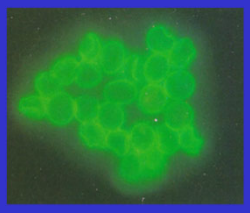
Ecology of Disease

Weekly theme: WATER

Lecture: Treatment



Prof Peter O'Donoghue

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Water-borne disease outbreaks USA 2003-2004

92 episodes (5,000 people)

- 30 linked to drinking water (2,000 people)
  - 20 gastroenteritis (bacterial, viral, protozoal) (Cu, Br, bleach, petrol)
  - 8 pneumonitis (Legionaires)
  - 2 dermatitis (chemical, NaOH)
- 62 linked to recreational water (3,000 people)
  - 43 pools/spas
  - 19 lakes/rivers

40% gastroenteritis
20% dermatitis
40% lung/eye/ear/bladder

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Need to cleanse water

- decontaminate (remove contaminants)
  - sediment
  - flocculate
  - filter
  - adsorb
- disinfect (destroy contaminants)
  - chemical
  - heat
  - energy sources

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Surface disinfectants

Chemical	Heat	Energy sources
• acids/alkalis	• autoclaving	• ultraviolet
• alcohols	• flaming	• gamma
• aldehydes	• steam-cleaning	• X-ray
• ammonials		• ultrasonic
• chlorines		• LAV electron
• phenols		
• iodines		

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Water disinfection

Watson's Law $K = C^n t$ (concentration.time)

- chlorine
- chloramine
- chlorine dioxide
- ozone
- ultraviolet radiation
- solar radiation
- gamma radiation
- high energy electron beams

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Drinking water treatment

- raw water storage
- pre-chlorination
- coagulation-flocculation
- water softening
- filtration
  - slow sand filtration
  - rapid sand filtration
  - diatomaceous earth filtration
- activated carbon (adsorbent)
- biological processes (aerobic biofilm processes)

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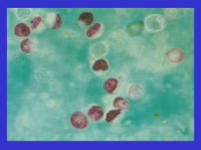
Exemplar: *Cryptosporidium*

Very small oocysts
Overlooked for years,
but now….



- newly recognized enteropathogen
- protozoan parasite similar to coccidia
- causes significant morbidity, some mortality
- anthroponotic, zoonotic, water-borne

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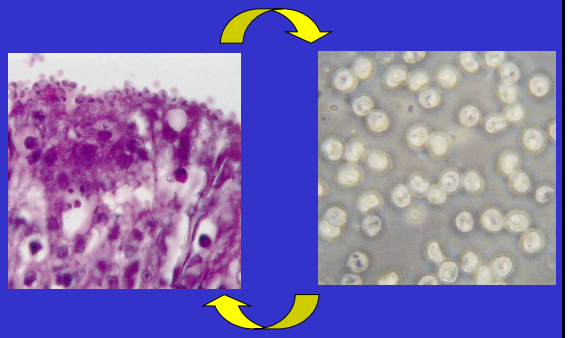
Enteric coccidia - *Cryptosporidium parvum*



endogenous stages | faecal-oral | exogenous oocyst

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Potted history

• emergence	1907 - discovery	
	1950 - avian disease	
	1980 - human disease	
• identity	protozoan parasite, typical coccidian	
	endogenous development on mucosa	
	exogenous transmissible oocysts	
• significance	clinical	- human
		- animal
	environmental	- food
		- water

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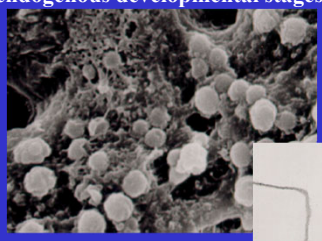
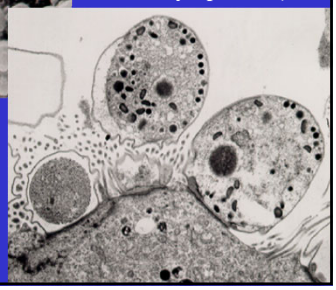
endogenous developmental stages



epicellular location
(intracellular yet
extracytoplasmic)



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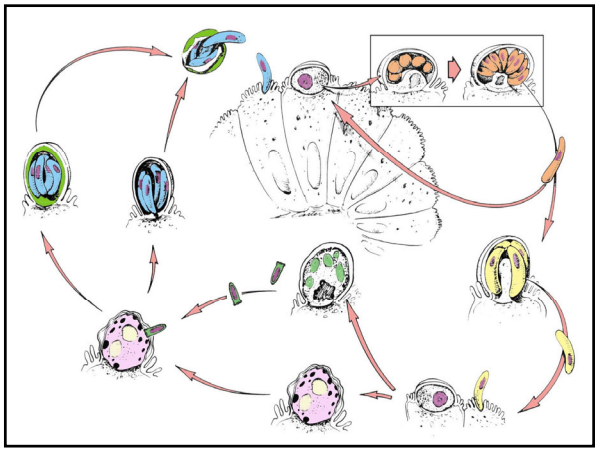

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Human infections

• prevalence	coprology 0-32%
	serology 25-91%
• disease	asymptomatic infections
	clinical infections (diarrhoea, resp. signs)
• susceptibility	immunodeficient (congenital, acquired)
	immunosuppressed
	malnourished
	young
• treatment	none (but most self-cure)
• transmission	human-human (faecal-oral)
	animal-human (zoonotic)
	water-borne

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Animal infections

• mammals	*C. parvum**	intestines	acute
	C. muris	stomach	chronic
	C. wrairi	intestines	chronic
• birds	*C. meleagridis*	intestines	acute
	*C. baileyi**	trachea	acute
• reptiles	*C. serpentis*	stomach	chronic
• fish	*C. nasorum*	stomach	chronic

Diagnosis: host occurrence, parasite morphology, site of infection, proteins, nucleic acids (rDNA, HSP, COWP)

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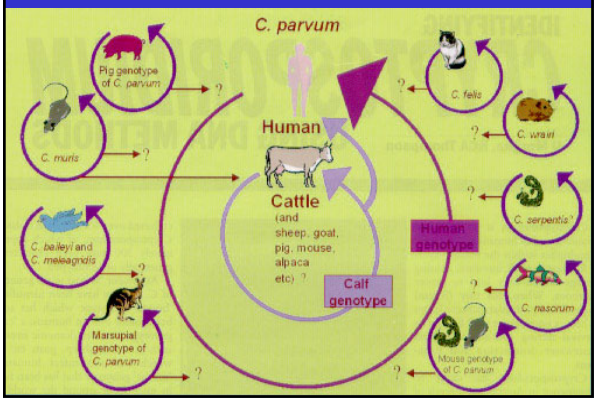
Genetic characterization



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Environmental

• food-borne	several small outbreaks (cider, milk, sausages, salads)
• water-borne	outbreaks due to system failure outbreaks due to treatment failure
• sources	human effluent (containment/treatment) agricultural waste (intensive industries) passive carriers (waterfowl, seagulls)
• control	watershed management (creek>river>reservoir>lake) water treatment (decontamination/disinfection)

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Recent events in Australia

1980's	- clinical cases in humans and animals
1990's	- oocysts detected in effluent
	- oocysts detected in raw surface water
1998	- oocysts detected in swimming pools (disease present)
	- oocysts detected in drinking water (disease absent)
	- Sydney water contamination (boil water alerts)

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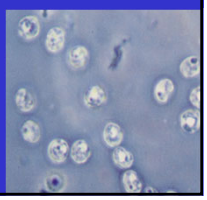
Detection Technologies

SAMPLING

- cartridge filtration
- membrane filtration
- immunomagnetic separation
- flocculation
- flow cytometry
- vortex flow filtration
- cross flow filtration
- continuous flow filtration



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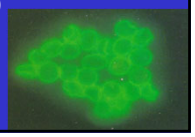
Detection Technologies

IDENTIFICATION

- microscopy (phase/DIC/fluorescence)
- histochemistry (acid-fast, lipid biomarker)
- enzyme immunoassays (ELISA)
- fluorescent *in situ* hybridization (FISH)
- DNA/RNA sequencing (PCR)
- laser scanning
- cooled charge-couple device



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Water Treatment

OOCYST REMOVAL

• sand filtration	4 log (99.99%)
• diatomaceous earth	4 log (99.99%)
• coagulation/flocculation	3 log (99.9%)
• micro/ultra filtration	6 log (99.9999%)
• dissolved air flotation	2 log (99%)

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Water Treatment

OOCYST DISINFECTION

• chlorine/monochloramine	Ct 7200 for 1 log
• chlorine dioxide	Ct 78 for 1 log
• ozone	Ct 5-10 for 2 log
• ultraviolet radiation	2 log
• boil water alert	rolling boil for 1-3'

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Other disinfection procedures

• ammonia	5% for 120', 50% for 30'
• formol saline	10% for 120'
• hydrogen peroxide	3% for 30'
• Exspor	5% for 30'
• Oocide	5% for 5'
• cold	-70°C
• dessication	airdrying 240'
• heat	65°C for 30'

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How to assess oocyst viability?

- vital dyes (PI-, DAPI+)
- nucleic acid stains (SYT09-, MPR71059+)
- *in vitro* excystation
- *in vitro* tissue culture
- *in vivo* animal infectivity
- genetic analysis
  - 18S rRNA-FISH
  - RT-PCR Hsp70 mRNA

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The Dilemma

- DETECTION (reliable recovery)
- IDENTIFICATION (differential diagnosis)

- VIABILITY (alive or dead?)
- INFECTIVITY (infective or not?)
- SPECIFICITY (infective to humans?)
- VIRULENCE (pathogenic or not?)

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Take home message

As far as water treatment is concerned:

- nothing is cast in concrete
- still developing technology (thankfully based on science)
- community need high
- society expectation high
- translates to political dollars

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