Host-Parasite Interactions

Aims

- What is a parasite?
- Parasite diversity.
- Host-Parasite Specificity
- Host-Parasite Coevolution
- Effect of parasite in the host.
- Parasites and the evolution of sexual reproduction.
- Parasites in control - manipulation of host behaviour.

Definitions of parasite

Webster's International Dictionary:

'An organism living in or on another organism, obtaining from it part or all of its organic nutrient, commonly exhibiting some degree of adaptive structural modifications and causing some real damage to its host'

Host-Parasite Specificity

- Host-parasite compatibility is based on recognition mechanisms which are both host in origin and of exquisite specificity. Such as red blood corpuscles to *Plasmodium vivax* infection in man which is being associated with Duffy (warm) blood group determinants which functions as erythrocyte receptors for the parasite.
- Another example is the use of components of the host's compliment system for the attachment to and the penetration of *Babesia* parasites into erythrocytes.
- The molecular basis of host-parasite specificity is unknown.
- Site selection and ability to recognise the local environment are features of parasitism.

Effect of Parasites on Their Hosts

- Several species of parasites are relatively harmless; many others produce pathological changes which may lead to severe ill health or death of the host.
- The parasite may compete with the host for food (Vitamin B12 by *D. latum* in humans); pernicious anaemia.

Effect of Parasites on Their Hosts

- The parasite may be the cause of decreased food utilization by the host; it may cause reduced appetite; increased passage of food through the digestive tract; decreased synthesis of protein for skeletal muscles.
- Changes in the absorptive surfaces of intestine.
- Blood sucking parasites remove the host tissues and fluids (Blood sucking parasites; arthropods)

Effect of Parasites on Their Hosts

- Destruction of host tissues (developing migrating larvae) attachment (head spines, suckers).
- Increase in size of the parasite (hydatid cyst; coenurus) pressure.
- Blocking of ducts produce infarction (*Strongylus*); lymph vessels to produce oedema and elephantiasis (Filariasis); or intestinal tract to produce necrosis and rupture (Ascarids).

Effect of Parasites on Their Hosts

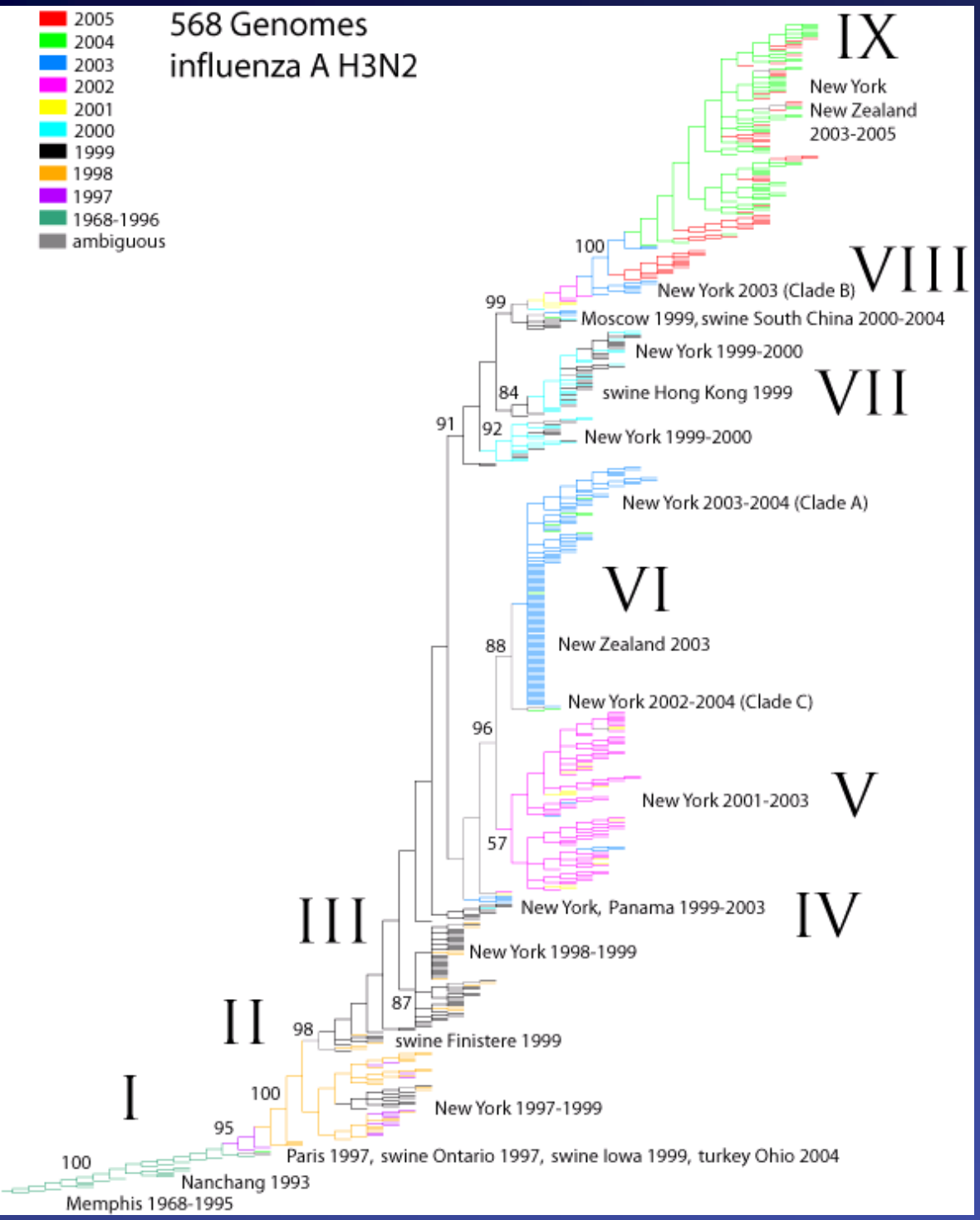
- Tissue destruction is a secondary effect may result from bacterial infection of lesion caused by the parasites. May result in initiation of malignant process like in *Spirocerca lupi* in dogs
- Proliferation of epithelium (*E. stiedai*); Fibrosis (Fasciola); aneurysm (*Schistosma*); lymphoid tissue (leishmaia);

Host-parasite coevolution

- Parasitism is an extremely popular lifestyle
- The majority of organisms are either infected by parasites or at risk from infection
- Parasites, by definition, harm their hosts
- Hosts are therefore under selection pressure to avoid parasitism
- Parasites are under selection pressure to evade host defences

Evolution of a parasite

- Influenza virus:
- Immunity is determined by two antigens, haemagglunin (HA) and neuroaminidase (NA).
- “Antigenic drift” leads to new strains with different HA or NA antigens, that are able to infect people who are resistant to other strains
- This is why we see periodic epidemics of influenza when new strains emerge and are strongly selected for.



Phylogeny of influenza

- This is a phylogeny of influenza A virus over an extended period
- Note that there is continual replacement of one strain by another, and that old strains go extinct

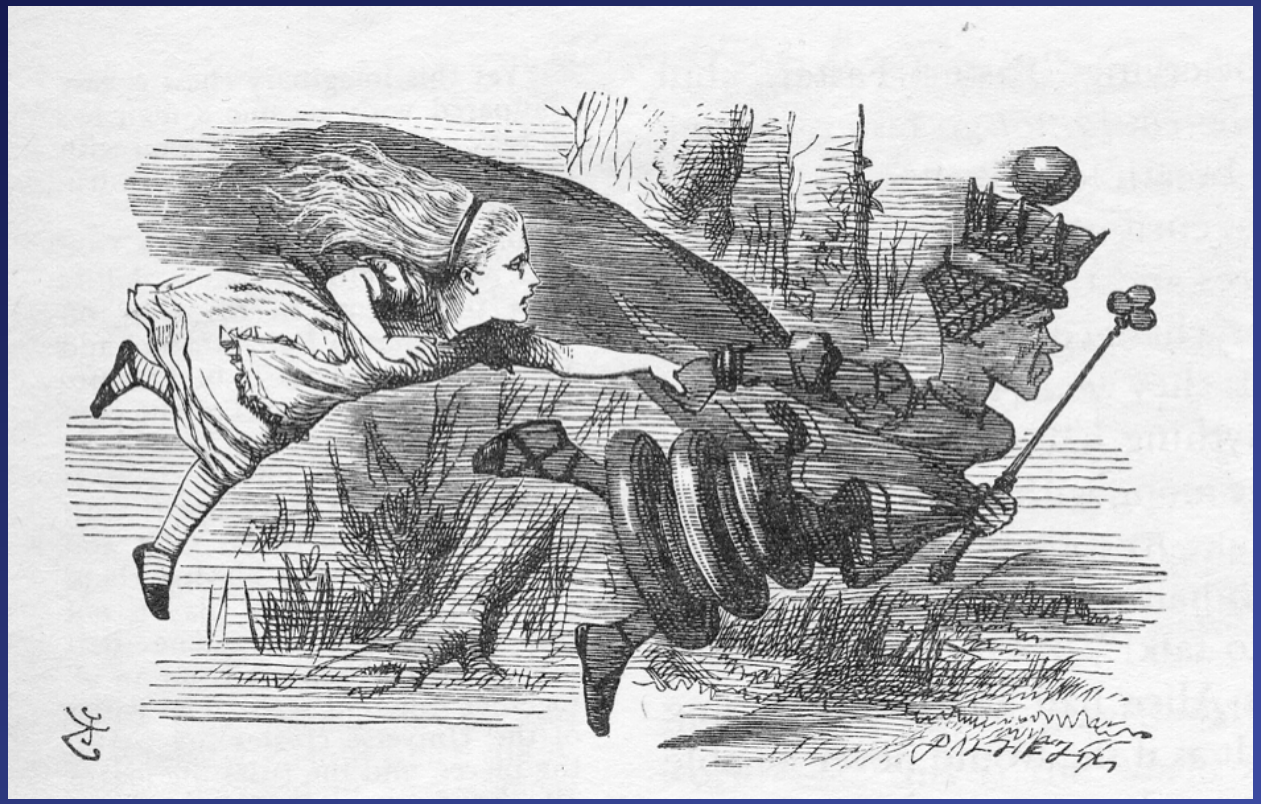
Host-parasite coevolution

- Parasites will be selected to exploit common host genotypes
- Hosts carrying rare resistance alleles will gain a selective advantage because they are not parasitised as much
- Rare host genotypes will become common
- The parasites will then be selected to exploit hosts carrying these resistance alleles.
- Thus the fitness of a genotype will depend on its *frequency* in the population

Host evolution

- In the same way that parasites are constantly evolving to overcome host defenses,
- Host organisms will be constantly evolving to resist parasitic infection
- This will lead to *Frequency dependent selection,* locking hosts and parasites into endless coevolutionary cycles
- This is what is often called the “Red Queen Effect”

The Red Queen



"Now here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that"

from *Through the Looking Glass,*
by Lewis Carroll

The **Red Queen Effect hypothesis**, also referred to as **Red Queen's**, **Red Queen's race** or **The Red Queen**, is an evolutionary hypothesis which proposes that organisms must constantly adapt, evolve, and proliferate not merely to gain reproductive advantage, but also simply to survive while pitted against ever-evolving opposing organisms in an ever-changing environment. The Red Queen hypothesis intends to explain two different phenomena: the constant extinction rates as observed in the paleontological record caused by co-evolution between competing species and the advantage of sexual reproduction at the level of individuals.

The phenomenon's name is derived from a statement that the Red Queen made to Alice in Lewis Carroll's *Through the Looking-Glass* in her explanation of the nature of Wonderland:

Now, *here*, you see, it takes all the running you can do, to keep in the same place.

The hypothesis is intended to explain two different phenomena: the advantage of sexual reproduction at the level of individuals, and the constant evolutionary arms race between competing species. In the first (microevolutionary) version, by making every individual an experiment when mixing mother's and father's genes, sexual reproduction may allow a species to evolve quickly just to hold onto the ecological niche that it already occupies in the ecosystem. In the second (macroevolutionary) version, the probability of extinction for groups (usually families) of organisms is hypothesized to be constant within the group and random among groups.

Parasitism and sex

- The evolution of sexual reproduction is a big puzzle in biology
- One possibility is that sexual reproduction benefits an organism by increasing the variability of the organism's offspring
- This only gives a big fitness advantage when the environment changes very rapidly
- One aspect of the environment that does change fast enough is the parasites that an organism is exposed to.

Evidence?

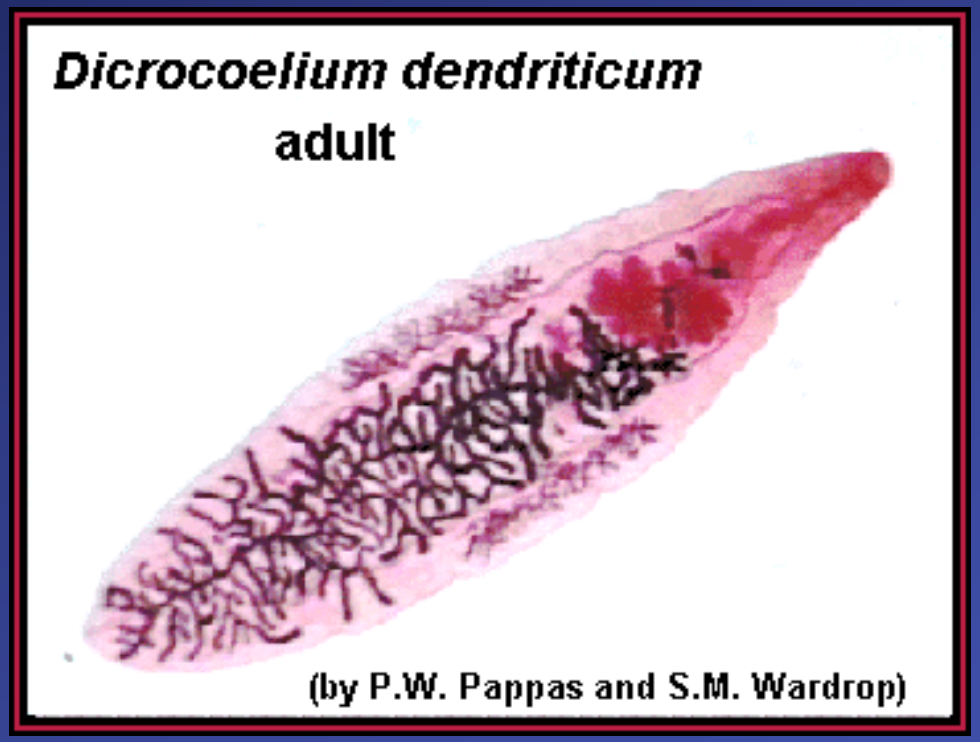
- Very hard to test experimentally
- One noteworthy study by Curtis Lively and coworkers
- *Potomopyrgus antipodiarum* - freshwater snail with both sexually and asexually reproducing individuals
- The proportion of asexually reproducing individuals is related to the amount of parasitism a population experiences
- More parasitism leads to more sexually reproducing snails

Parasites and host behaviour

- Parasites don't just face selection pressure to overcome host defences
- Transmission between hosts is crucial to a parasite's fitness
- Some parasites have *complex life-cycles*, infecting more than one host before reaching adulthood
- In these cases, some parasites seem to change host behaviour to enhance their transmission rate

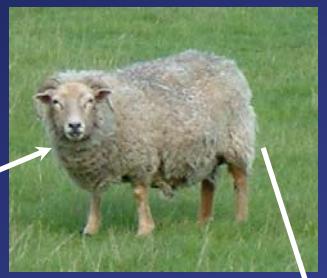
Dicrocoelium dendriticum

the lancet liver fluke



Dicrocoelium dendriticum

Ants are accidentally eaten by grazing sheep. Parasites grow to adulthood

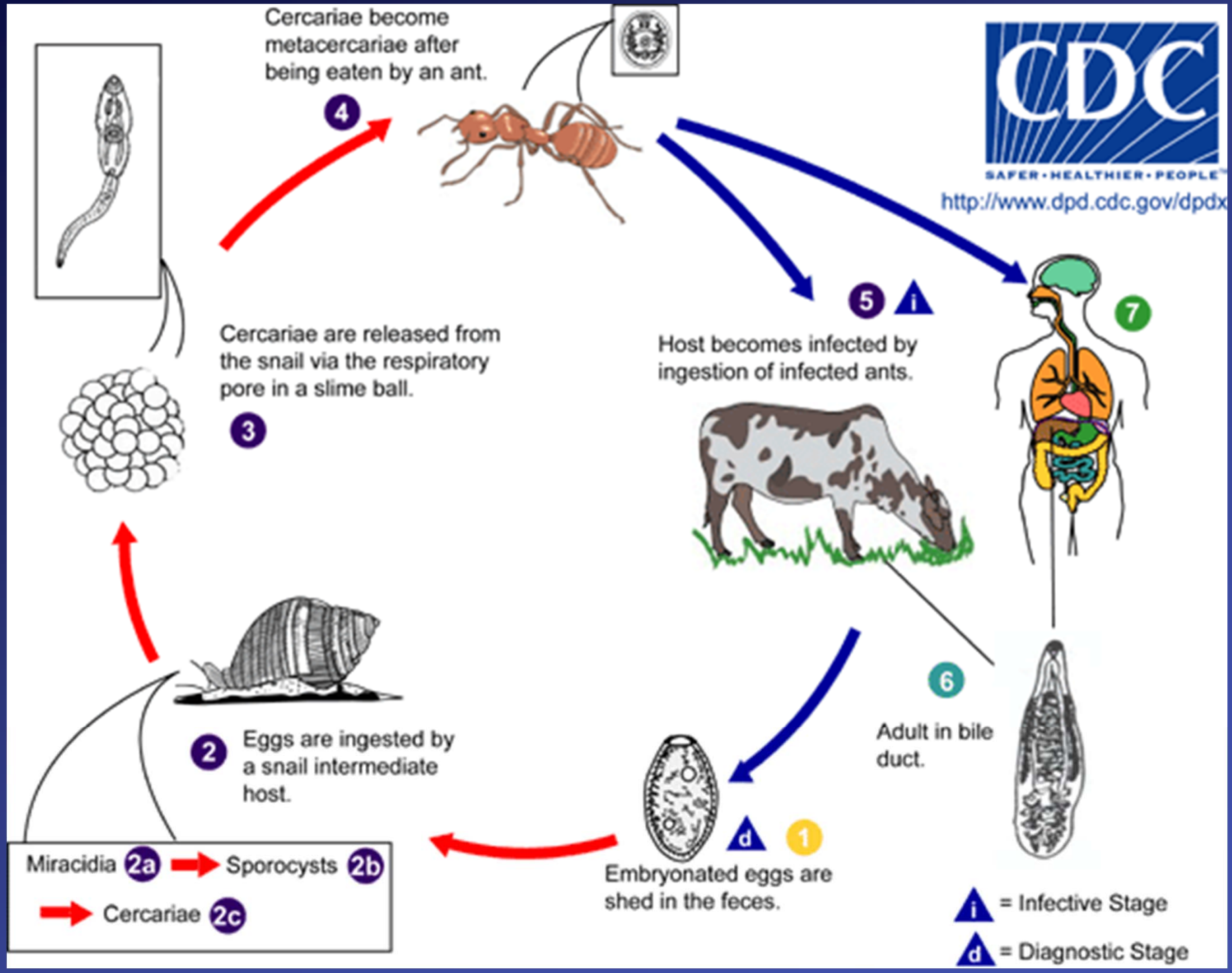


Eggs passed in faeces, eaten by snail

Slime balls eaten by ants. The larvae encyst

Snails produce “slime balls” containing parasite larvae

Eggs hatch, parasite reproduces asexually


Cercariae become metacercariae after being eaten by an ant.
4
CDC
SAFER·HEALTHIER·PEOPLE
http://www.dpd.cdc.gov/dpdx
5 i
Host becomes infected by ingestion of infected ants.
7
Cercariae are released from the snail via the respiratory pore in a slime ball.
3
6
Adult in bile duct.
2
Eggs are ingested by a snail intermediate host.
d 1
Embryonated eggs are shed in the feces.
Miracidia 2a
Sporocysts 2b
Cercariae 2c
i = Infective Stage
d = Diagnostic Stage