BioMedical Parasitology

Parasite biodiversity

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Three modes of existence on Earth!

- aquatic (many species)
- terrestrial (some species)
- parasitic (overwhelming majority)

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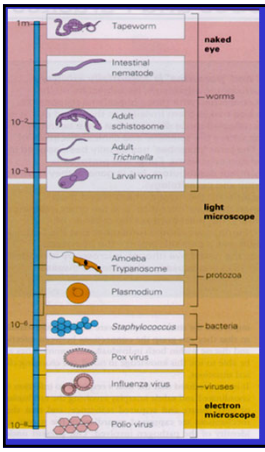

ORGANISMS

pathogens	hosts
arthropods	humans
helminths	animals
protozoa	
fungi	
bacteria	
viruses	

8 orders of magnitude

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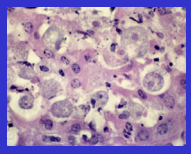
PARASITOLOGY



PARASITE + HOST

morphology	underpins	diagnosis
pathogenicity	causes	pathology
biochemistry	determines	treatment
transmission	influences	control

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Parasitology revolves around TAXONOMY

CHARACTERS (constellation approach)

Phenotypic
- host occurrence, range, specificity
- parasite morphology, development, ultrastructure
- parasite biology, life-cycle, transmission
- parasite biochemistry, metabolism, culture
- host-parasite immunology, serotyping, antigens
- pathophysiology, virulence, disease, resistance

Genotypic
- genome (DNA) structure, sequences, polymorphisms

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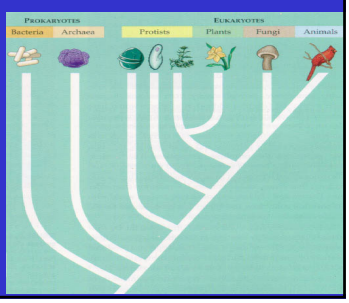
Classification

Phenotype
(parasite morphology/biology/geography...)

Cladistics
(relationships)

Genotype
(DNA, genes)

Phylogeny
(evolution)



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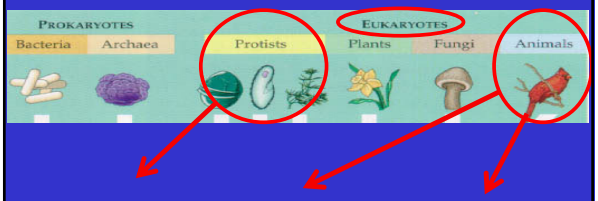
Three major parasite groups



unicellular Protozoa | multicellular Arthropods | multicellular Helminths

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PROTOZOA (unicellular eukaryotes)

flagellates | amoebae | sporozoa | ciliates

whip-like flagella | temporary pseudopodia | non-motile 'spores' | hair-like cilia

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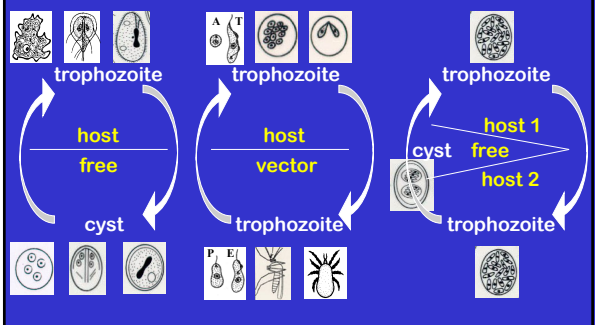
Generalized PROTOZOA life-cycles



faecal-oral | vector-borne | predator-prey

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HELMINTHS

nematodes | cestodes | trematodes

roundworms | tapeworms | flatworms/flukes

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Generalized HELMINTH life-cycles

Nematodes (E-L-A)	Cestodes (E-L-A)	Trematodes (E-M-S-R-C-A)
egg	egg	egg
larva (L1-4)	larval cyst	miracidia
adults (M+F)	adult	sporocyst
		redia
		cercaria
		metacercaria
		adult

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ARTHROPODS

INSECTS | ARACHNIDS

fleas | flies | lice | ticks | mites

fleas chiggers | flies mosquitoes | sucking lice chewing lice | hard ticks soft ticks | mites

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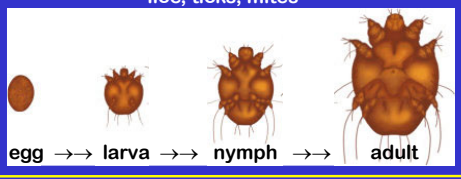
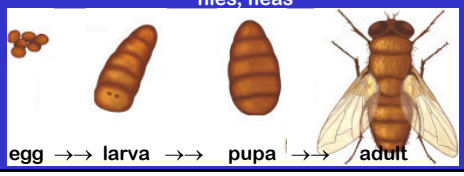
INCOMPLETE METAMORPHOSIS (gradual change)
lice, ticks, mites



COMPLETE METAMORPHOSIS (sudden change)
flies, fleas



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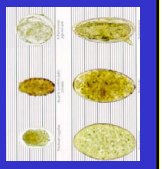
PARASITOLOGY

Biodiversity
1. species richness (taxonomy)
2. relative abundance (epidemiology)



Need to characterize:
3. virulence (pathogenicity)
4. host specificity (host range)
5. site specificity (organs, tissues)
6. host susceptibility (cohorts)
7. transmission (modality)
8. immunology (protection)

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1. Biodiversity

Number of species – where? - when?

What is a species? (splitters/lumpers)
- phenetic (similar organisms)
- biologic (habitat, behaviour,...)
- genetic (reproductive isolation)

Parasite species richness varies according to:
- host body size
- host geographic range (latitudinal/altitudinal gradients)
- host population density

consistent with Island Biogeography Theory
(hosts are resource islands varying in size and proximity)
and Epidemiological Theory (density-dependent models)

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2. Epidemiology

Study of disease distribution (temporal/spatial)
- host numbers (prevalence – incidence)
- parasite numbers (abundance – intensity)
- severity (asymptomatic – fatal)
- duration (acute – chronic)

Diseases may be:
- established (endemic/enzootic)
- locally acquired (autochthonous)
- imported/introduced/exotic
- epidemic (outbreak)

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Quantitative Parasitology

- Prevalence (cross-sectional) (point/period)
- Incidence (longitudinal) (change over time)
- Abundance (parasite burden per host)
- Intensity (parasite burden per infected host)

Survey	Host	No. parasites
Jan.	1	0
Jan.	2	0
Jan.	3	0
Jan.	4	2
Jan.	5	4

Survey	Host	No. parasites
July	6	0
July	7	0
July	8	4
July	9	4
July	10	6

- Prevalence = 5/10 = 0.5 (= 50%)
- Incidence = 3/5 – 2/5 = 0.2 (= +20%)
- Mean abundance = 20/10 = 2 parasites per host
- Mean intensity = 20/5 = 4 parasites per infected host

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3. Virulence

Capacity to cause disease (morbidity/mortality)
- often measured as LD_{50} or ID_{50}

Virulence factors
- multiplication
- feeding
- cytotoxicity
- immuno-evasion
- tropism (tissue/cell)
- host specificity (ecological - sympatry)
  (ethological - behaviour)
  (physiological - molecular)

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4. Host specificity

Biodiversity estimates $P = H \cdot (P_h/H_p)$

- P = total number of parasite species (parasite species richness)
- H = total number available host species (host species richness)
- P_h = average number of parasite species per host species (host susceptibility to parasitism) (≥1)
  (e.g. cattle have 10 coccidia species)
- H_p = average number of host species per parasite (host range / specificity) (≥1)
  (e.g. *Toxoplasma* can infect most mammals)
  - oioxenous (parasitize single host species)
  - stenoxenous (parasitize closely-related hosts)
  - euryxenous (parasitize unrelated hosts)

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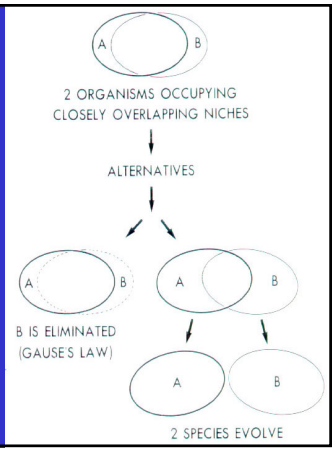
5. Site specificity

- predilection sites
  - anatomical (segment of gut)
  - histological (cells involved)
- competition
  - elimination
  - divergent evolution
- niche partitioning



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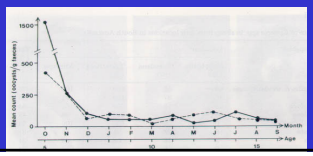
6. Host susceptibility

- age (young/old)
- gender (pregnant/lactating females)
- physiological state (malnourished, stressed...)
- immuno-competency
  - congenital immunodeficiencies (genetic deficits)
  - acquired immunodeficiences (infection)
  - immunosuppression (chemotherapy/transplants)



neonates especially vunerable

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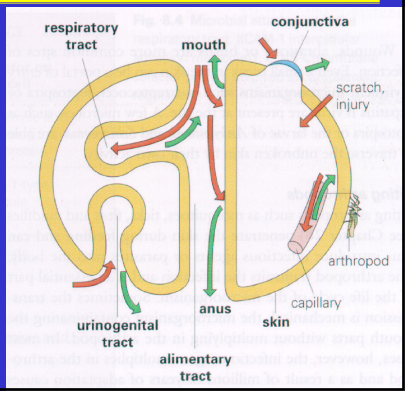
7. Transmission routes

- faecal-oral
- vector-borne
- predator-prey
- sexual
- vertical
- aerosol
- contact



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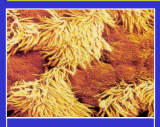
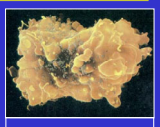
8. LINES OF IMMUNOLOGICAL DEFENSE





first line BARRIER	second line INNATE	third line ADAPTIVE (ACQUIRED)
nonspecific	nonspecific	specific
parasites encounter external coverings and their secretions	parasites penetrating barriers encounter phagocytes & inflammation	surviving parasites encounter cell-mediated and humoral responses

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PARASITE ASSEMBLAGES

Protozoa	Arthropods	Helminths
amoebae flagellates sporozoa ciliates	arachnids insects	nematodes cestodes trematodes
entamoebae trichomonads coccidia holotrichs diplomonads haemosporidia trypanosomes piroplasms	ticks mites flies fleas lice	roundworms tapeworms flukes flatworms
'micro-parasites' (multiplicative) (acute)	'macro-parasites' (cumulative) (chronic)	

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