



"Parasitism"

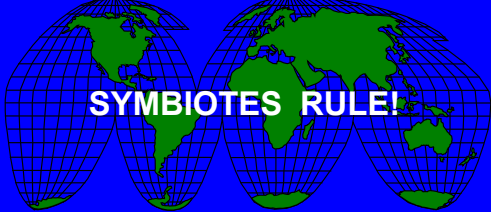



Professor Peter O'DONOGHUE

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Three modes of existence on Earth!

- in aquatic environments (many species)
- in terrestrial environments (some species)
- in other organisms (overwhelming majority)



SYMBIOTES RULE!

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Parasitism

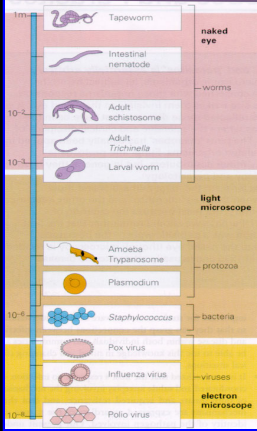
Host-Parasite Interaction

- Cost/benefit analysis
 - parasite derives food/shelter (for growth and reproduction)
 - host is derimentally affected (structural/functional deficits; morbidity/mortality) (immune system fights back; immunopathology)

Examine parasite biodiversity

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Infectious diseases



pathogens

arthropods } **macro-parasites**
(reproduce slowly, overdispersion, chronic diseases)

helminths }

protozoa }

fungi }

bacteria }

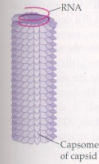
viruses }

micro-parasites
(reproduce quickly, high intensity, acute diseases)


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VIRUSES are genetic freaks!

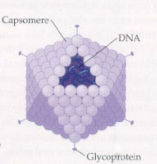
(acellular - DNA or RNA encased in a capsule)



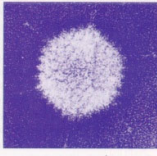
mosiac virus



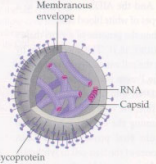
10 nm



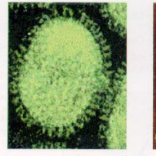
adenovirus



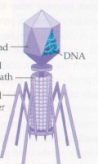
50 nm




influenza virus



50 nm



T4 bacteriophage



50 nm

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VIRUS CLASSIFICATION BY STRUCTURE

NA	strands	envelope	family	diseases
DNA	double	present	Herpes- <i>viridae</i>	herpes, chickenpox
	absent	absent	Pox/Adeno/Papo	smallpox, tumors, warts
	single	absent	Parvo-	animal viruses
RNA	double	absent	Reo-	Colorado tick fever
	single	present	Toga/Retro	rubella, dengue, AIDS
	absent	absent	Picorna-	polio, hepatitis

VIRUS CLASSIFICATION BY TISSUE TROPHISM

group	tissues affected	diseases
pneumotrophic	respiratory system	influenza, RSV, colds
dermotrophic	skin/subcutaneous	smallpox, herpes, mumps, measles/rubella
viscerotrophic	blood/viscera	yellow fever, dengue, hepatitis, AIDS
neurotrophic	nervous system	rabies, polio

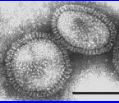
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PNEUMOTROPHIC VIRUSES

Influenza (ssRNA virus)
[envelope with Haemagglutinin (16 types) and Neuraminidase (9 types)]

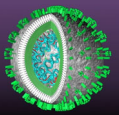
Flu, multiple symptoms, may develop into bronchitis or pneumonia
Highly contagious, spread by respiratory droplets and fomites
Highest risk for elderly and immunocompromised individuals

Type A (humans, animals, birds) - every 2-3 years
Type B (humans only) - every 4-6 years



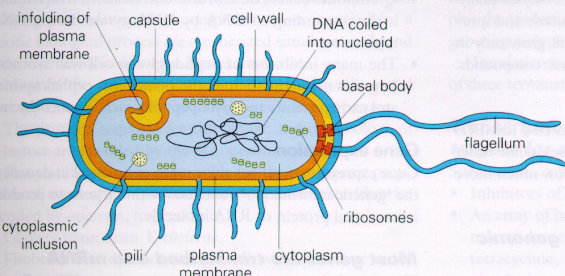
Overall mortality ~ 1% BUT epidemics (pandemics)


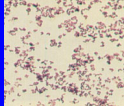


H1N1 Spanish flu	(1918)	40m deaths
H2N2 Asian flu	(1957)	2m deaths
H3N2 Hong Kong flu	(1968)	1m deaths
H1N1 Russian flu	(1977)	no pandemic
H5N1 bird flu	(1997)	6 deaths



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Bacteria are primitive nuts! (= prokaryotes)



	-coccus (sphere)	Gram stain	
	-rod (bacillus)	Gram+ (blue)	
	-spirillum (spiral)	Gram- (pink)	

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Bacteria grouped according to major mode of transmission

Transmission	disease	agent	organ	signs
airborne	diphtheria	Gram+ rod	resp. tract	pseudomembrane
	legionellosis	Gram-rod	lungs	pneumonia
	tuberculosis	acid-fast rod	lungs	tubercle
food/water	botulism	Gram+ rod	nerve ends	paralysis
	typhoid	Gram- rod	gi tract	ulcers, fever
	cholera	Gram- rod	intestine	diarrhoea
soilborne	anthrax	Gram+ rod	blood	haemorrhages
	tetanus	Gram+ rod	nerve ends	spasms
arthropodborne	bubonic plague	Gram- rod	lymph nodes	buboes
	Lyme disease	spirochaete	skin	lesions
sexually	syphilis	spirochaete	skin	chancre
	gonorrhoea	Gram- coccus	urethra	discharge
contact	leprosy	acid-fast rod	skin	tumours
	yaws	spirochaete	skin	lesions
	'staph'	Gram+ coccus	skin, blood	abscesses, fever

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Air-borne diseases

Tuberculosis (re-emergence)

- Gram+ rod *Mycobacterium tuberculosis*
- globally, someone is infected with TB every second (~30m)
- slow progressive, insidious, chronic disease
- asymptomatic - granuloma - tubercule - fatal
- highly infectious via aerosol droplets
- each person with active TB infects 10-15 people per year

Problems


- diagnosis (skin test, X-ray, culture, PCR)
- timely treatment (long-term)
- treatment failure (MDR, XDR-TB)
- vaccination rationale



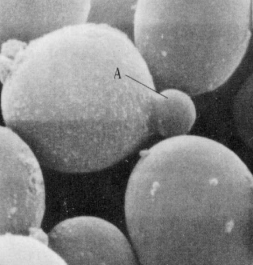
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FUNGI are not plants or animals!

- no chlorophyll, chitinous walls, heterotrophic
- complex life-cycles involving spore formation



filamentous fungi



ovoid yeasts

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Important fungal diseases

type	location	disease	genera
superficial	cutaneous	tinea	<i>Malassezia</i>
		ringworm	<i>Microsporum/Trichophyton</i>
subcutaneous	various	sporotrichosis	<i>Sporothrix</i>
		mycetoma	various
deep	systemic	histoplasmosis	<i>Histoplasma</i>
		blastomycosis	<i>Blastomyces</i>
opportunistic	various	cryptococcosis	<i>Cryptococcus</i>
		candidiasis	<i>Candida</i>
		aspergillosis	<i>Aspergillus</i>

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SUPERFICIAL MYCOSES

tropics haven for fungi
(warm, moist environments, nutrient-rich substrates)

Causes of tinea	Anthropophilic (human sources)	Zoophilic (animal sources)	Geophilic (soil sources)
<i>Trichophyton</i>	✓	✓	
<i>Microsporum</i>	✓	✓	✓
<i>Epidermophyton</i>	✓		

Dermatophytes

- infections spread by contact with arthrospores
- keratin-loving organisms (skin, nails, hair)
- annular scaling patches, pruritis, alopecia
- treatment radically improved (topical/oral)




Problems:

- timely diagnosis, increasing incidence
- long-term treatment (1 week – 1 year)

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PROTOZOA are single-celled animals!

flagellates




whip-like flagella

amoebae




temporary pseudopodia

sporozoa



non-motile 'spores'


ciliates



hair-like cilia

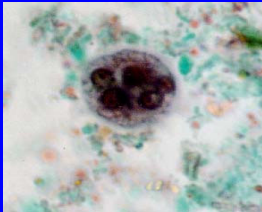
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Entamoeba histolytica (amoebic dysentery)



trophozoite in colon

faecal-oral transmission




cyst in faeces

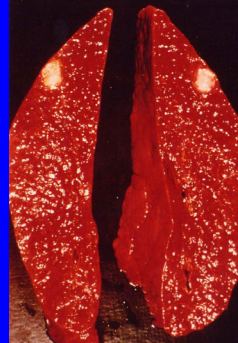
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lesions

colonic ulceration

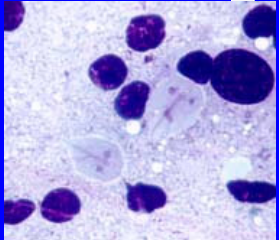


soft tissue abscesses



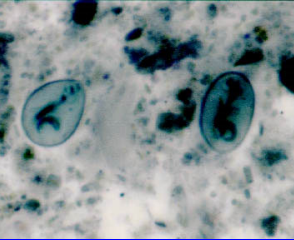
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Giardia transmission cycle



trophozoite

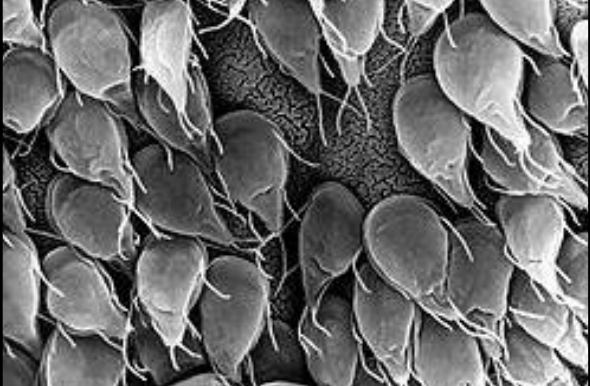
faecal-oral



cyst

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malabsorption



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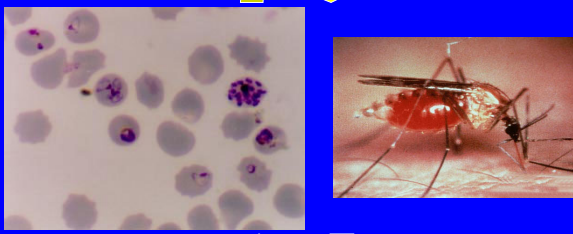
malabsorption - diarrhoea



Problems: parasite genotypes (anthroponotic, zoonotic)
chronic infection (failure-to-thrive)

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Plasmodium spp. (malaria)



zoites-schizonts salivarian transmission mosquitoes


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haemolysis – anaemia - fever






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cytoadherence - ischaemia



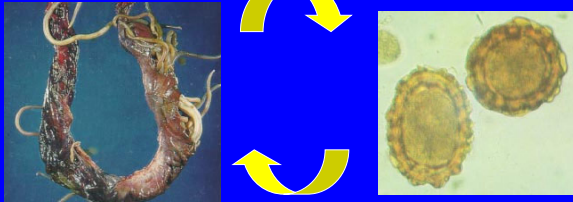
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HELMINTHS are multicellular worms

nematodes	cestodes	trematodes
		
roundworms	tapeworms	flukes

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Ascaris (roundworm)



adult worms 15-30 cm
(in small intestinal lumen)

egg 60 x 40 μm
mammillated coat

important species in humans and pigs


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Pathogenesis

- allergic reactions (urticaria, eosinophilia)
- larval migration (pneumonitis)
- mechanical blockage (gut obstruction)
- malnutrition

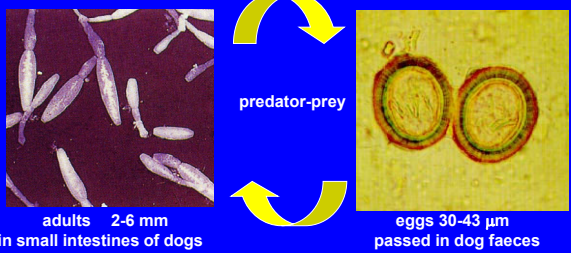
Problems:

- aggregated distribution
- re-infection



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Echinococcus granulosus (hydatid tapeworm)



adults 2-6 mm
in small intestines of dogs

eggs 30-43 µm
passed in dog faeces


predator-prey

hydatid disease caused by larval metacestodes

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Pathogenesis

- cysts produce chronic space-occupying lesions
- cause organ enlargement accompanied by various signs (abdominal distention, epilepsy, blindness, etc.)
- transmission:
 - domestic and sylvatic cycles



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PARASITIC ARTHROPODS

ARACHNIDS	INSECTS
	
8 legged freaks (ticks, mites)	6 legged bites (lice, fleas, flies)

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HUMAN HEAD LICE

Pediculus humanus capitus
(cooties, greybacks, mechanized dandruff)

- attach to hair (esp. back of neck and behind ears)
- infestations associated with crowding
- bites cause red papules
- intense pruritis
- dermatitis
- secondary infection

Problems

- emerging resistance to chemicals
- resurgence in schools
- clean hair/girls



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HOW DO WE SURVIVE!

Constant state of germ warfare

- immune system
- therapies
- prevention



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Understand pathogenicity

Capacity to cause disease (morbidity/mortality)

- often measured as LD₅₀ or ID₅₀

Virulence factors

- multiplication
- feeding
- cytotoxicity
- immuno-evasion

Is it in parasite's best interest to kill?

- need walking wounded for transmission

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Understand pathology

Consequences (degree of damage)

- asymptomatic
 - undetected (carriers)
 - subclinical (may still effect production)
- symptomatic (disease)
 - clinical signs/symptoms/lesions (morbidity)
 - death (mortality)
 - reproductive losses (mortality)

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Understand susceptibility

Host susceptibility/resistance

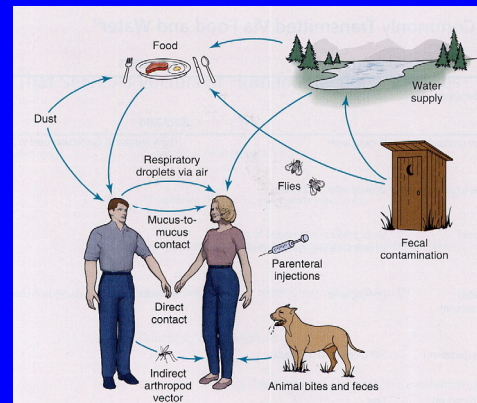
- immunological state (exposure, protection)

Host specificity

- range
 - narrow (species-specific)
 - broad (reservoirs, cross-transmission)
- mechanisms
 - ecological (sympatry)
 - ethological (behavioural)
 - physiological (molecular)
- phylogeny
 - co-evolution
 - host-switching

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Understand transmission



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Transmission

Horizontal (within generation)

- ingestion (faecal-oral, food, water, fomites)
- respiratory (air-borne aerosols)
- contact (dermal, sexual)
- vector-borne (arthropods)

Vertical (between generations)

- transplacental
- transmammary

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Principles of control

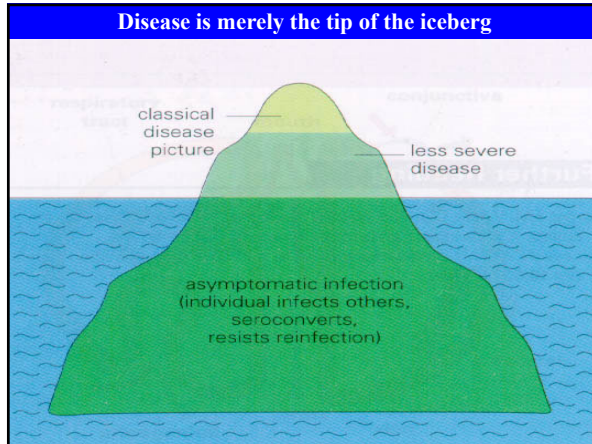
1. Treat clinical infections

- chemotherapy
- immunotherapy

2. Prevent infections

- chemoprophylaxis
- vaccination
- biological (break transmission cycle)

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Co-evolution

Despite the number of pathogens, many do not cause overt clinical disease in their hosts because they have evolved together to live in a stable relationship where the existence of neither is threatened.

This balance is called enzootic (or endemic) stability, whereby:

- the pathogen does not kill the host
- the host does not kill the pathogen

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Protozoan exemplar - Sarcocystis

- Tissue cyst-forming coccidian (esp. muscles)
- Macrocysts lead to rejection of carcass from export or condemnation from human consumption
- Prevalence around 5% but low intensity

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Sarcocystis

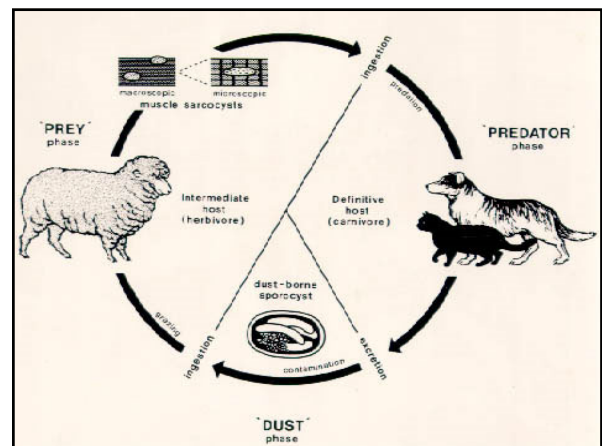
- Microcysts not considered at meat inspection
- Prevalence around 95% and intensity high

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Sarcocystis

- Sarcocysts contain millions of cystozoites awaiting uptake by definitive host (predator)
- Two cycles discovered for sheep (dog & cat cycles)

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Acute sarcocystosis

- asexual proliferation in vascular endothelial cells
- schizonts in arterioles then capillaries

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Acute sarcocystosis

- schizogony linked with acute disease
- characterized by petechial haemorrhages
- possible cause of weaner illthrift/mortality

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Acute sarcocystosis

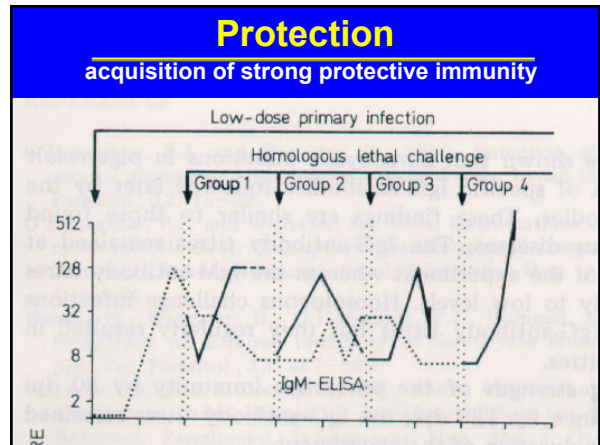
Disease associated with:

- mortality
- morbidity
- reduced weight gain
- reduced wool growth
- reproductive failure (abortion/stillbirth)

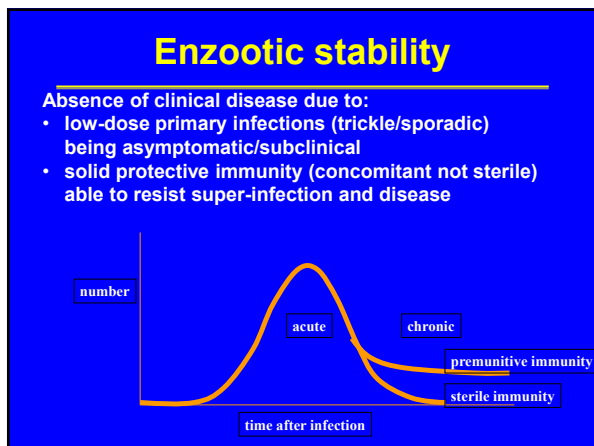
- **BUT ONLY IN EXPERIMENTAL LABORATORY ANIMALS GIVEN HIGH DOSES**
- **CONDITION NOT SEEN IN FIELD ANIMALS**

WHY?

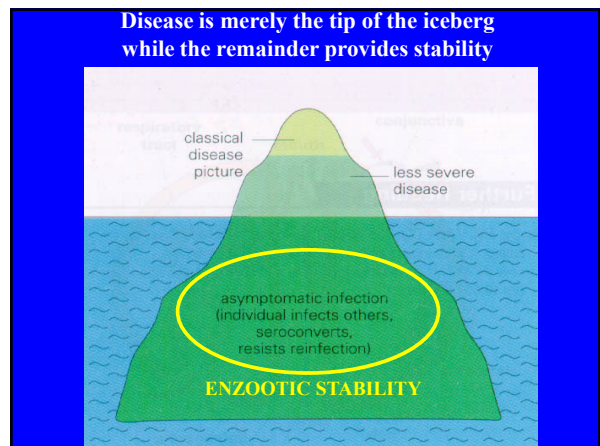
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Co-evolution

Host-parasite interactions

- virulence/pathogenesis hypothesis (influenced by co-evolutionary history)
- dual-inheritance theory (mirrored evolution)
- oscillation hypothesis (ecological fitting)
- host specificity (strict v. switching)
- Red Queen hypothesis (continuing adaptation to maintain relative fitness)
 - advantage of sexual reproduction
 - constant evolutionary arms race

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Evolutionary arms race

Host immune system works to:

- repel/destroy invaders
- undertake damage control
- protect against re-infection

Parasites develop survival strategies to avoid:

- innate immune responses
- acquired immune responses

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