Animal Parasites

Parasitism → most common form of symbiosis

1/4th of all animal families are parasites

20-50% of all animal species are parasitic

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

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

Benefits to parasitic lifestyle:
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

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

Some Animals Parasitic on Humans

worldwide, 3 of every 4 people are infected with parasites

bacteria, viruses, protozoa, worms, etc kill 17,310,000 people/yr

typical #'s of parasite species with human hosts:

insects	→ 8
mites & ticks	→ 4
nematodes	→ 12
tapeworms	→ 4
flukes	→ 1

especially common in developing, tropical countries

the most common kinds of internal human parasites are the "helminthes":

liver and blood flukes
tapeworms
roundworms

Blood & Liver Flukes
(Trematodes)

endoparasites, relatives of the planarians

most relative small, <.5"

leaf shaped body (=fluke)

most are **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

eg. <u>Chinese Liver Fluke</u> *(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 (dozens) → no symptoms

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

adults typically live 15-30 years but up to 50 years

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

Intermediate Hosts

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

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

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

eating infected raw fish (sushi) completes life cycle

eg. <u>Sheep Liver Fluke</u> *(Fasciola)*

adults live in bile ducts of liver

eggs passed in feces

miracidium penetrates land snail and becomes sporocyst the redia then cercaria

cercaria leave snail and encyst (metacercaria) on vegetation

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

can infect humans

eg. Blood Flukes; Schistosomiasis (*Schistosoma*)

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

3 different species

aquatic 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 blood flukes of birds may attempt to bore through humans while in water
= swimmers itch

Tapeworms
(Cestodes)

very different from flukes

body consists of a **scolex** for attachment and a long "body" of reproductive sacs (= **proglottids**)

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

proglottids almost completely made up of male and female reproductive organs

any two proglottids can exchange sperm

some species may produce a dozen proglottids/day

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

tapeworms comletely lack a digestive system

human tapeworms grow up to 30' long (10M)

can live up to 20 years

tapeworms require two separate hosts to complete their lifecycle

typically a predator is the host of the adult worm, larvae are found in prey

Adults live in intestines of host

eggs or whole proglottids are 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 muscles, heart, or other organ

encysts as the larval stage:

a fluid filled sac = **bladder worm** (cysticercus)

two of the most common human tapeworms:

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

→ eggs can remain viable for up to 5 months

eaten with grass 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

transferred to us 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

Roundworms
(Nematodes)

a very large group of animals

most are free living in soil and water

→ called threadworms

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 in dogs and cats

a few roundworms are important human parasites

virtually every human being is host to some parasitic nematode at some time in their lives

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

elongated worm-like body

most <2.5" (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

eggs or larvae are ingested fecally contaminated food

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

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 also have a tendency to "wander"; particularly if living conditions become unfavorable

eg. fever, anaesthetics, worming tablets

they may exit the anus or out the mouth

occasionally may perforate intestine or enter bile ducts

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

<u>THE</u> 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

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

eggs are highly contagious:

not dependent on fecal contamination of food or soil

eggs are very resistant and spread directly on skin and in air, etc

infections easily spread to all family members

larvae may hatch and can also reenter intestine to reinfect

eg. Trichinella (trichina worm; trichinosis)

probably the most *dangerous* roundworm disease of humans

smaller than pinworm → barely visible to naked eye

causes **trichinosis**: a potentially lethal disease

in US an estimated 2.5% of the population is infected each year; ~750,000/yr

infections are also common in other parts of world

each worm requires **two separate hosts** to complete its life cycle:

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

the adults and larvae can develop in same hosts but each worm requires two hosts to complete its life cycle

adults live in the intestine

in low numbers produce very few symptoms

after mating, the female burrows into the wall of the intestine and releases juveniles into the blood

juveniles circulate to all parts of body

but coil up and encyst only in skeletal muscle cells

eg. diaphragm, chest & abdominal wall, tongue, biceps, deltoid

humans are infected by eating poorly cooked infected meat

often due to undercooked pork, bear, sausage

Symptoms of infection:

human infections often appear in small, sporadic outbreaks due to:

undercooked pork, bear, sausage

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

Beneficial Effects of Endoparasites

1. weight loss

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

→ larvae sold as weight loss pills

2. dampen an overactive immune system

helminths are able to survive in hosts because they can suppress the host's immune system

light infections of flukes and other helminths are used to control allergies and some autoimmune diseases

Ectoparasites

live or feed on the outside of the host

usually only temporarily attach to host

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

Leeches

small group of only ~500 species

mainly freshwater, a few marine

most are carnivorous predators

a few are ectoparasites

have an anterior and posterior **suckers** to attach to host while feeding

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

(eg. *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 enzymes and relies on bacterial symbionts for digestion of proteins

Medicinal Leech (*Hirudo*)

in past centuries medicinal leech, *Hirudo*, was used to suck out "bad blood"

once believed many bodily disorders were the result of bad blood or too much blood

→ were collected almost to extinction in Europe

now a protected species

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

usually very tiny; <1mm

→ some mites are so small they can only be identified with electron microscope

many mites are free living 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 air sacs of snakes, birds and mammals

eg. follicle mites
usually commensal, NOT parasitic
found in hairs of face especially around nose, and in ear wax
~ 1 in 5 people harbor them, proportion increases in older folks
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"
minute, reddish; 0.2x0.15"; barely visible to eye
feed on skin of many vertebrates including humans
red bugs are mite **larvae** that are very small and can easily go through clothing and burrow in skin
adults are not parasites
chiggers don't actually burrow into skin but secrete saliva to dissolve skin cells for food

the irritation is largely due to sensitization to saliva and its enzymes that the chigger injects to liquify the skin cells
12-24 hrs after infection itching is at its worst

eg Ticks

much larger than mites

all ticks are parasites during some part of their life cycle

some lay up to 12,000 eggs

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, sometimes seriously

especially if "head" is torn off

anticoagulants are sometimes toxic

may cause fever and inflammation

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

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

eg. Rocky Mountain Spotted Fever
eg. Lyme Disease
also other viral, fungal and bacterial diseases

eg. Lice

looked on today with disgust and loathing but: high proportion of some populations (50%)

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

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"

eg. bed bug

4-5mm
nocturnal
feed on blood
in day, hide in bedding and cracks and crevices anywhere in room
in large infestations produces distinctive "bedbuggy smell"
can live up to a year even without food

eg. mosquitoes

besides being blood parasites are also vectors for malaria, yellow fever, dengue fever, elephantiasis, etc

mosquitoes indirectly kill more people each year than any other cause (infect up to 1 Billion each year and kill up to 3 million)

Human Benefits of Ectoparasites

1. leeches used today in medicine to speed healing of reattached fingers and limbs

2. leeches have become leading research models for understanding how the nervous system works

3. some chemicals used by the leech in obtaining and digesting blood are being studied for treating circulatory diseases

4. leeches have also affected history:

eg. land leeches of India

live in extremely large numbers in humid forests of India

live in trees and shrubs and fall like "drops of dew" onto any humans passing underneath

their mass attack caused the retreat of a British regiment during the Sikh rebellion in India in mid 1850's!

5. some blood sucking insects are used to assess the health of wildlife populations

eg. *Dipetalogaster maximus* (hemiptera) is used as a high tech syringe

can take up to 4 ml in one meal

donor doesn't feel a thing

used as a way to get blood samples from wild animals that are difficult to sample in other ways

eg. can measure stress hormone levels in nesting terns without having to capture them

eg. used to survey rabies infections in bats
removes blood sample using a needle; they recover quickly