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Utility of modern genomic tools for broad surveillance of emerging and zoonotic pathogens

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Traditional approach

Wait for an outbreak (zoonotic or wildlife)

Attempt pathogen identification
(symptoms if unambiguous, culture)

Design of a pathogen-specific test

Monitor the specific pathogen

Traditional approach

Works for

Single pathogen

Unambiguous symptoms

Culturable

Fails for

Emerging or novel pathogens

Co-infections

Dysbiosis

Unculturable (majority)

Ambiguous/unknown symptoms

Asymptomatic reservoirs

Virulence & antibiotic resistance

~~Reactive~~

Proactive

One Health
Approach



NGS alternatives

Meta- barcoding

- Single domain
- PCR biased
- Transient
- Genus resolution

Meta- genomics

- Excludes RNA viruses
- Transient
- Strain-level resolution

Meta- transcriptomics

- All domains
- Metabolically active
- Strain-level resolution

Traditional approach vs metabarcoding

Chlamydia psittaci

Clostridium botulinum

Pasteurella multocida

Vibrio cholera

6 genera may or may not
contain pathogens

Gorham *et al.* 2016

Elmberg *et al.* 2017

OPEN

Spatial Organization of the Gastrointestinal Microbiota in Urban Canada Geese

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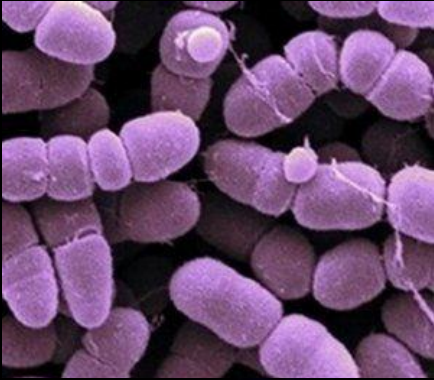
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16S rRNA gene
metabarcoding of
bacteria

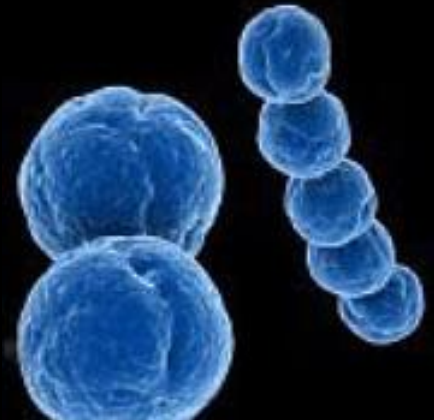
30 geese
Montgomery
County, MD



Human pathogens



Clostridium perfringens 100%
foodborne disease (!) and human
gas gangrene

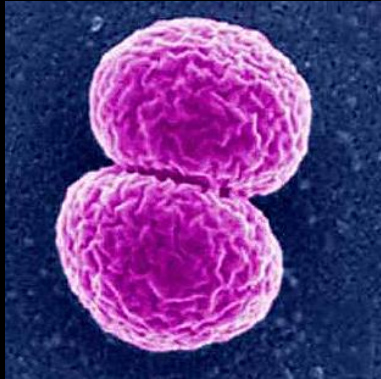


Streptococcus suis 100%
meningitis → hearing loss
skin necrosis → gangrene of the
fingers and toes

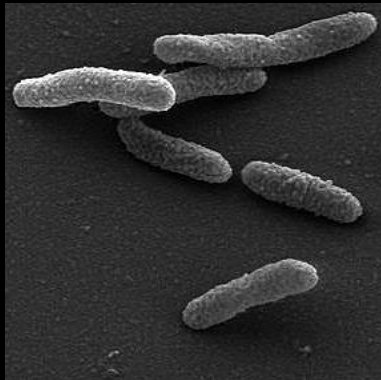


Staphylococcus aureus 86.7%
serious wound infections and food
poisoning

Avian pathogens



Neisseria sp. 100%
gander gonorrhoea
> 90% unfertilized eggs

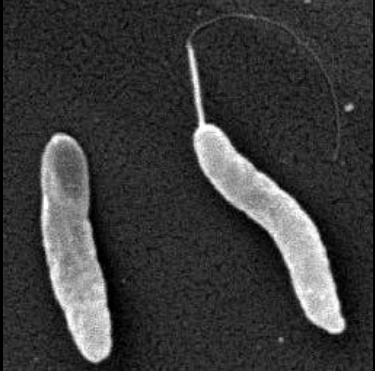


Riemerella anatipestifer 100%
“goose flu” → septicemia and death
in young ducks and geese



Enterococcus cecorum 63.3%
enterococcal spondylitis in different
poultry types

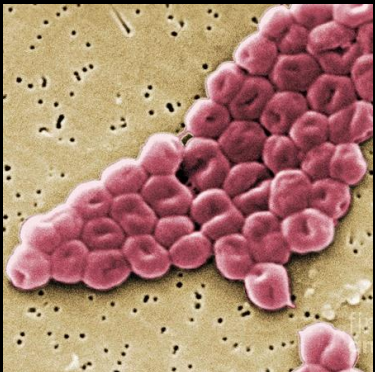
Mammal and fish pathogens



Lawsonia intracellularis 50%
proliferative enteropathy in pigs,
horses, dogs, cats, etc.



Lactococcus garvieae 23.3%
important pathogen in pisciculture



Acinetobacter Iwoffii /johnsonii
87%/57% emerging pathogens of
farmed carp/trout; transmission
antibiotic resistance genes

Priorities for NGS surveillance

Frequent close contact of human and
wildlife:

- **Wildlife used by Native American communities for subsistence** (e.g. Alaskan seabirds)
- Nuisance urban wildlife (e.g. resident Canada geese, vultures)
- Popular game species (e.g. waterfowl, doves, gamebirds)



