

Ecology of Disease

Theme: WATER
Lecture: Quality



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WATER

Variable conceptions about water quality

- pristine streams
- rich deltas
- clean rain water
- dirty flood water
- pure spring water
- polluted industry effluent
- disgusting sewage



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WATER

Concern about the quantity and quality of:

- drinking water
- surface/ground water
- sewage/effluents
- waste water
- boiler/cooling water
- aquaculture
- swimming pools/spas



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Water Quality

Affected by:

- precipitation (rainfall)
- surface water (storm water, runoff)
- ground water (aquifers)
- evaporation (concentration)
- changing land use



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Land Use

- untouched (pristine catchment)
- deforestation (\uparrow pH, \uparrow erosion)
- agriculture (\uparrow salinity, \uparrow organics/inorganics)
- industrialization (\uparrow chemicals, \uparrow heat)
- urban development (\uparrow contaminants, organic enrichment, sewage, surfactants)



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Changing cycles

Many rivers self-cleansing

- seasonal flooding (silt, salt delivered to sea)



Rivers now impounded for:

- flood mitigation (weirs maintain levels)
- navigation (various watercraft)
- irrigation (crops, pasture)
- storage (reservoirs, dams, lakes)
- power generation (hydroelectricity)

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Water Quality

Combination of:

- **physical characters** (pH, alkalinity, turbidity, colour, temperature, hardness, total dissolved solids = conductivity)
- **chemical load** (N, P, S compounds, metals, electrolytes, gases, inorganic pollutants such as pesticides, herbicides)
- **biota** (viruses, bacteria, protista, metazoa)

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Current concerns for potable water

Abiotic

- magnesium - hypertension
- aluminum - Alzheimer
- arsenic - cancer
- fluoride - bone density
- tetrachloroethylene - cancer
- hard water - eczema
- nitrates/nitrites - cancer

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Current concerns for potable water

Biotic

- protozoa - *Cryptosporidium*
- *Giardia*
- cyanobacteria - microcystin
- cylindrospermopsin
- algae - taste
- odour
- bacteria - *E. coli*
- *Legionella*

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Current concerns for water distribution systems

- biofilms - surface conditioning
- adsorption/accumulation
- detachment
- taste and odour problems
- algae (allergic/toxic)
- fungi
- protozoa
- invertebrates
- endotoxins (heat stable LPS)

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Epidemiology

Disease outbreaks reported to US-EPA & CDC

last decade: 1000 waterborne outbreaks
1.2 million cases

due to:	untreated groundwater	49%
	untreated surface water	24%
	distribution failure	16%
	miscellaneous	11%

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Chain of infection

Depends on:


- type of infectious agent (virus, bacteria, protozoan, helminth)
- reservoir hosts (zoonoses)
- mode of transmission (water, food, contact)
- portal of entry (oral, nasal, urogenital)
- host susceptibility (young, aged, unsound)

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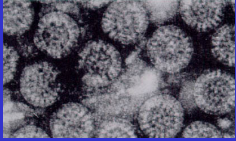
EXEMPLARS

compare

BACTERIA



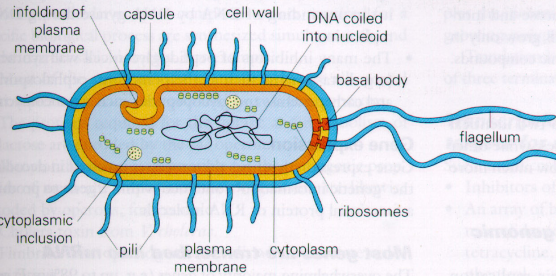
VIRUSES



both commonly associated with water-borne outbreaks of gastro-enteritis manifest by nausea, vomiting, diarrhoea

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BACTERIA (prokaryotes = primitive nuts)



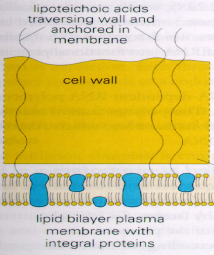
Labels in diagram: infolding of plasma membrane, capsule, cell wall, DNA coiled into nucleoid, basal body, flagellum, cytoplasmic inclusion, pili, plasma membrane, cytoplasm, ribosomes.

3 basic shapes

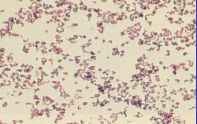
- rod (bacillus)
- sphere (coccus)
- spiral (vibrios, spirilla, spirochaetes)

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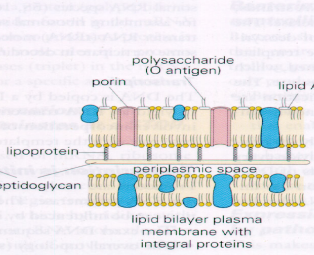
TWO TYPES OF BACTERIA (Gram +/-)



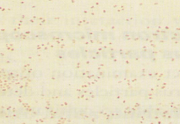
Gram-positive



resist bile



Gram-negative



produce toxins

Labels in diagrams: lipoteichoic acids traversing wall and anchored in membrane, cell wall, lipoprotein, peptidoglycan, lipid bilayer plasma membrane with integral proteins, porin, polysaccharide (O antigen), lipid A, periplasmic space.

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Gastroenteric bacteria


- up to 10^{12} bacteria per gram faeces
- ~9% wet weight
- minimum infective dose 10^4 - 10^6

- Gram neg. anaerobic (e.g. *Salmonella*)
- Gram neg. aerobic (e.g. *Pseudomonas*)
- Gram pos. spore-forming (e.g. *Bacillus*)
- Gram pos. non-spore-forming (e.g. *Corynebacterium*)

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Salmonella


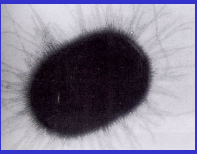
- ~2,000 serotypes from mammals
- cause gastroenteritis, typhoid, paratyphoid
- produce endotoxins
- symptoms incl. fever, nausea, diarrhoea
- commonly associated with food poisoning
- also water-borne



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Escherichia coli

- various strains in g-i tract of mammals
- several bear virulence factors
 - ETEC = entero-toxigenic *E.c.*
 - EPEC = entero-pathogenic *E.c.*
 - EHEC = entero-haemorrhagic *E.c.*
 - EIEC = entero-invasive *E.c.*

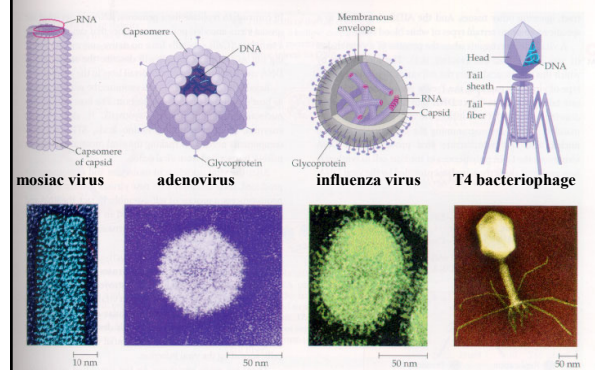
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Gastroenteric viruses

- ~ 140 types of enteric viruses
- responsible for 4-12% water-borne epidemics
- minimum infective dose ~20 PFU (plaque forming units)
- orally ingested with water
- multiply in g-i tract
- excreted in huge numbers in faeces

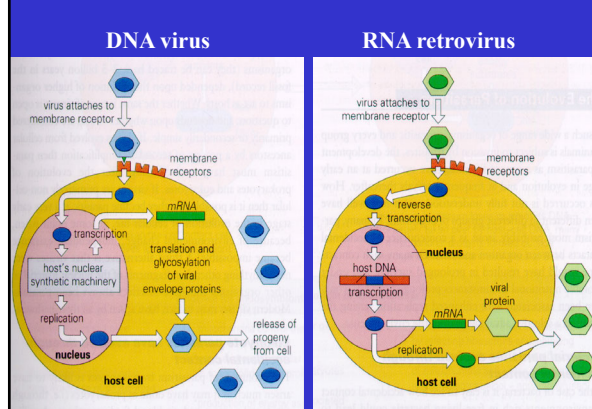
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FOUR TYPES OF VIRUSES (ss/ds DNA/RNA encased in capsule)



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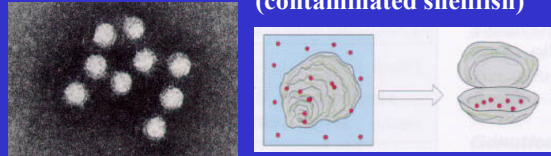
Viral genome



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Hepatitis A virus

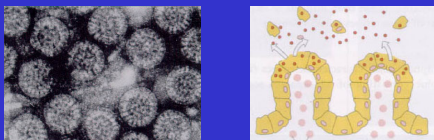
- RNA enterovirus causing infectious hepatitis
- liver damage with necrosis & inflammation
- common clinical sign is jaundice (bilirubin)
- frequently transmitted by direct contact
- also water-borne (contaminated water)
(contaminated shellfish)



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Rotavirus

- double-stranded RNA virus
- common cause of acute infantile gastroenteritis (children < 2 years old)
- profuse diarrhoea causing severe dehydration
- rehydration therapy (oral/intravenous)
- associated with contaminated water supplies



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DIAGNOSTIC DILEMMA

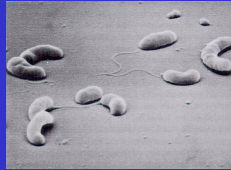
- clinical surveillance retrospective
- environmental monitoring proactive
- direct detection of pathogens costly, time-consuming, technically demanding
- need indicator organisms to:
 - detect contamination
 - check water treatment
 - monitor distribution
 - assess water quality



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Criteria for ideal indicator organisms

- enteric origin
(but must not multiply in environment)
- nonpathogenic
(but presence correlated with pathogen)
- equally resistant to environmental insults
- easily detectable



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Candidate indicators

- total coliforms (not all faecal origin)
- faecal coliforms (cannot diff. human/animal)
- faecal streptococci (poor persistence)
- anaerobic bacteria (too resistant)
- bacteriophages (variable resistance)
- yeasts & acid-fast organisms (too resistant)
- heterotrophic plate count (dep. on incubation)
- chemical indicators (sterols, toxins, chlorine)
- physical indicators (turbidity, particle counts)

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Recommended surrogate measures

Test	Source water	Treatment train
routine	1. chlorine demand 2. turbidity 3. faecal indicators	1. free chlorine residual 2. turbidity 3. total coliforms 4. plate count
periodic	-	1. enterococci 2. <i>Clostridium</i>
diagnostic	1. sanitary survey	1. sanitary survey 2. microbial id.

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What price quality?



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