Animal Parasites

Parasitism → most common form of symbiosis

endoparasite

→ parasite lives on the inside of host

digestive system often very simple or gone altogether

eg. tapeworms

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

if larval stage has a different host than the adult,

then:

intermediate vs **definitive** (primary) host

Benefits to parasite:

gets easy access to food

protection, esp if endoparasite

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

Parasitic Adaptations

1. **Structures for penetration and attachment to host**

hooks, suckers, teeth, enzymes

most common point of entry to host is through mouth

must be resistant to digestive juices

2. **Loss of superfluous structures**

reduced sense organs

reduced nervous system

reduced locomotion

3. **Reduction or loss of digestive system**

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

4. Enhancement of reproductive capacity

host is a small "discontinuous" habitat
at times extraordinary means are needed to find new hosts
eg. hermaphroditic
some can even self fertilize if necessary
eg. production of large #'s of eggs
Liver fluke (*F. hepatica*) → 20,000 eggs/day
Ascaris → 200,000 eggs/day
Tapeworm (*Diphyllobothrium*)
→ 1M egss/day for 15 years
(=5.5 trillion eggs/lifetime)

5. 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

6. Usually have a resistant stage in life cycle

for getting from one host to another
which is often in a different kind of environment

7. Behavioral Adaptations

Can improve the odds of completing life cycle
by certain behaviors of the parasite or by altering the host behavior

Parasite Behavior

behavior is an important tool for animal survival

social, mating, territorial behaviors etc

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

all behavior has a genetic basis
→ follows Darwinian evolution to some degree
predictable
programmed
adaptive (reproductive advantage)

simple behaviors are either:

Instinctive	or	Learned
taxes		imprinting
reflexes		habituation
fixed action patterns		conditioning
mimicry, camoflage		social:
		courtship
		reproductive
		family
		group

The most basic theory of behavior:
stimulus → response

may or not be aware of the stimulus
stimulus may be internal or external
→ perceived by sensory organ or cell

response is controlled or modified by nervous or endocrine system

The simplest behaviors are simple movements of some kind

Examples of Behaviors Useful for Parasites:

1. **Host finding behaviors**
   - **eg. Golden nematode (*Heterodera*)**
     parasite of potato plants
     chemical in soil diffusing from plant stimulates emergence of larva from cyst and attracts it toward plant
   - **eg. *Entobdella***

skin parasite of a flatfish
some larvae hatch only when stimulated by host chemical

eg. *Acanthocotyle*
skin parasite of rays
encapsulated larvae are fully developed in 15days
will remain alive if unhatched upt to 3 months
regardless of prodding, poking, variations in light, etc
but addition of host skin mucus triggers hatching in 2-4 seconds

eg. *Entobdella* (different species)
skin parasite of a stingray
larvae emerge within 3 seconds of sudden darkness
then swim vertically upwards

2. Periodic Behaviors
really just a special case of above
but key 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

eg. Loa loa → diurnal vector
eg. Wulcheria → nocturnal vector
but in S Pacific vector bite in day so are diurnal here

eg. Pinworm (*Enterobius*)
migrates to anus when host is asleep
day or night → keys on sleep physiology of host

eg. Rabbit Flea (*Spilopsyllus*)
parasite's ovaries develop in response to
corticoid hormones of pregnant host
→shortly after rabbits are born
levels of pituitary hormones in young stimulate
fleas to copulate and lay eggs
afterwords, most fleas return to mom and
complete regression of their gonads occurs

3. Opportunistic Behaviors
in some cases parasites are able to exploit
irregular and unpredictable possibilities for transmission

eg. Guinea worm (nematode: *Dracunculus medinensis*)

Intermediate Host = copepods (plankton)
Definitive host = mammals (include humans)
infecting by drinking water with infected copepod
parasite moves to subcutaneous tissue
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 momemt limb enters water the female protrudes and discharges 1000's of infective larvae

eg. Pseudodiplorchis

parasite's eggs must be laid in water and find new host while it is in water
host is spadefoot toad
toad lives in desert
hibernates 9-10 months of the year, 3' below ground
only becomes active during annual rains
only returns to water to reproduce
spawning occurs over a 3 day period
but toads are strictly nocturnal (9pm→ 4am=7 hr window)
→ so total opportunity for transmission is <24hrs/yr
=greatest restriction of any helminth parasite
→ yet in one study 50% of toads were infected

4. 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

a. Change Hosts Activity Levels

if adult host is a predator and intermediate host is prey

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

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

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

another species: when disturbed it ducks for cover; when infected it skims the surface of the water

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. Carpenter ants infected with *Brachylecithum*
become lethargic, lose normal photophobic response
tend to wander around on rocks in exposed sun
become obese
easy targets for robins

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

c. Protective Behavior toward Parasite

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 a male:
body assumes shape of a female
reduced length of some segments
broadening of abdomen
testes reduced or converted to ovaries
if crab is female:
changes are not as extensive but egg development is inhibited

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

Blood & Liver Flukes
(Trematodes)

relatives of the Planarians

most relative small, <.5”

leaf-like shape (=fluke)

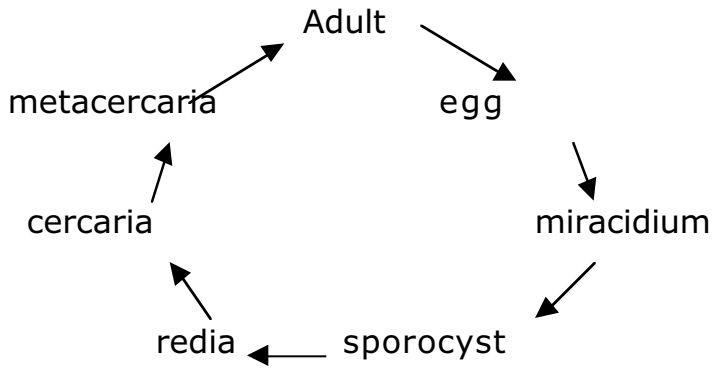
almost all are **endoparasites**

hermaphrodites that produce 1000’s of eggs

this group includes some of our most serious parasites

inhabit a wide variety of sites in their hosts:
- digestive tract
- respiratory tract
- circulatory system
- urinary system
- reproductive system

most have fairly complex life cycle with 1 or more intermediate host



egg: released in feces, must reach water to develop

miracidium: free swimming larva
hatches from egg
penetrates tissue of snail where it transforms into

sporocyst: reproduces asexually (twinning) to yield many larvae

redia: also reproduces asexualy to produce more larvae

cercaria: emerges from snail
penetrates second intermediate host or encysts on

vegetation

metacercariae: these are "juvenile" flukes when host is eaten by definitive host the adult grows

eg. Chinese Liver Fluke *(Opisthorchis sinensis)*

a serious problem in China, Asia and Japan

has one of the most complex life cycles of any parasite

humans are the "final" host
but also infects cats, dogs, pigs

Life Cycle

Adult Flukes

mature in intestine then move to bile ducts in liver

light infections → no symptoms

heavy infections (to 20,000) → can cause liver damage

adults can live up to 50 years

1000's of eggs can be released in feces /day

Intermediate Hosts

eggs hatch into miracidium and burrow into snail where they go through 2 more larval stages and reproduce asexually

a single egg can result in 100's of infections

cercaria emerge from snail and burrow into fish where they develop into metacercaria

eating infected raw fish (sushi) completes life cycle

eg. Sheep Liver Fluke *(Fasciola)*

adults live in bile ducts of liver

eggs passed in feces

miracidium penetrates snail and becomes sporocyst the redia then cercaria

cercaria leave shail and encyst (metacercaria) on vegetation

when vegetation is eaten by sheep or other ruminant the adult grows

can infect humans

Blood Flukes

eg. Schistosomiasis (*Schistosoma*)

affects 200 Million worldwide
esp Africa, S. America, Mid East, Far East

3 different species

snail is intermediate host, humans are final host

Adults live in "portal vein" in liver

separate sexed
smaller female lives in groove in larger males
body

eggs are passed in feces and/or urine

in heavy infections many eggs may lodge in
liver and cause damage

if eggs reach water, they hatch and infect a snail

cercaria are released from snail and burrow into
human final host
→ one of few parasites that can actively
bore through skin to get into host

rice farmers are easily infected

in N America: some bird species may attempt to
bore through humans while in water
= swimmers itch

Lung Flukes

eg. *Paragonimus*

lives in lungs of many mammals

found in east Asia, SW Pacific and some 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

fatal cases are common

one N American species occurs in minks with the larva in crawfish
→ only 1 human case reported

Tapeworms (Cestodes)

very different from flukes

Adults

adult in intestines of host

usually long flat bodies consisting of a chain of "egg sacs" (=**proglottids**) that bud off an attachment organ (=**scolex**)

up to 10M (30' long)

can live up to 20 years

scolex with **hooks** and **suckers**

completely lack digestive system
→ absorb predigested food

some species may produce a dozen proglottids/day

each proglottid is a reproductive sac with male and female organs

any two proglottids can exchange sperm

when gravid a proglottid may contain up to 100,000 fertile eggs

eggs shed or whole proglottids released in feces

Larva

once eggs are shed they must be ingested by intermediate host

usually a vertebrate prey of the final host

once eggs are ingested, it hatches and larva bores through intestine of host and into blood

travels to skeletal muscle, heart or other organ

secretes a protective cyst

some of these cysts develop into a fluid filled sac = **bladder worm** (cysticercus)

eg. Beef & Pork Tapeworm
(*Taenia* = *Taeniarhynchus*)

adults in humans

mature adult may reach >30 feet

scolex buries itself in intestinal wall

can produce over 2000 proglottids

gravid proglottids break off and pass out with feces

they crawl out of the feces and onto vegetation

proglottids dry and release eggs
→ can remain viable for up to 5 months

picked up by grazing cattle

but could also be pets, esp dogs and other humans
→ unsanitary conditions
→ kissing pets

when cattle eat the eggs they hatch and larvae burrow through intestine into blood

encyst in muscle tissue of intermediate host as bladder worms

~1% of US cattle are infected

when "measly" meat is eaten
eg. rare roast beef. steaks,
eg. poorly cooked barbecue

the adult develops in intestine

when person is infected numerous gravid proglottids are expelled daily

sometimes they crawl out the anus

the pork tapeworm is more dangerous for humans since cysticerci also can develop in humans
→ esp eyes and brain

eg. Echinococcus

parasites of dogs and other canines

juvenile develops in >40 species of mammals including humans

ie. Humans can be intermediate host
→ bad for parasite since humans are rarely eaten by dogs

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

grows slowly, for long time (up to 20 yrs)

can reach size of basketball

within main cyst are "daughter cysts" that bud off, each contains 1000's of scolices

only treatment is surgical removal
→ very dangerous

Spiny Headed Worms
Acanthocephala

one of the most completely parasitic organisms in the animal kingdom:
everything but reproductive system and hooks are degenerate

look like roundworms but with cylindrical retractable proboscis with rows of spines

requires two hosts:

Adult
endoparasite in vertebrates
attach to intestine by spiny proboscis
especially fish, birds and mammals
none in humans
host may contain 1000's of worms

Juvenile
in arthropods
arthropods eat feces with eggs to get infected
larva can modify the insects behavior to make it more likely to be eaten by final host

Roundworms
(Nematodes)

a very large group of animals

most are free living in soil and water

but many are important plant and animal parasites:
plant parasites cause billions of dollars in damage to crops each year
livestock also suffer heavy losses
common parasites of pets
eg. heartworms

a few are important human parasites
virtually every human is host to some parasitic nematode
human parasites are the best known of the roundworms but make up only a small % of total species

compared to the other parasites we've discussed they
have fairly well developed tissues and organs and organ systems

elongated worm-like body

most <5 cm long

tube within a tube =complete digestive tract

nervous system with ganglia

excretory system

dioecious (separate sexed)

most produce eggs, a few give birth to live young

eg. Ascaris

one of the largest roundworm parasites ~1 ft long

1 Billion people in the world are infected

even in US infections are not uncommon

main cause of infection is fecally contaminated food

→ larvae can survive up to 7 years in soil
(long after any trace of feces remains)

Life Cycle:

eggs or larvae are ingested

larva burrows into blood and circulates to lungs as it develops and matures

ascends trachea or is coughed up and reswallowed

arrives again in intestine ~ 2months after initial infection

if another worm of opposite sex is there they mate

female can release ~200,000 eggs/day

Symptoms:

local inflammation if juveniles get in "wrong" tissue

if high #'s in lungs can get severe pneumonia

if a few adults in intestine → minor effects

many may cause blockage

adults may exit mouth or anus

eg. Toxocara

common roundworm of puppies and kittens

virtually ALL puppies and 20% of kittens are infected until "wormed"

esp in SE US

smaller but similar life cycle

Toxocara can infect children
→ but won't complete life cycle
→ usually killed in liver or lungs

it can wander through various tissues and
organs before it dies and cause inflammation

eg. Pinworms (*Enterobius*)

one of the most common human nematode infections

small worm: 1/2 –3/4" long

humans are the only hosts

THE most common helminth infection in US
→1 in 3 children (30%); 1 in 10 adults are infected

is seldom a health problem
→ feeds on bacteria and wastes, not on "hosts" tissues

highly contageous:
not dependent on fecal contamination of food or soil
eggs are very resistant and spread directly on skin and in air, etc

Life Cycle:

after copulation male dies,

female crawls to anus to deposit 1500 eggs and dies

this can cause intense itching
→ eggs are spread on bed sheets, air , fingers, etc

infections easily spread to all family members

larvae may hatch and can also reenter intestine to reinfect

eg. Hookworms (*Necator*)

eg. Filarial Worms

250 Million humans infected

common in tropical countries as cause of diseases:
elephantiasis
river blindness

most common filarial worm in US is dog heartworm, Dirofilaria
up to 45% infection rate in US dogs
a few human cases
adults live in ventricles of heart
transmitted by mosquitoes
cant treat → dead worms would clog vessels

Elephantiasis

female up to 10 cm long

Life Cycle:

adults live in lymphatic system

female releases live young into blood (microfilariae)

mosquito carries larval worms to new victims

eg. Trichinella

smaller than pinworm → barely visible to naked eye

adult can live in several hosts: humans, pigs, rats, many wild animals

the adults and larvae develop in same hosts but

each worm requires two hosts to complete its life cycle

Life Cycle:

adults burrow into the lining of the intestine

female produces living young

enter blood and circulate to all areas of body

when they reach muscle tissue, juveniles coil up and encyst
(eg. diaphragm, thorax, abd wall, tongue, biceps, deltoids)

humans are infected by eating poorly cooked infected meat

Symptoms

range from mild to life threatening

as larvae move around in body they may cause local inflammation

as they encyst in muscle tissue may cause soreness and achy muscles

larvae are viable for up to 2 years
– are slowly killed and calcified

heavy infections may be fatal

human infections often appear in small, sporadic outbreaks due to:
undercooked pork, bear, sausage

Ectoparasites

live or feed on the outside of the host

usually only temporarily attach to host

eg. leeches, mites, ticks, lice, flies, mosquitoes, etc

<u>Leeches</u>

small group of only ~500 species

mainly freshwater, a few marine

most are carnivorous predators

a few are temporarry or permanent ectoparasites

have an anterior and posterior sucker to attach to host

protrusible **pharynx** with 3 toothed jaws to pierce skin of host

as they feed they secrete:
a local **anasthetic**
a **histamine-like substance** to dilate blood vessels
an **anticoagulants** (=hirudin)

are able to consume blood meal several x's their own weight
(Hirudo takes up to 15 ml)

have very slow digestion;
eg hirudo can take up to 200 days to digest one meal
and can live another 100 days on the energy gained
in some their guts secrete no proteolytic enzymes
and rely on bacterial symbionts for digestion of proteins

eg. Medicinal Leech (Hirudo)

once used to suck out bad blood
were collected to near extinction in Europe
now are a protected species
introduced to US but are rare in nature

Arthropods

mites, ticks, lice, fleas, mosquitoes, flies, etc

many are more dangerous for the diseases they transmit than for the direct damage they do to host

eg. Mites >30,000 species, probably lots more

many mites are freeliving and feed on decaying vegetation; some are predators

some are blood sucking parasites during all or part of their life cycles

some mites have become adapted to live as internal parasites in the lungs and iar sacs of snakes, birds and mammals

eg. follicle mites
found in hairs of face especially around nose, and in ear wax

usually symptomless
in a few may cause redness or irritation
same mite in dogs causes **mange**

eg. chiggers (redbugs)

"there is probably no creature on earth that can cause more torment for its size than a redbug"
is actually a larvae: minute, reddish; 0.2x0.15"barely visible to eye
the irritation is largely due to sensitization to saliva that it injects
12-24 hrs after infection itching is at its worst

eg Ticks

surpass all other arthropods in the numbers and variety of diseases that they can carry

all ticks are parasites during some part of their life cycle

most infest mammals , many attack birds, a few attack cold blooded vertebrates

some show host preference; others are nonselective

attracted by animal smells from a distance of up to 50'
→ tend to collect on game trails

wounds made by ticks are very likely to become infected
especially if "head" is torn off
may even result in blood poisoning

most ticks will not let go even if touched or prodded by chemicals or heat

best removed by gentle pulling

most ticks have a 3 host life cycle

ticks also important vectors for disease:
Rocky Mountain Spotted Fever
Lyme Disease

eg. Lice

looked on today with disgust and loathing but:
high proportion of some populations (50%) esp children have them
common in jails, camps, etc
in some countries lice are believed to be an indication of robust

health and fertility

can suck on blood intermittently for hours at a time

eggs = nits, deposited on hairs or clothing

2 genera of human lice:
- head and body lice
- crab louse

eg. head lice
- prefer fine hair of head

eg. body lice
- generally live on clothing when not feeding
- a female can lay 80-100 eggs at a time

head and body lice can spread:
- typhus
- trench fever
- relapsing fever

eg. crab louse
- mainly in coarse hairs of body:
  - pubic area, armpits, beard, eyebrow, eyelashes
- almost exclusively confined to caucasians
- almost always venereally transmitted
- each female can lay 25 eggs at a time

eg. Fleas

over 1000 species of fleas

have compressed bodies and backward spines and bristles to help them move through fur
piercing, sucking mouthparts

long powerful legs → enormous jumping power
- eg. human flea (Pulex irritans; really a pig flea)
  - can jump 13" horizontally; 7.75" vertically
  - equivalent jump for human:
    - 450' broad jump
    - 275' high jump

most breed and lay eggs in nests of hosts

cat and dog fleas lay eggs in fur of host

most fleas suck blood wherever they can find it

fleas are fairly indiscriminant in host choice
→ since they change hosts easily they easily transmit diseases:
typhus, plague, etc

David Harum: "A reasonable amount of fleas is good for a dog,
they keep him from broodin' on bein' a dog"