Acoelomate Animals

several phyla including **Platyhelminthes** share the following characteristics:

1. have 3 true embryonic tissue layers (=**triploblastic**):
   ectoderm
   mesoderm
   endoderm

   between epidermis and digestive cavity is filled with a 3rd tissue layer = **mesoderm**

   → mesoderm allows development of muscle layers in body wall

   → mesoderm allows more elaborate organs more specialization and greater division of labor than in Cnidaria

2. have **true organs**

   each **organ** is a combination of several tissues specialized for a particular function

   sponges have various specialized cells but no true tissues or organs

   jellyfish and corals have 2 true tissue layers and a few simple organs

3. **acoelomate**=without body cavity

   → organs are embedded in tissue, not in any body space (like us)

   like cnidaria and ctenophora

   → only 1 "internal space" =digestive cavity

4. in terms of development these organisms are **protostomes**

   → mouth develops first in embryo during gastrulation

5. most have **bilateral symmetry**

   such design allows for a "front end" = **cephalization**

   head contains sense organs, simple brain

   was a major new design

   → more efficient search for food, mates, etc

   most animals before this were sedentary filter feeders

Phylum Platyhelminthes (Flatworms)

[**helminth** = worm]

simplest phylum at "organ level" of complexity

very diverse group but most are poorly known

includes flatworms, flukes, tapeworms

25,000 living species, few fossils → no hard parts

poorly known in fossil record but possible trails have been found from 565MY

may be first animal to have a head & tail
may be first animal to have bilateral symmetry
may be first animal to show directed movement

wide variety of body forms all with bilateral symmetry

body is usually elongated & slender, leaf-like or long & ribbon-like

→ flattened body allows them to still rely on diffusion for exchange of gasses, nutrients and wastes

range in size from few mm → 10 M long

free living in ocean and freshwater habitats, moist soil

diverse array of parasitic species that parasitize members of virtually every other animal phylum

more specialization and division of labor among greater variety of tissues and organs

acoelomate = no body cavity around digestive system

have three true tissue layers (primary germ layers) = **triploblastic**

embryonic tissues		adult tissues
ectoderm	→	epidermis
mesoderm	→	parenchyma
endoderm	→	gastrodermis

mesoderm makes more elaborate organs possible
→ it differentiates into different kinds of muscle layers

organ systems are better developed

only major phylum that is mostly parasitic species

of 4 classes, 3 are made up of entirely parasitic species

<u>Body Wall</u>

A. Epidermis

free living forms have single layer of ciliated cells

parasitic forms have **syncytial** layer that lacks cilia

B. Muscle Layers

two layers around body wall:
circular muscle
longitudinal muscle

no rigid skeleton for muscles to act on

thick muscle layers in **pharynx** (=feeding tube) make it "prehensile"

in some primitive species these muscle cells resemble the epitheliomuscular cells of cnidarians

Feeding & Digestion

free living forms are mainly **carnivores**

most species are **endoparasites**

incomplete digestive tract in most

in some planarians digestive tract is highly branched to distribute food throughout the animal

some parasites (eg. tapeworms) completely lack a digestive system

pharynx = muscular "throatlike" tube

eversible in some → can be extended to find food

secretes enzymes to partially digest food before "eating" then suck in liquified food

once ingested enzymes are secreted into GVC

mostly extracellular digestion
some intracellular after phagocytosis

Respiration

no respiratory system

flatworms have high surface/volume ratio

gas exchange through flattened body wall

Nervous System

beginnings of **cephalization**

ie. at least some members have **distinct head**

flatworms were probably the first creatures to have a "brain"

head with cephalic **ganglia** (~ simple brain)

have pair of ventral nerve cords

connected by ladder like interconnections

with true synapses between nerve cells

Excretion

they are the simplest major phylum with an excretory system

some wastes like ammonia are eliminated by diffusion through the body wall

others have primitive excretory system
= **protonephridia** (tube closed at one end and exiting body at other end)

→ in most takes the form of **"flame cells"**

cupshaped area with tuft of flagella beat of flagella resemble candle flame under microscope

wastes and excess water diffuse into bulb

flagella create current to send wastes through tube which opens to outside of the body

Reproduction

many reproduce both sexually and asexually

Asexual

fission

pinch in half

some times produces a chain of zooids

→ superficial resemblance to segmentation

regeneration

flatworms have considerable powers of regeneration

replacement of lost parts

also to recover from long food shortage

budding

tapeworms bud off proglottids (reproductive sacs)

polyembryony

flukes

one egg can produce 100's of larvae

increases chances finding a host

Sexual

almost all flatworms are **monoecious** (hermaphrodites)

cross fertilization not self fertilization

some with internal fertilization

Classification

Class Turbellaria (planarians)
- free living
- ventral mouth
- locomotion by creeping on cilia and mucous

Class Monogenea
- ectoparasites on skin or gills of fish
- simple life cycle – no intermediate host

Class Trematoda (flukes)
- all are parasitic
- endoparasitic flukes
- parasites in blood or digestive system
- up to 5 developmental stages in 2 or more hosts

Class Cestoda (tapeworms)
- all are parasitic
- endoparasites in intestine
- bud long chains of proglottids

Class Turbellaria
(Planarians)

almost all are free living

mostly bottom dwelling aquatic forms

- mostly freshwater
- some are marine
- a few are even terrestrial (6 sp in US)

flattened, slender, ribbonlike or leaflike bodies

→ still rely on diffusion for much exchange of gasses, nutrients and wastes

often brightly colored

- some marine forms have warning coloration

Body Covering

epidermis is **ciliated**

- secretes **mucous trail** and uses cilia to glide on it

land planarians can glide ~6'/hr

contains rhabdites

discharge into water
swell and form protective mucous sheet around body
may also release toxins to subdue prey and escape predators

Feeding & Digestion

incomplete digestive tract in most
→mouth, no anus

some have more than one mouth & more than one pharynx

mainly carnivorous

feed on small crustacea, nematodes, rotifers, insects

can detect food at a distance by chemoreceptors

entangle their prey in mucous

wraps its body around prey

some marine flatworms prey on molluscs using a **neurotoxin** produced by symbiotic bacteria

they engulf the whole animal or cover the opening of its shell then produce the toxin to kill it

pharynx = muscular "throatlike" tube

- extend prehensile proboscis to get prey

secretes enzymes to help "predigest" prey

sucks up bits of prey

in intestine secrete enzymes which further digest prey

phagocytic cells in gastrodermis take up bits of pieces of prey and complete digestion intracellularly

GVC extends to most parts of body
→ also serves as distribution system

undigested food is egested through mouth

Nervous System & Senses

distinct head with cephalic **ganglia**

pair of **ventral nerve cords** connected by ladder-like interconnections

sense organs concentrated on head (vision, smell, touch, taste)

paired sense organs allow brain to discern the direction of the stimulus

2 eyespots (=**ocelli**)

can't form images, only detect light

auricles contain **tactile cells**

tactile cells are also distributed over body surface

auricles also contain **chemoreceptors**

some turbellaria have **statocysts** for reacting to gravity

Excretory System

protonephridia with "**flame cells**"

in freshwater forms this is mainly a way to get rid of excess water

metabolic wastes still excreted through body wall

reduced or absent in marine forms

Reproduction

Asexual Reproduction

a. Regeneration

turbellarians have considerable powers of regeneration

→replacement of lost parts

→also to recover from long food shortage

some can survive for months by self digesting up to 90% of their body

early researchers also reported learning by cannibalism

taught planarian to run a maze
cut in half and allowed to regenerate
both new worms learned the maze quicker

→ has never been repeated???

b. transverse fission

pinch in half: anterior end splits from posterior end

sometimes produces a chain of zooids

→ superficial resemblance to segmentation

c. fragmentation

when alarmed, some land planarians can break up into dozens of "blobs of slime"

in a few hours each piece will become a new worm

Sexual Reproduction

most are monoecious (hermaphrodites)

during breeding season each individual develops both male and female organs

cross fertilization not self fertilization

some with **internal fertilization**

some with vaginas & penises - usually open through common genital pore

in some monoecious flatworms mating ritual resembles a fight:
the male organ consists of two dagger-like penises.
during mating, two flatworms "penis fence"
each trying to get penis in genital pore of the other

some without vagina or genital pore use hypodermic impregnation:
each tries to stab the other with its penis while trying to avoid getting stabbed by the other
the one who gets stabbed absorbs the sperm and fertilizes its eggs

fertilized egg is enclosed in cocoon which is attached by stalks to underside of stones or plants

most have no larval stage

embryos emerge as juveniles that grow into adults

a few marine species produce planula-like larva (=Mullers larva)

→ciliated ball of cells (has 8 ciliated lobes)

Examples of Turbellarians

eg. Dugesia
common in fw streams

eg. Phagocata

up to 20 pharynxes each with a mouth

eg Terricola = land planarians

fraction of an inch to almost 1' long

creatures of dark or dim light

no eyes, 2 eyes or 100's of eyes

hunters and scavengers

some terrestrial planarians are fast enough to catch fruit flies (*Drosophila*)

eg. one Brazilian species pursues earthworms into their burrows

enfolds it

mouth exudes digestive enzymes that liquifies it

then sucks up liquified worm

eg. Bipalium

terrestrial planarian common here

it also can eat small earthworms

eg. some marine planarians have symbiotic **zoochlorella** (algae) or feed on algae

some marine forms also have "kleptonematocysts"

they eat cnidarian polyps and keep the stinging cells to use for defense

Animal Parasites

the other classes of Platyhelminths contain only parasitic species

Parasitism → most common form of symbiosis

20-50% of all animal species are parasitic

1/4th of all animal families are parasites

ectoparasites
→ parasite lives on outside of host
some can use gut for food storage and expand to many times their normal size
eg. leeches, ticks, fleas

endoparasite
→ parasite lives on the inside of host
digestive system often very simple or gone altogether
eg. tapeworms, flukes, roundworms

Benefits to Endoparasitic Lifestyle:

constant environment

gets easy access to food

protection from predators

Costs to Parasite:

host is a small "discontinuous" habitat
parasite must locate and infect new hosts to propagate its species

must be able to overcome hosts defenses:
inflammation
immune response

but can't kill host

→ the most successful parasites do as little harm as possible to their hosts

Some Typical Endoparasitic Adaptations

1. Structures for penetration and attachment to host

hooks, suckers, teeth, enzymes
most common point of entry to host is through mouth

2. Usually have a resistant stage in life cycle

for getting from one host to another
which is often in a different kind of environment
if endoparasite - needs to survive trip through digestive system

3. Reduction in "unnecessary" structures

reduced sense organs
reduced nervous system
reduced locomotion

reduced digestive system
some endoparasites have lost gut entirely
some ectoparasites use gut mainly for food storage (eg. leeches, ticks)

4. Tendency toward being Hermaphrodite

only need any two, not male and female
some can even self fertilize if necessary→ but usually don't

5. Enhancement of reproductive capacity

host is a small "discontinuous" habitat
→ need extraordinary powers of reproduction to insure survival

reproductive organs are often the largest, most apparent organ systems present

often able to produce of large #'s of eggs
Liver fluke(*F. hepatica*) → 20,000 eggs/day
Ascaris → 200,000 eggs/day
Tapeworm (*Diphyllobothrium*)
→ 1M eggs/day for 15 years
(=5.5 trillion eggs/lifetime)

6. Use of intermediate larval stages on intermediate hosts

→ to enhance chances of getting to final host

Even with large numbers of eggs chances of success are relatively small

eg. *F. Hepatica*
in most favorable situation
3-4 out of 20,000/day will actually hatch

simplest life cycle:
adult parasite → eggs → ingestion by new host

more complex life cycle:
adult parasite → eggs → intermediate host → definitive host

most complex life cycle:
flukes have several intermediate states that reproduce

7. Behavioral Adaptations

behavior is an important tool for animal survival

this is also true for parasites: behavior can be used to enhance their chances for success

Examples:

1. Simple host finding behaviors

eg. *Entobdella* (Monogenea)
skin parasite of a stingray
eggs are released and settle to bottom
larvae emerge from eggs within 3 seconds of sudden darkness
then swim vertically upwards

2. Periodic Behaviors

parasite keys in on cyclic stimulus

eg. Filarial Worms
live in blood
transmitted by mosquito or fly

larvae (microfilariae) move to peripheral blood on periodic basis
corresponds to "biting hours" of local vector (flies & mosquitoes)

eg. Guinea worm
(nematode: *Dracunculus medinensis*)
occur in tropical areas; lots of rice fields
eggs must be laid in water to be able to get to its intermediate host
female may contain up to 1 Million eggs each with a developing larva inside
larvae must be released in water to complete life cycle
to do this female moves to part of body likely to be immersed in water
→ lower legs
creates an ulcer
at moment limb enters water the female protrudes anus and discharges 1000's of infective larvae

3. Host Modifying Behaviors

an alternative to modifying the parasites own behavior is to alter the hosts behavior to make it more likely to complete parasites life cycle

eg. *Echinococcus* (Tapeworm)
sheep infected with hydatid cysts lags behind healthier members of heard → more easily caught and eaten by coyote

b. Conspicuous Behavior

eg. Acanthocephalans: adult in birds (ducks); larva in amphipods (small aquatic crustaceans)

Amphipods (fw crustaceans) typically hide in dark vegetation during the day to avoid predation

when infected with acanthocephalan worm which as adult infects birds, became highly photophilic and conspicuous

eg. burrowing clams infected with a fluke,
rather than burrowing into sediment,
remain closer to surface where they are more likely to be preyed upon

eg. Fluke (*Leucochloridium*)
adult in birds; larva in snail
when infected, snails tend to crawl to tips of vegetation instead of hiding like normal
in snail, larvae migrate to tentacles of snail
larvae are brightly colored with red and green bands they pulsate
makes snails very conspicuous in daytime
at night the larvae withdraw into the snails body

eg. *Sacculina*
one of best adapted parasites known
Sacculina is a highly modified barnacle that has become a parasite of crabs
as it matures it sheds all appendages, becomes an oval sac and penetrates a crab host
develops an extensive system of branches extending into every appendage
a saclike growth appears under the crabs abdomen where eggs and sperm form (*Sacculina* is a hermaphrodite)

the crabs metabolism is completely altered:
if crab is female:
changes are not as extensive but egg development is inhibited
if crab is a male:
body assumes shape of a female

reduced length of some segments
broadening of abdomen
testes reduced or converted to ovaries

→ both male and female resemble mature female bearing eggs: physically and behaviorally

Helminths

The most common human endoparasites are flukes, tapeworms (classes of Platyhelminths) and roundworms

These three are grouped together as "helminths" (=parasitic worms)

over 25% (1.5-2 Billion) of the world's population is infected at any one time

that's orders of magnitude greater infection rate as HIV

yet proportionally, helminth diseases receive only a small fraction of the research dollars

as such most are listed as "neglected tropical diseases"

over 135,000 die each year from helminth infections

helminth infections also have considerable effects on:

overall health and tissue damage & inflammation, anemias

persistent poverty

decreased productivity

poorer birth outcomes

decreased cognitive abilities, epilepsy and neurological disorders

malnutrition & anorexia

Class Trematoda

over 3x's more species than any of the other classes of flatworms

class includes some of our most serious parasites

almost all are endoparasitic

adults mainly found in vertebrates

leaf-like body shape (=**flukes**)

two suckers for attachment:

one around mouth
the other further down on the body

adults & larvae inhabit a wide variety of sites in hosts:

digestive tract
respiratory tract
circulatory system
urinary system
reproductive system

flukes tend to inflict greater harm to their hosts than do tapeworms

flukes can be found in veins of intestines, bladder, bile ducts and lungs

in high numbers they can cause blockages and damage

they feed aggressively on body fluids

can clog ducts and trigger gall stones and excessive enlargement of liver

Body Wall

body covered by thin flexible **cuticle**

protects from hosts digestive enzymes

integument is **syncytium** (not divided into individual cells) with no cilia

muscle layers are embedded in "tegument"

Feeding & Digestion

like turbellaria, they have well developed, incomplete digestive tract

→but with mouth at anterior end

gut usually divided into two branches

some dissolved nutrients can also be absorbed directly through skin

excretory and nervous systems similar to planarians

Reproduction

most are **monoecious** and capable of self fertilization

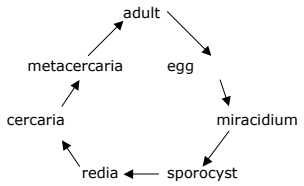
trematodes typically have a complex life cycle with
1 or more larvae occurring in intermediate hosts and adults in definitive host

adults are typically parasites of fish or other vertebrates

1 to 5 larvae occur in intermediate hosts, usually a mollusc

polyembryony occurs usually in several larval stages allowing a single egg to develop into 100's of potential adults

typical life cycle:



egg
usually passes in feces
must reach water to develop

miracidium
free swimming larva
penetrates tissue of snail

transforms into …

sporocyst
sporocyst reproduces asexually (polyembryony)
yeilds more sporocysts or…

redia
also reproduces asexualy
produces more redia or…

cercaria
emerge from snail
penetrate second intermediate host
or encyst in vegetaton to become…

metacercaria
these are juvenile flukes
when eaten by definitive host develop into adult fluke

Some larval flukes are able to change hosts behavior to make them more likely to get to final host:

eg. burrowing clams infected with a fluke,
rather than burrowing into sediment,
remain closer to surface where they are more likely to be eaten

eg. *Dicrocoelium* (Trematode, Fluke)
has 3 host life cycle:
adult in vertebrate, eg sheep
1st larva in terrestrial snail
2nd larva in ants
eggs released by host are eaten by snail
cercariae emerge entangled in slime of snail forming a sticky ball
ants eat these slimy balls
ants behavior changes so they are more conspicuous and more likely to be eaten by vertebrate:

→ when infected they crawl up blade of grass;

seize the grass in their jaws and remain there until the next morning
sheep are early grazers and eat the ant

eg. Fluke (*Leucochloridium*)
adult in birds; larva in snail
when infected, snails tend to crawl to tips of vegetation instead of hiding like normal
in snail, larvae migrate to tentacles of snail
larvae are brightly colored with red and green bands they pulsate
makes snails very conspicuous
at night the larvae withdraw into the snails body
during the day they are easy prey for birds

Examples of Flukes

eg. *Clonorchis sinensis* (Chinese Liver Fluke)

the most important human liver fluke

one of most complex life cycles:

primary host and two intermediate hosts

5 larval stages

serious problem in China, Asia, Japan

humans are final host (also cats, dogs, pigs) in which the adult lives

transmitted to humans by eating raw fish

Adult

10-20 mm long
oval, with 2 ventral suckers
simple digestive sacs
hermaphrodite
almost 80% of body is devoted to reproduction

flukes mature in intestine then move to bile ducts in liver

typically lives 15-30 years (up to 50 yrs)

light infection are asymptomatic or may produce light abdominal pain

heavy infection (up to 20,000) can cause liver damage, cirrhosis and death

1000's of eggs released each day in feces into water

eggs can survive weeks in water

if snail eats egg **miracidium** larva hatches from egg and developes into **sporocyst** then **redia** then **cercaria**

through polyembryony, a single egg can produce 250,000 cercaria

cercariae burst out of snail and burrow into fish and encyst in muscle as **metacercariae**

if fish is eaten by mammal the metacercaria cyst dissolves in intestine and fluke moves to liver of their adult host

eg. *Fasciola hepatica* (Sheep Liver Fluke)

adult lives in liver and bile ducts of liver of sheep, other ruminants and can live in humans

feed on blood

can produce up to 50,000 eggs/day for several years

eggs passed in feces

if pasture is wet the eggs hatch into free living miracidium

miracidium ingested by snail or penetrates land snail and becomes **sporocyst**, then **redia**, then **cercaria**

through polyembryony, a single miracidium larva can produce up to 4000 cercaria larvae

cercaria leaves snail and encysts as **metacercaria** on vegetation

when vegetation is eaten by sheep or ruminants, the adult hatches and moves to liver

eg. *Schistosoma* (blood fluke, schistosomiasis)

doesn't occur in US; but >400,000 immigrants are infected

one of the worlds major helminth infections

→ affects 200M worldwide:
esp Africa, S. America, Mid East, Far East

150,000 die each year from direct effects of the parasite; especially renal failure

another 200,000 die from related causes

snail is intermediate host, humans are final host for 3 mainly human species

other species of Schistosoma infect birds and mammals

mature adults live in portal vein of liver, feeding on blood

differ from most other flukes by being **dioecious** (separate sexed)

males larger

females smaller, stay in groove (=**gynecophoric canal**) in males body

female penetrates wall of blood vessel in liver and release eggs into bile ducts

eggs move from bile ducts to intestine and passed in feces

eggs might also enter bladder and be released in urine

many eggs can lodge in liver and cause abdominal pain, fever and bloody diarrhea, ulcerations, etc

eggs may also be carried to lungs causing inflammation

if eggs reach water they hatch into ciliated **miracidium**

have only a few hours to find snail host or they die

if eaten by snail they develop into **sporocyst**, then **cercaria** (no redia stage)

if humans are in contaminated water:
cercariae bore directly thru skin to get into blood

cercaria are one of few parasites that can bore through skin

rice farmers are easily infected

in North America some blood flukes of birds may atempt to bore into humans

they don't survive and cannot infect us

but their burrowing and death in skin can cause **swimmers itch**

eg. *Paragonimus* (Lung fluke)

lives in lungs of host

many mammals are hosts

found in East Asia, SW Pacific and parts of S. America

eggs coughed up, swallowed then eliminated in feces

metacercaria develop in fw crabs

infection is acquired by eating uncooked crab meat

infection causes breathing difficulties and chronic cough

fatalities are common

one species found in N America infects minks with its larvae in crayfish

only 1 human case reported

Class Monogenea

A group of small (rarely >.75") mostly ectoparasitic flatworms

widespread and common

1000's of species

once placed with trematodes

all are parasites

→mainly ectoparasites on gills or skin of fish

some species infect other cold blooded animals

one species infects the eye of hippos, no other warmblooded birds or mammals

a few are found in urinary bladder of frogs and turtles

have anterior and posterior attachment organs

seem to cause little damage to their hosts

all are hermaphrodites

direct life cycle with single host

they have no intermediate hosts

egg hatches into ciliated larva

larva and adult have large posterior attachment organ with hooks

Class Cestoda (Tapeworms)

>1000 species

most specialized class of flatworms

all are endoparasites

can grow up to 10 M (30') long

1991: doctors removed 37' tapeworm from Mississippi woman

max tapeworm length ever recorded is over 90' taken from a sperm whales intestine

adult can live up to 20 years

Body Plan

very different from other classes of flatworms

→no head

front end of the animal is not a head, it's a special organ for attachment (=**sclex**)

→ has suckers and hooks

use for attachment, not for feeding or sensing the environment

→"body" consists of a long chain of reproductive sacs = **proglottids**

proglottids bud off the **scolex**

(a chain of proglottids = strobila)

bud from scolex with oldest ones furthest away

→ not same as segmentation since each proglottid acts as an individual animal

some individuals can produce a dozen proglottids/day

some tapeworms have up to 3000 proglottids

Body Wall

tegument is syncytial (not subdivided into separate cells) with **microvilli** (microtrichs) to increase surface area for absorption

tegument secretes a protective **cuticle**

no external cilia

well developed muscle layers beneath body wall

Feeding & Digestion

completely lack digestive system

→ absorb food through skin (=tegument)

Nervous System

simple nervous system

proglottids are united by nerve cords,

but no special sense organs

Excretion

somewhat similar to other flatworms

protonephridia continuous throughout proglottids

Reproduction & Life Cycles

each proglottid acts as "individual"

→ any two proglottids can exchange sperm

when gravid each proglottid may contain up to 100,000 eggs each

Life Cycle

almost all tapeworms require at least 2 hosts; mainly vertebrates

but same host can bear either the adult or the larval parasite

typically the intermediate host is the prey of the adult host

all are monoecious (hermaphrodites)

the most mature proglottids are those furthest away from the scolex

unlike most hermaphrodites, tapeworm proglottids can cross fertilize in same animal

testes usually develop before ovaries so generally can self-fertilize a single proglottid

eggs or mature proglottids are shed in feces

once egg is released must be ingested by intermediate host (another vertebrate)

→ usually a vertebrate "prey" of a final host

once eggs ingested larva hatches and bores through intestines of host and into blood

travels to skeletal muscle, heart and other organ

secretes a protective **cyst**

in some, cyst develops into a "**bladder-worm**" or **cysticercus**

humans can get infected with eggs by unsanitary habits with feces, not washing hands, kissing pets, etc

but humans make poor intermediate hosts from the parasites perspective

→ nothing eats them

Examples of Tapeworms

eg. Beef Tapeworms *(Taenia saginata)*

>50 Million infection worldwide; especially South America, SE Asia, Africa

adult in human intestine

mature adult may reach 10 M (30 ft) or more

scolex buries itself in intestinal wall

→ has 4 suckers to attach (no hooks)

can bud over 2000 proglottids

numerous proglottids are released each day:

gravid proglottids break off and pass with feces

sometimes they crawl out anus

they crawl out of feces into nearby vegetation

proglottids dry and release eggs

→ can remain viable on grass up to 5 months

picked up by grazing cattle

when eaten by cattle the eggs hatch

larva burrows through intestine and into blood

reach skeletal muscles where they encyst as **bladderworms**

= "measly meat"

In US infections are not uncommon:

34 M cattle in US; ~1% of US cattle are infected
20% not federally inspected
1/4th of the infections are missed in inspection of meat

→ 5 in 10,000 or ~150,000 in US infected

humans become infected by eating 'rare' or poorly cooked roast beef, steaks and barbecues

when measly meat is eaten bladderworm hatches and adult develops in intestine of final host

takes 2-3 weeks for mature worm to develop

if just a few the infection will be mild or asymptomatic

light infections may cause weight loss

→ "diet pills"

heavier infections may cause diarrhea and vomiting

eg. Pork Tapeworm (*Taenia solium*)

pork tapeworm is more dangerous to humans since the larval stage can more easily develop in humans

adults usually live in human small intestine
juvenile in muscles of pigs

adult can live up to 10 years and grow to 10' long

generally doesn't occur in US but thrives in Mexico and Central America

occasionally shows up along border.

WHO estimates that 2.5 Million are infected with adult worm and many more with larvae worldwide

scolex has hooks *and* suckers

life cycle is similar to beef tapeworm

each proglottid can release 50,000 eggs

eggs eaten by pigs and larva migrates to skeletal muscles

humans usually infected by eating poorly cooked pork and adult develops in intestine

if humans ingest eggs rather than the larva

the eggs will develop into a bladderworm that encysts in body tissues

=cysticercosis

can cause serious problems by lodging in:

eyes → blindness

brain → neurological symptoms or death

muscle → pain and weakness, inflammation

and other visceral organs

treatment usually involves surgery

eg. Echinococcus (dog tapeworm)

about 1 Million are infected worldwide.

one of the most dangerous tapeworms

a group called "tissue tapeworms"

adult is very small: only a few mm

adults occur in dogs, coyotes, wolves and other canines

juvenile develops in >40 species of mammals (eg. monkeys, sheep, reindeer, cattle) including humans

sheep infected with juvenile lag behind healthier members of heard → more easily caught and eaten by coyote

humans can become intermediate hosts by fecal-oral route; eg. kissing pets

(humans are dead end choice for parasite since few eat humans)

once ingested, juvenile moves to various tissues; eg. liver, lungs, brain

juvenile stage is special kind of cysticercus = **hydatid cyst**

grows quickly; 1 cm/month, for up to 20 years

may be no symptoms for years

can reach size of basketball

→ up to 4 gallons

within main cyst daughter cysts bud off

each daughter cyst contains 1000's of scolices

symptoms and signs depend on the cyst's location and size

in humans, growth of cyst can cause damage to organ

if cyst ruptures the fluid itself can produce anaphylactic shock, even death

only treatment is surgical removal

eg. Fish Tapeworm (*Diphyllobothrium latum*)

humans and other animals are definitive host

ocurs wherever fish are an important food source and the water supply is easily contaminated with sewage

endemic in Europe, Asia, US & Canada

2 intermediate hosts: copepods & fish

in humans, adult attaches to intestinal lining by scolex (no hooks)

eggs are released in feces

if feces enters water eggs may be eaten by tiny crustacean, copepod

fish eats copepod and bladderworm encysts in fish muscle

if fish are improperly cooked, or eaten raw (sushi) the infection is transferred to humans

thorough cooking or freezing (-10º C) for 24 hrs kills the parasite

eg. *Diphylidium caninum*

adult in small intestine of dog or cat

up to 6" long

fleas are intermediate host

fleas eat tapeworm eggs released in pet feces

egg hatches and encysts in flea

dog eats fleas and bladderworm hatches into adult

Human Costs of Parasitic Flatworms

250-300 Million people worldwide are infected with some type of parasitic flatworm

(some put that number much higher)

results in Billions of dollars in healthcare costs and lost productivity

also affects livestock and pets

Beneficial Effects of Parasitic Flatworms

1. weight loss

light infections of adult tapeworms cause little damage and may cause a loss in weight

→ larvae once sold as weight loss pills in US

today the treatment is only available in Mexico, the approximate cost is $1500.

tapeworm infestation can result in a loss of one to two pounds per week.

once the target weight loss is reached, a deworming agent is given

However, Tapeworm infestation can result in:

The formation of cysts in the liver, eyes, brain, and spinal cord with potentially lethal consequences.

if pork tapeworm much more serious

intestinal blockages

malnutrition

2. Helminth Therapy

a type of immunotherapy to treat autoimmune diseases and immune disorders by deliberately infecting patient with intestinal parasites

research has found that intestinal parasites, particularly roundworms have the ability to temper the immune system and prevent the overreactions that cause allergies, asthma, ulcerative colitis, Chron's disease, etc

helminthes have thrived in mammals for millions of years

over that time they have adapted to survive the onslaught of the hosts immune responses to the infection

"Hygiene Hypothesis"

→ as hygiene has improved allergies, asthma and other autoimmune diseases have dramatically increased

in developed countries, where improved sanitation has largely eliminated helminth infections there has been an increase in such autoimmune disease in the past 100 years

these same diseases are rare in poor countries where intestinal parasites are endemic

there is a large "underground market" in helminth parasites fueled by these findings – medicine is just now catching up