Common
INTESTINAL HELMINTHS
of Man

Life Cycle Charts

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1. 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:


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**

<table>
<thead>
<tr>
<th>Nematodes</th>
<th>Within Host</th>
<th>External Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Enterobius vermicularis</em></td>
<td>4 - 7 weeks</td>
<td>6 hours</td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>8 weeks</td>
<td>10 - 15 days</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>10 - 12 weeks</td>
<td>21 days</td>
</tr>
<tr>
<td>Hookworm</td>
<td>4 - 7 weeks</td>
<td>5 - 6 days</td>
</tr>
<tr>
<td><em>Strongyloides stercoralis</em></td>
<td>4 weeks</td>
<td>3 - 4 days (Direct)</td>
</tr>
</tbody>
</table>

*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 reinfection, 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

- Ingested
- Embryonated egg (infective stage)
- Larvae hatch in intestine
- Penetrate and develop in mucosa
- Adults in lumen of cecum
- Gravid female migrates to perianal region
- Egg on perianal folds (diagnostic stage)

EXTERNAL ENVIRONMENT
LIFE CYCLE of—

*Trichuris trichiura*

Penetrate and develop in mucosa

Adults in cecum

Larvae hatch in intestine

Ingested

Embryonated egg (infective stage)

Egg in feces (diagnostic stage)

1 - cell

Advanced cleavage

2 - cell stage

EXTERNAL ENVIRONMENT
LIFE CYCLE of

Ascaris lumbricoides

MAN

Adults in lumen of small intestine

EXTERNAL ENVIRONMENT

Eggs in feces
(diagnostic stage)

Unfertilized

Fertilized - 1 cell

2-cell stage

Advanced cleavage

Embryonated egg with 2nd stage larvae (infective stage)

Larvae hatch in intestine

Ingested

Gastric acid kills reaching stomach

Swallowed

Pharynx

Trachea

Lungs

Circulation
LIFE CYCLE of—

**Hookworm**

- Swallowed
- Attached to small intestine
- Adults in small intestine
- Eggs in feces (diagnostic stage)
- **EXTERNAL ENVIRONMENT**
  - Habditisform larvae hatch
  - Habditisform larvae in soil
  - (occasionally in old feces)
  - Pharynx
  - Trachea
  - Lungs
  - Circulation
  - Penetrates skin
  - Pilariform larvae (infective stage)
**LIFE CYCLE of**

**Strongyloides stercoralis**

- **Swallowed**
- **Pharynx**
- **Circulation**
- **Penetrates intestine or perianal skin**
- **Egg** (in mucosa | occasionally in feces)
- **Filariform larva**
- **Habditiform larva in feces** (diagnostic stage)
- **Filariform larva** (infective stage)

**DIRECT DEVELOPMENT**

**EXTERNAL ENVIRONMENT**

- **Free-living adults in soil**
- **Habditiform larva in soil**
- **Eggs in soil**

**INDIRECT DEVELOPMENT**

**MAN**

- **Adult in mucosa of small intestine**
- **Eggs in mucosa (occasionally in feces)**
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>
<thead>
<tr>
<th>Cestodes</th>
<th>Definitive Host</th>
<th>Intermediate Host (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>T. saginata</em></td>
<td>8 - 10 weeks</td>
<td>9 - 10 weeks</td>
</tr>
<tr>
<td><em>T. solium</em></td>
<td>8 - 10 weeks</td>
<td>9 - 10 weeks</td>
</tr>
<tr>
<td><em>D. latum</em></td>
<td>3 weeks</td>
<td>4 - 8 weeks</td>
</tr>
<tr>
<td><em>H. nana</em></td>
<td>4 weeks</td>
<td>- - - - - - -</td>
</tr>
<tr>
<td><em>H. diminuta</em></td>
<td>3 weeks</td>
<td>2 weeks</td>
</tr>
<tr>
<td><em>D. caninum</em></td>
<td>3 weeks</td>
<td>3 - 4 weeks</td>
</tr>
</tbody>
</table>
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*

Scolex attaches to intestine

Cysticercus in muscle (infective stage)

Circulation

Oocyst hatches, penetrates intestinal wall

Egg in feces

Gewid proglottid

Embryonated eggs or proglottids ingested

MAN

in feces or environment (diagnostic stages)

CATTLE

Adult in small intestine
LIFE CYCLE of—

**Taenia solium**

- Oncosphere hatches penetrates intestinal wall
- Embryonated eggs or proglottids ingested
- Cysticerus in muscle (infective stage)
- Circulation
- Gravid proglottid in feces or environment
- Cysticercus in lungs, brain, eye, connective tissue
- Egg
- Embryonated eggs or proglottids occasionally ingested
- Circulation
- Oncosphere hatches penetrates intestinal wall
- Adult in small intestine
- Scolex attaches to intestine
- Cysticercus in muscle (infective stage)
- (diagnostic stages)
LIFE CYCLE of —

*Diphyllolothrium latum*

- Scolex attaches to intestine
- Adult in small intestine
- Unembryonated egg in feces
  (diagnostic stage)
- Embryonated egg in water

CRUSTACEAN FISH

- Piscicercoid in body cavity of crustacean
- Ingested by crustacean
- Parasite in muscle of fish
  (infective stage)
- Crustacean ingested by fresh water fish
LIFE CYCLE of—

*Hymenolepis nana*

- Ingested
- Embryonated egg (infective stage)
- Gravid proglottids disintegrate
- Oocyst hatches
  - Cysticercoid develops in villus
  - Cysticercoid emerges from villus
- Scolex attaches to intestine
- Adult in small intestine

**MAN**

**EXTERNAL ENVIRONMENT**
LIFE CYCLE of—

\textit{Hymenolepis diminuta}

\begin{itemize}
  \item Adult in small intestine
  \item Gravid proglottids disintegrate
  \item Scolex attaches to intestine
  \item Ingested
  \item Cysticercoid in body cavity (infective stage)
  \item Parasites disintegrate in intestine
  \item Oocyst hatches
  \item Ingested
\end{itemize}

\textbf{MAN—RAT—MOUSE}

\begin{itemize}
  \item Embryonated egg in feces (diagnostic stage)
\end{itemize}

\textbf{INSECTS}
LIFE CYCLE of—

*Dipylidium caninum*

**DOG and CAT (MAN)**

- Adult in small intestine
- Egg packet
- Gravid proglottid
- (Diagnostic stage)
- In feces or on perianal hairs

**INSECTS**

- Cysticercoid in body cavity (infective stage)
- Oncosphere hatches penetrates intestinal wall
- Embryo-coated egg ingested
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**

<table>
<thead>
<tr>
<th>Trematodes</th>
<th>Definitive Host (man)</th>
<th>Intermediate Host (snail)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. mansoni</em></td>
<td>5 – 7 weeks</td>
<td>4 – 5 weeks (<em>Biomphalaria, Australorbis</em>)</td>
</tr>
<tr>
<td><em>S. japonicum</em></td>
<td>4 – 5 weeks</td>
<td>4 – 5 weeks (<em>Oncomelania</em>)</td>
</tr>
<tr>
<td><em>S. haematobium</em></td>
<td>4 – 8 weeks</td>
<td>4 – 5 weeks (<em>Bulinus, Physopsis</em>)</td>
</tr>
<tr>
<td><em>P. westermani</em></td>
<td>5 – 6 weeks</td>
<td>13 weeks (<em>Pomatiopsis, Hua, Thiara</em>)</td>
</tr>
<tr>
<td><em>C. sinensis</em></td>
<td>4 weeks</td>
<td>3 – 4 weeks (<em>Alocinma, Bulinus, Hua</em>)</td>
</tr>
<tr>
<td><em>F. hepatica</em></td>
<td>12 weeks</td>
<td>5 – 8 weeks (<em>Lymnoea</em>)</td>
</tr>
<tr>
<td><em>F. buski</em></td>
<td>4 weeks</td>
<td>4 – 7 weeks (<em>Segmentina, Hippeutis</em>)</td>
</tr>
</tbody>
</table>

*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

Mature in intrabepatic portal blood

Adults in blood vessels
S. mansoni: lower intestine
S. japonicum: intestine
S. haematobium: bladder

Penetrates into snail tissue

Cercaria (tail lost during penetration)

Penetrates skin

Cercaria free - swimming (infective stage)

Spoecyst in snail (2 generations)

Miracidium hatches

S. m.  S. j.  S. h.

in faeces

in urine

MAN

SNAILS
LIFE CYCLE of

Paragonimus westermani

Abdominal cavity
Penetrates diaphragm

Penetrates intestinal wall

Excrysta in stomach

Adult in cystic cavities in lungs (and other sites)

MAN

Ingested

Metacercaria in crustacea (infective stage)

(snail as intermediate host)

SNAILS CRUSTACEA

Cercaria in crustacea

Egg embryonated in water

(Schistosoma japonicum)

Sporocyst in snail tissue

Redia in snail tissue

Miracidium hatchea penetrates snail
LIFE CYCLE of

Clonorchis sinensis

MAN

SNAILS FISH

Embryonated egg in feces (diagnostic stage)

Ingested by snail

Sporocyst in snail tissue

Redia in snail tissue

Microdiuid hatches

Cercaria free - swimming

Penetrates under scales of fresh water fish

Metacercaria in fresh water fish (infective stage)

Ingested

Excysta in duodenum

Adults in bile duct

Migrates to bile ducts
LIFE CYCLE of

Fasciola hepatica

- **Penetrates intestinal wall**
- **Penetrates liver**
- **Excysts in duodenum**
- **Adult in bile duct**

**HERBIVORES (MAN)**
- **Ingested**
- **Metacercaria on water plant** (infective stage)
- **Unembryonated egg in feces** (diagnostic stage)

**SNAILS**
- **Cercariae in small tissue**
- **Sporocyst in small tissue**
- **Redia in small tissue**
- **Egg embryonates in water**
- **Miracidium hatches penetrates snail**

**WATER PLANTS**
**LIFE CYCLE of**

**Fasciolopsis buski**

- **Attaches to mucosa of small intestine**
- **Excysts in duodenum**
- **Adult in small intestine**
- **Ingested**
- **Unembryonated egg in feces**
  - **(diagnostic stage)**

**MAN**

**SNAILS**

**WATER PLANTS**

- **Miracidium hatches in snail**
- **Sporocyst in snail tissue**
- **Redia in snail tissue**
- **Egg embryonates in water**
- **Cercariae free—swimming**
- **Metacercaria on water plant (infective stage)**