* occurs in hogs and occasionally, dogs. *F. hepatica* is primarily a parasite of sheep and cattle and other herbivores. Man is only an occasional host of this species and is indicated as such by the parenthesis around MAN on the chart. The following table gives some of the common snail hosts and the developmental times required to complete the life cycle in both intermediate host and man.

Table 3

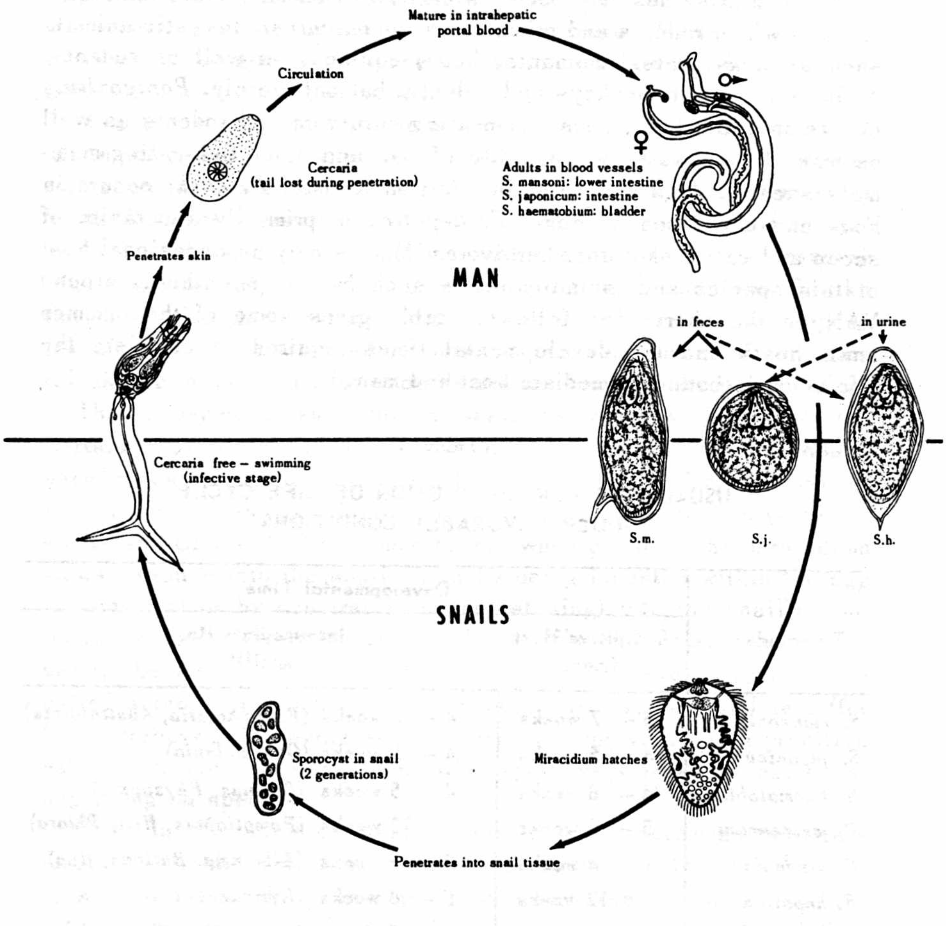
USUAL TIME FOR COMPLETION OF LIFE CYCLE UNDER FAVORABLE CONDITIONS

Trematodes	Developmental Time	
	Definitive Host (man)	Intermediate Host (snail)*
S. mansoni	5 – 7 weeks	4 – 5 weeks (*Biomphalaria, Australorbis*)
S. japonicum	4 – 5 weeks	4 – 5 weeks (*Oncomelania*)
S. haematobium	4 – 8 weeks	4 – 5 weeks (*Bulinus, Physopsis*)
P. westermani	5 – 6 weeks	13 weeks (*Pomatiopsis, Hua, Thiara*)
C. sinensis	4 weeks	3 – 4 weeks (*Alocinma, Bulinus, Hua*)
F. hepatica	12 weeks	5 – 8 weeks (*Lymnoea*)
F. buski	4 weeks	4 – 7 weeks (*Segmentina, Hippeutis*)

*The genera of snails listed in parenthesis represents only a few of the common hosts for the trematodes and is by no means a complete listing.

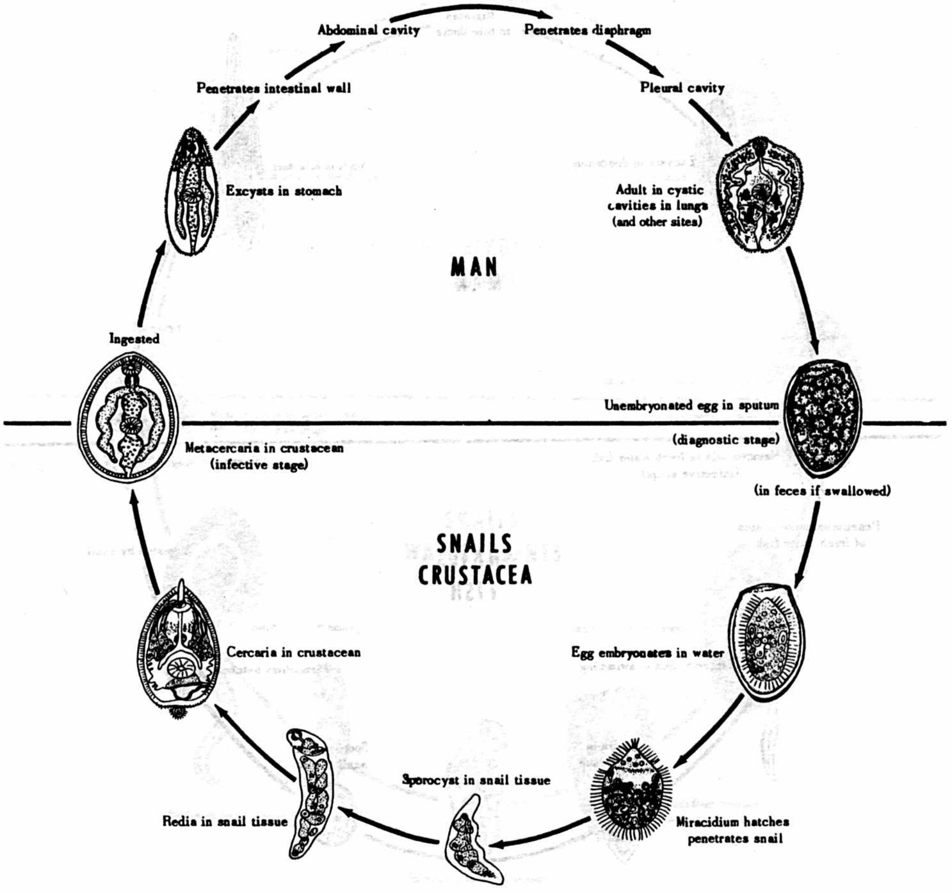
LIFE CYCLE of

Schistosomes



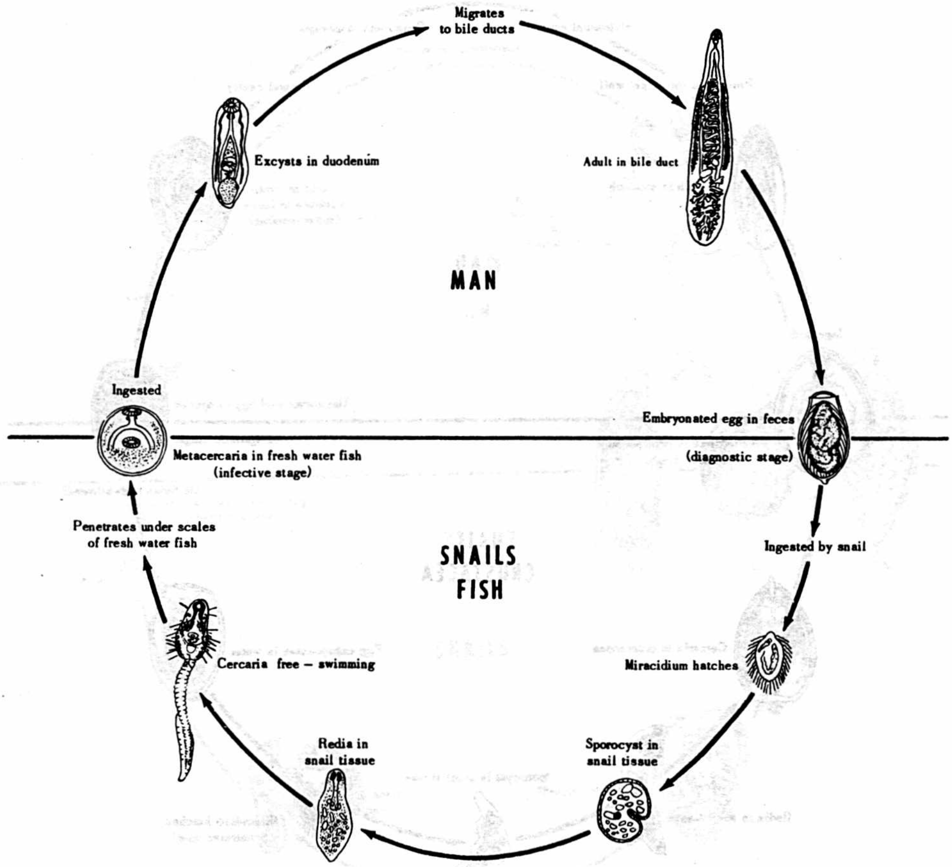
LIFE CYCLE of

Paragonimus westermani



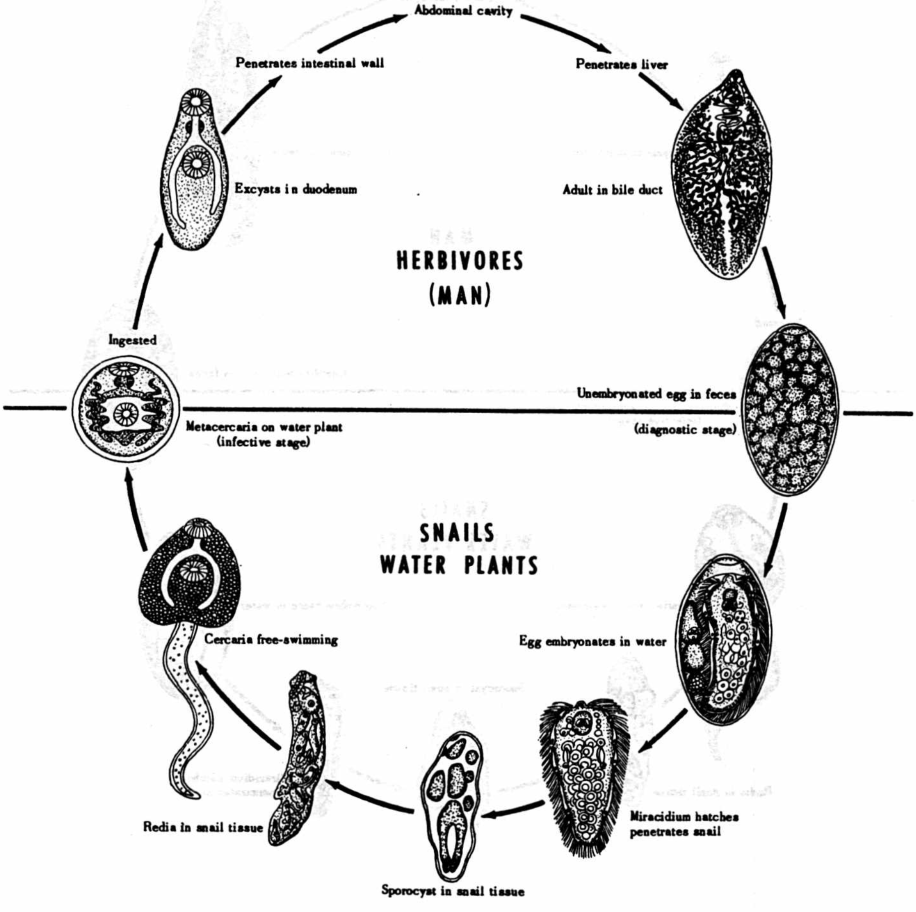
LIFE CYCLE of

Clonorchis sinensis



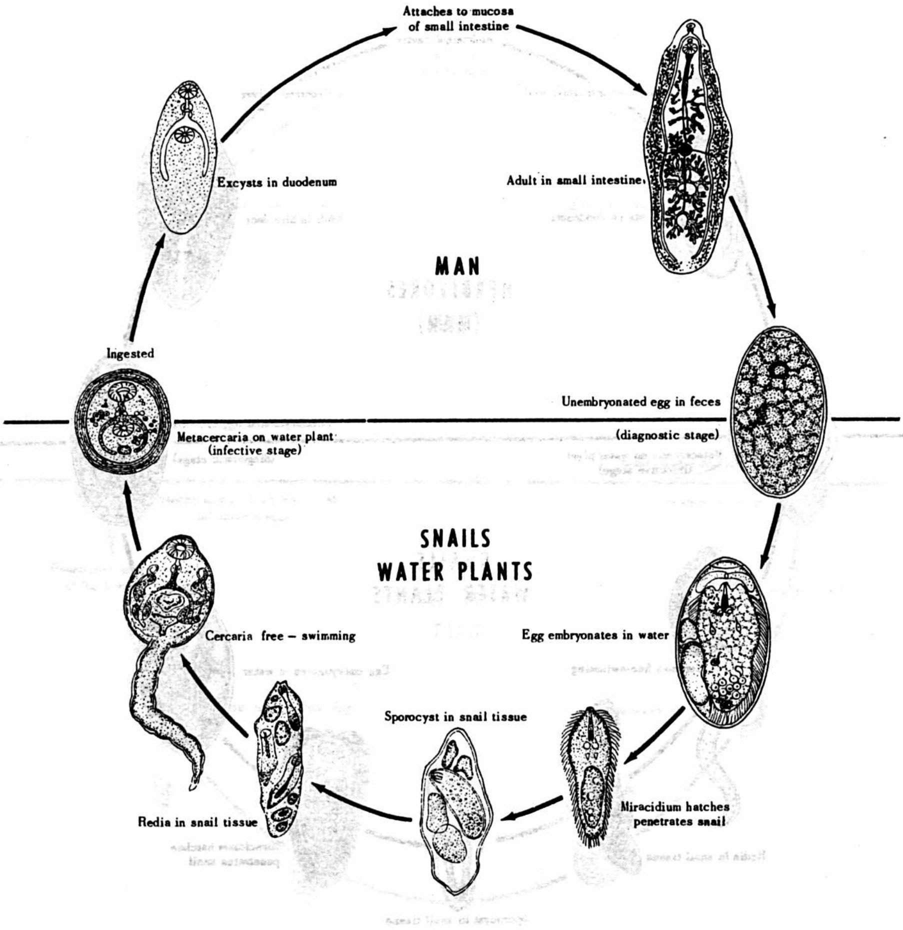
LIFE CYCLE of

Fasciola hepatica



LIFE CYCLE of

Fasciolopsis buski



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