

Principles of vaccination

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For BSc Global Health 2011

Aims

- To outline the underlying principles of vaccination

Objectives

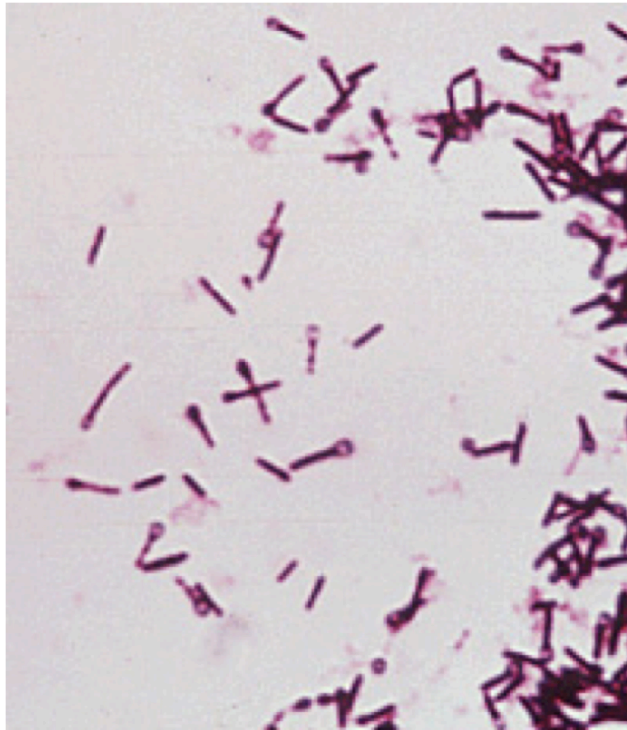
- What vaccines are available?
- What diseases do they prevent?
- How do they work?
- How do we assess if they work?
- What's new?

- So what is available.....?

Bacterial			Viral		
Live	Not live	Both	Live	Not live	Both
BCG*	Tetanus*	Typhoid+	Measles*	Hep B +	Polio*
	Diphtheria*		Mumps +	HPV+	Flu+
	<u>Pertussis*</u>		Rubella+	Hep A+	
	<u>Hib*</u>		Rotavirus+	TBE+	
	<u>Mening+</u>		VZV+	Rabies	
	<u>Pneumo+</u>		YF+		
	Cholera+		Small pox		
	Anthrax				

- * In most national schedules
- + In some national schedules

Tetanus – the organism



Clostridium tetani

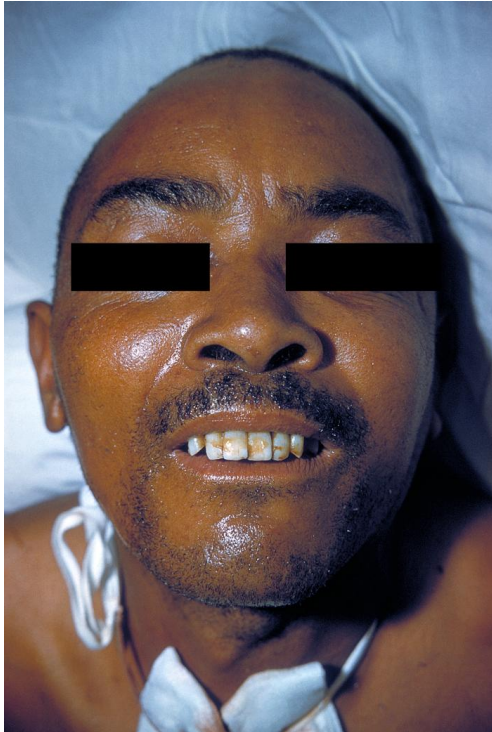
Tetanus – the disease



- Ubiquitous organism
- Toxin mediated
- High risk injuries



Tetanus – the disease



Adult tetanus

Infant tetanus

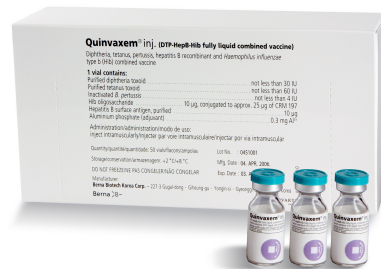


Tetanus - risk



High risk birthing practices...

Tetanus – the vaccine



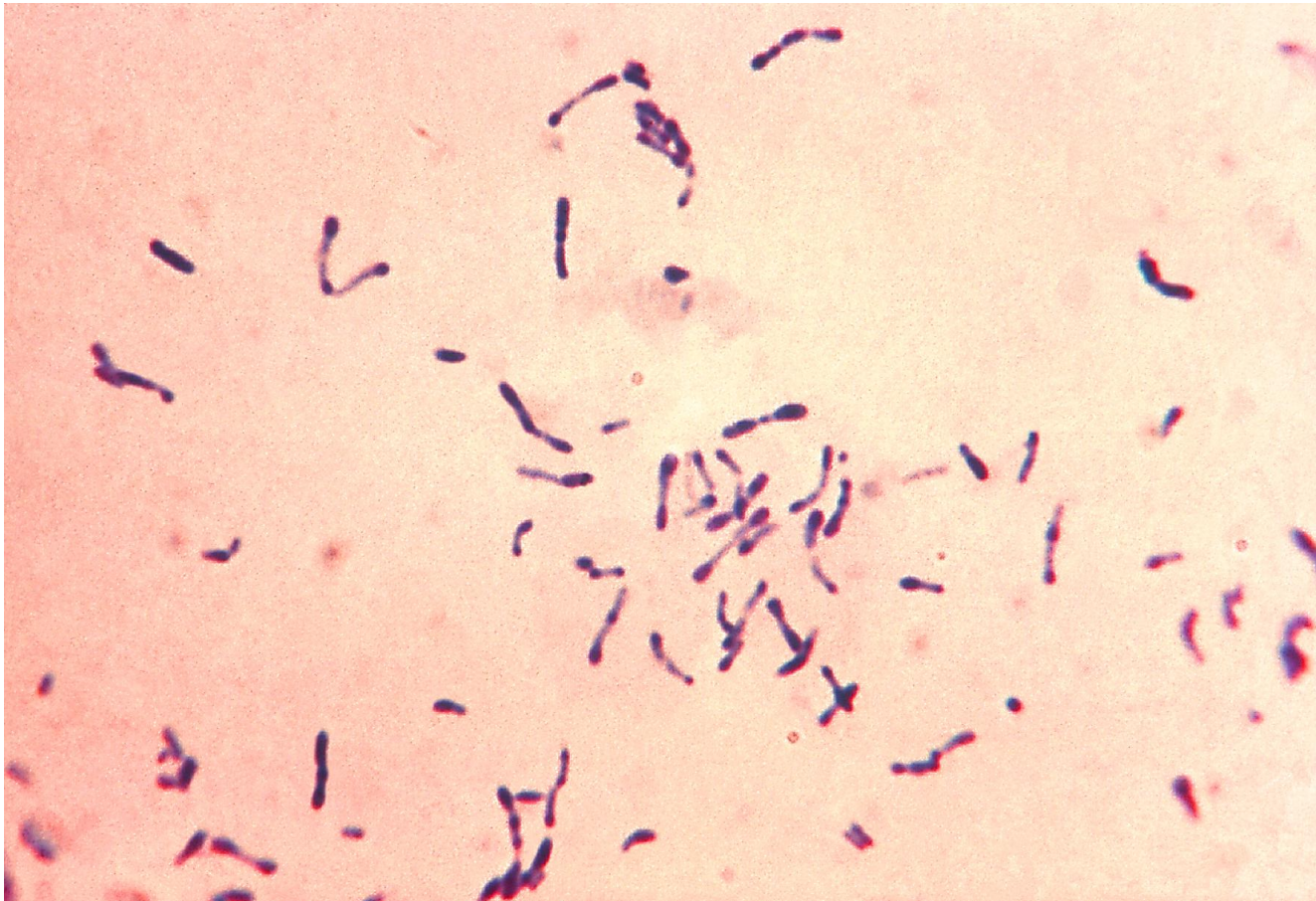
- Toxoid vaccine
- Available as combination
- Globally availability



Tetanus - prevention



Diphtheria – the organism



Corynebacterium diphtheriae

Diphtheria – the disease



Pharyngeal involvement



Cutaneous form

Diphtheria – the vaccine



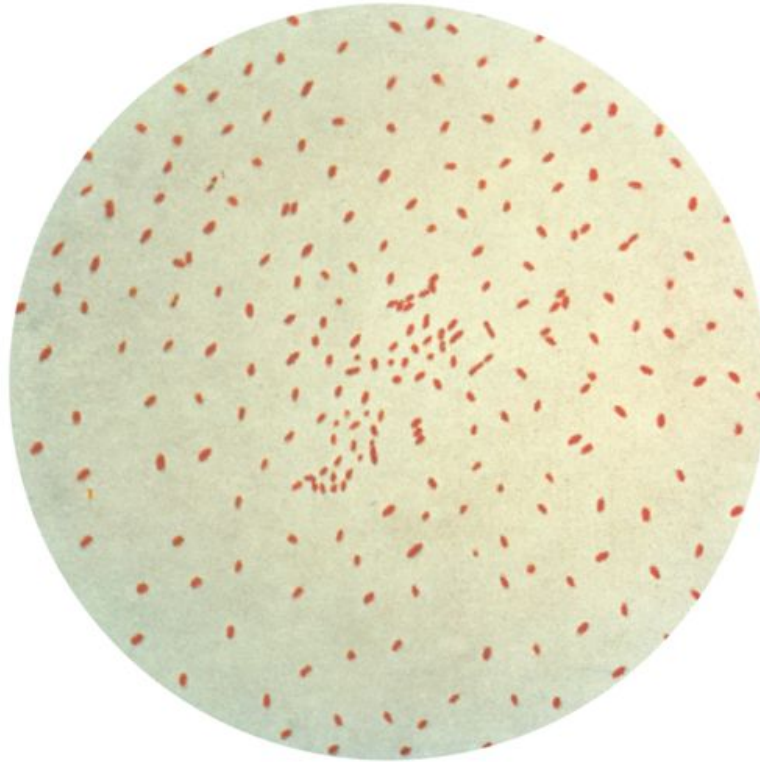
- Toxoid vaccine
- Available in combination
- Global availability



Diphtheria - prevention



Pertussis – the organism



Bordetella pertussis

Pertussis – the disease



- Characteristic clinical features
- Whooping cough
- “100 day cough”
- High risk in neonatal period and early infancy



Pertussis – the vaccine

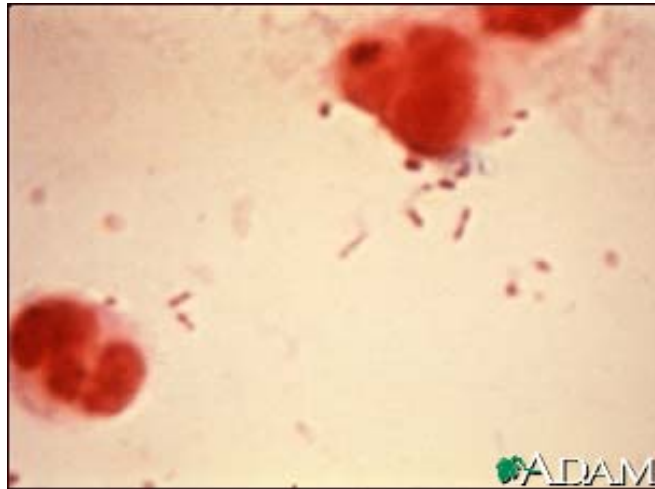


- Whole cell
- Acellular
- Available in combination

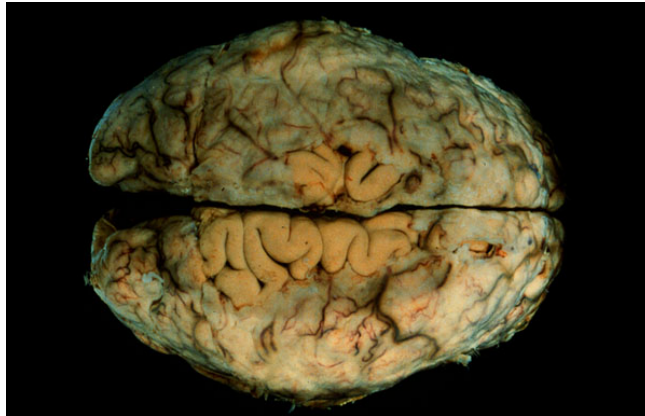
Pertussis - prevention



Haemophilus influenzae type b (Hib) - the organism



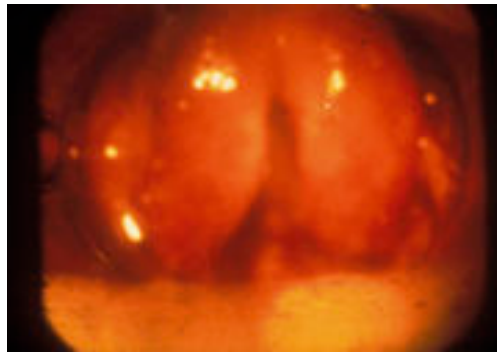
Hib – the disease



Meningitis



Pneumonia



Epiglottitis



Periorbital cellulitis

Hib – the vaccine

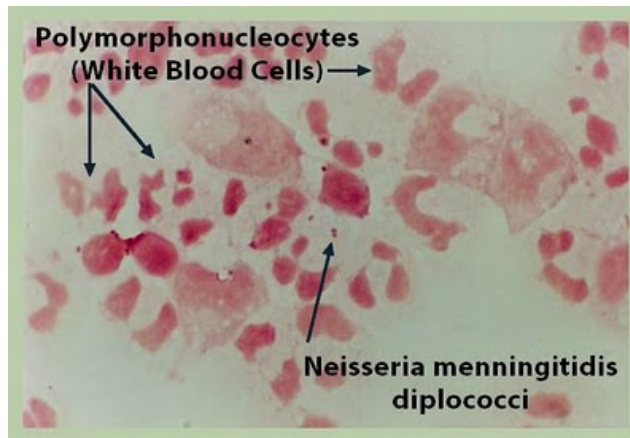


- Protein polysaccharide conjugate vaccine
- Available as combination

Hib - prevention



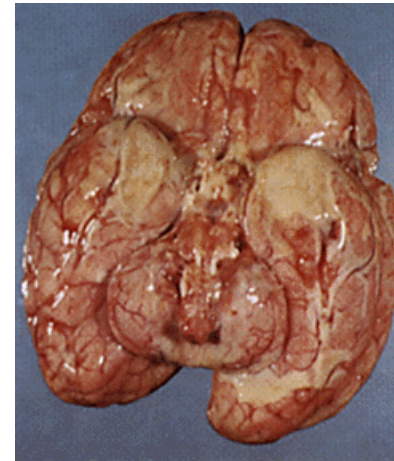
Neisseria meningitidis - the organism



Neisseria meningitidis - the disease



Meningococcal sepsis



Meningitis



Neisseria meningitidis – the vaccine



- Conjugate vaccine
- Polysaccharide vaccine
- MenC
- Men A/C/Y/W135

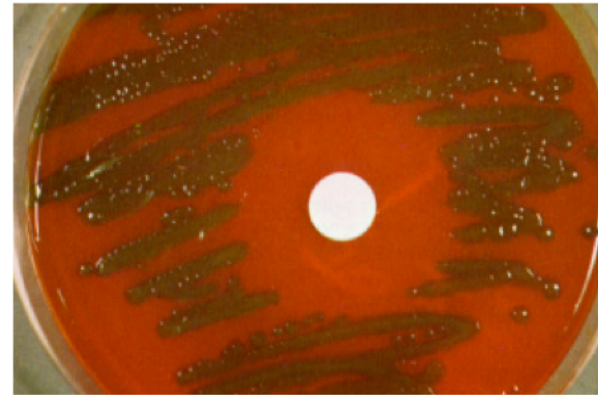
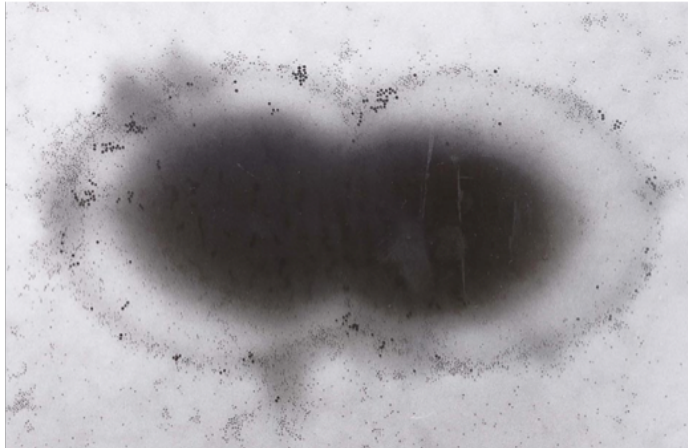


Neisseria meningitidis

- prevention



Streptococcus pneumoniae (Sp) – the organism

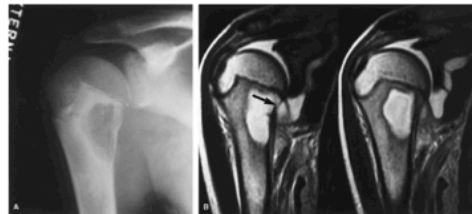


Sp – the disease

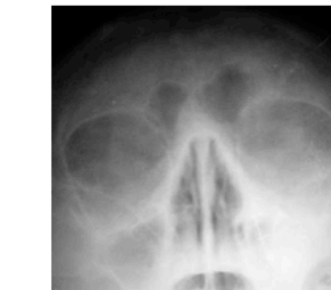
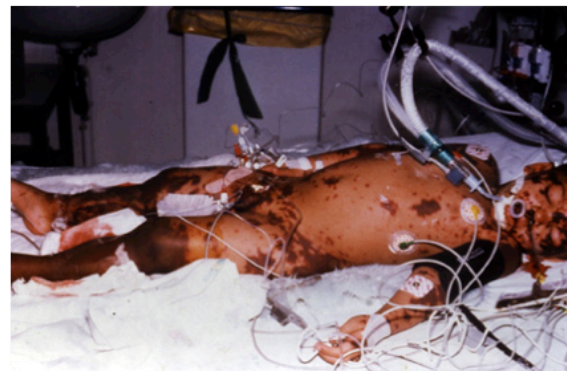
Otitis media



Joint and bone infection



Meningitis

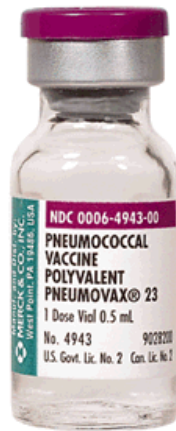


Pneumonia

Fulminant sepsis

Sinus infection

Sp – the vaccine



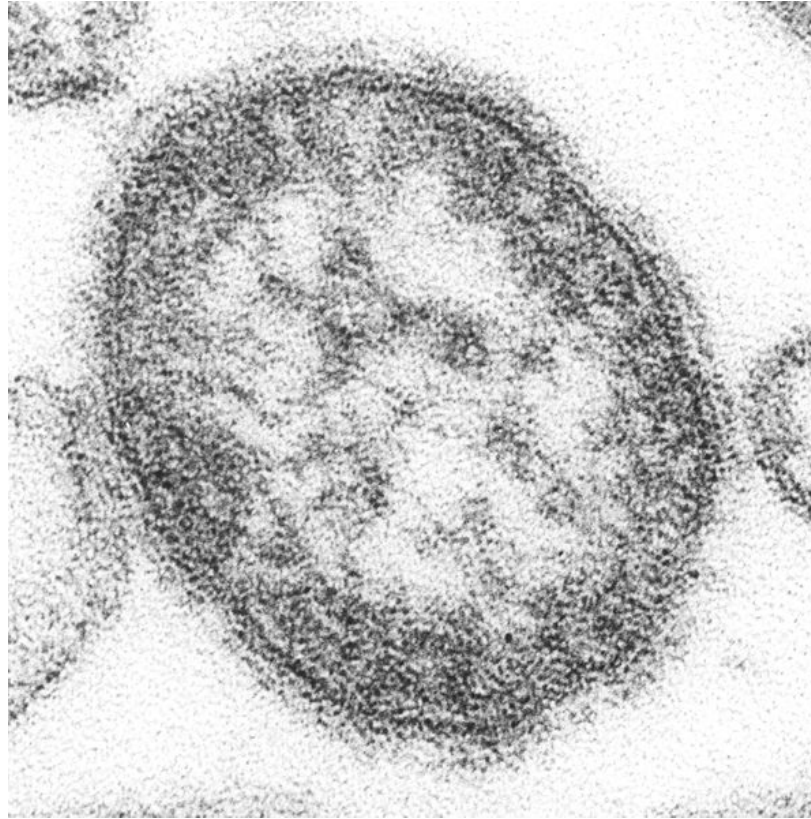
- Conjugate vaccine
- Polysaccharide vaccine
 - Debated efficacy
 - Used in at risk groups



Sp - prevention



Measles – the organism



Pleiomorphic paramyxovirus - morbillivirus

Measles - the disease



Koplik spots

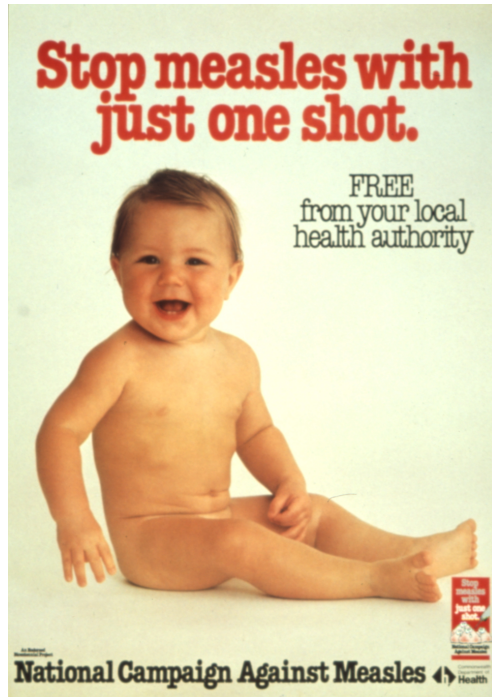


“Morbilliform” rash

Measles – the vaccine



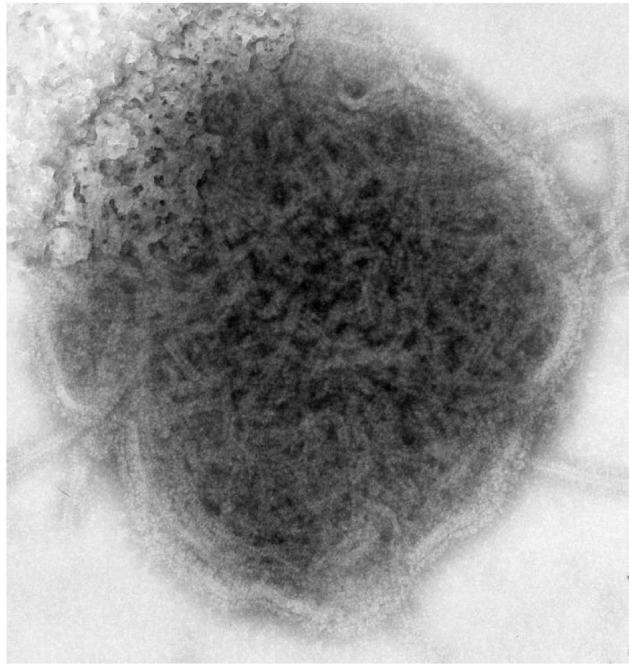
- Live attenuated vaccine
- Available singularly or in combination
- Side effects
- Safety debate....



Measles - prevention



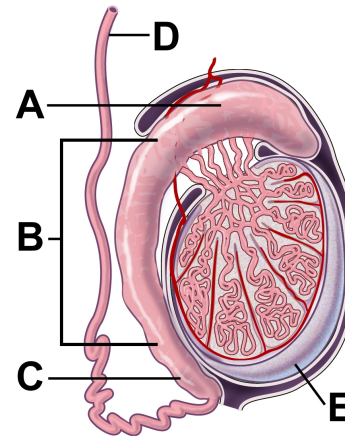
Mumps



Paramyxovirus - rubulavirus

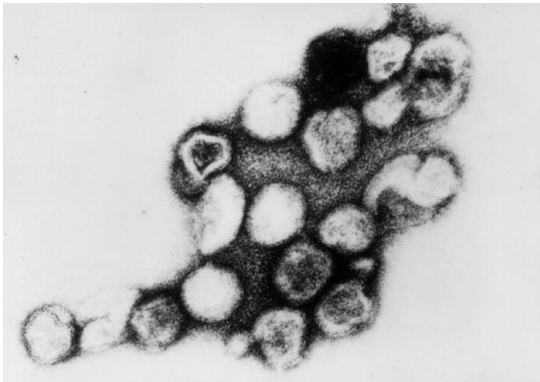


Glandular involvement



Orchitis

Rubella



Togaviris - rubivirus

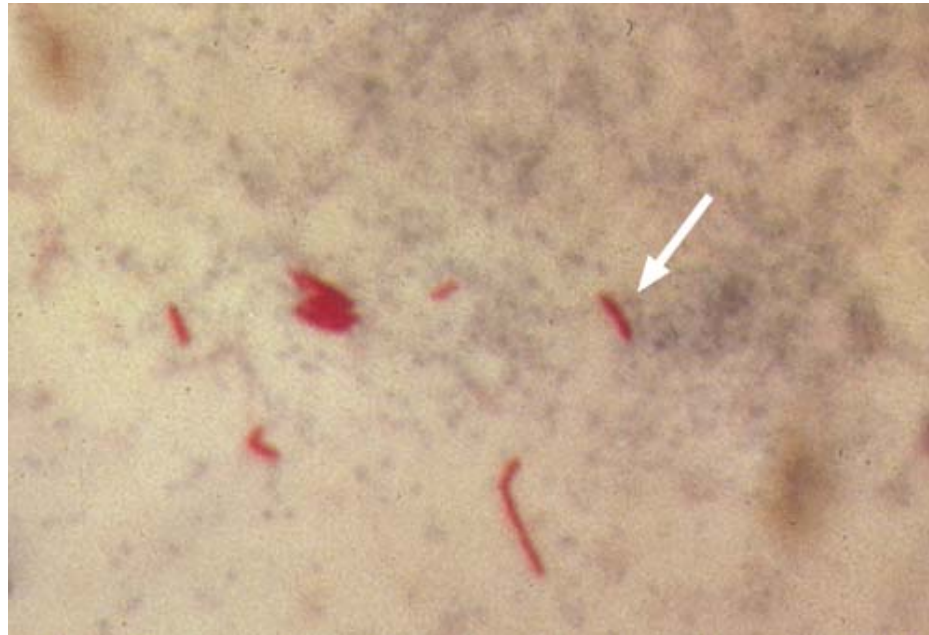


“German measles”



Congenital infection

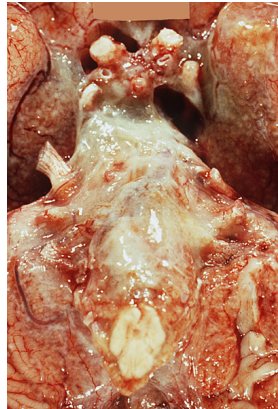
Tuberculosis – the organism



Mycobacterium tuberculosis

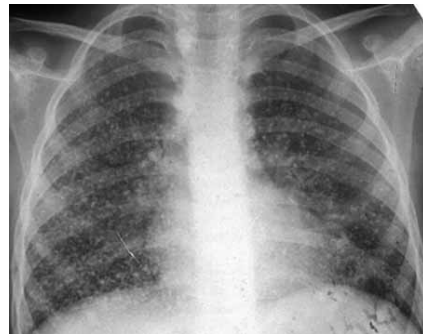
Tuberculosis – the disease

TBM



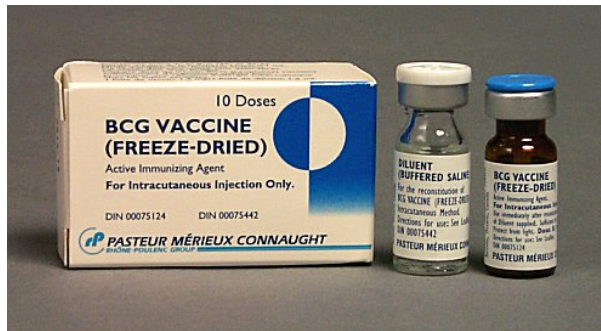
Post primary
cavitory disease

Disseminated TB



LTBI

Bacillus Calmette-Guérin (BCG) - the vaccine

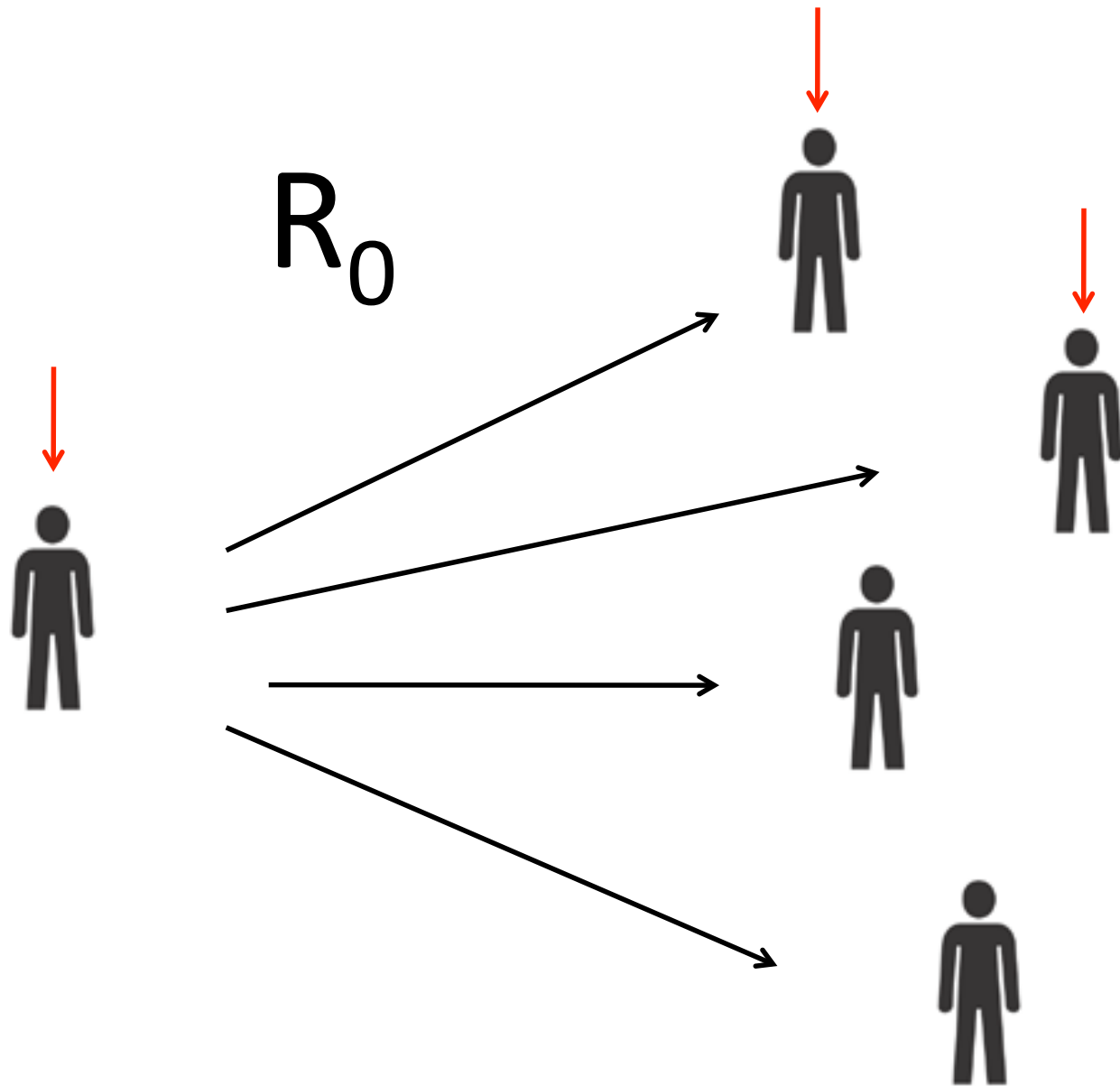


- Live attenuated
- Variable efficacy
- Mainly severe disease in young children
- Side effects...

How do they work on a
population level?

Herd immunity

- The persistence of infectious disease within a population requires the density of susceptible individuals to exceed a critical value such that on average each primary case of infection gives rise to at least one secondary case
- Not necessary to vaccinate everyone...just enough to reduce the susceptible fraction below a critical point
- Multiple factors impact on the relative impact of herd immunity



Basic reproductive number

- R_0 – the average number of secondary cases produced by one primary case in a wholly susceptible population
- $R_0 > 1$ for sustained infection in a community
- The value of R_0 is community dependent
 - Social and behavioural factors
 - Biology of disease and host
 - Demography of the community
- Vaccination needs to reduce R_0 to < 1
- Allows estimation through mathematical modeling of the proportion needed to be vaccinated to control/eliminate a given infectious disease in a given population

Further reading

- Anderson RM, Nokes DJ. Mathematical models in disease study. *Epidem. Inf.* 1988;101:1-20

How do we assess if a vaccine works?

- Animal studies
- Immunogenicity
- Efficacy

- Effectiveness

$$VE = \frac{I_{unv} - I_{vac}}{I_{unv}} \times 100$$

Alternatively represented as:

$$VE = \left(1 - \frac{I_{vac}}{I_{unv}}\right) \times 100 = (1 - RR) \times 100$$

Key: VE = vaccine efficacy; I_{vac} = the vaccinated;
 I_{unv} = the unvaccinated; RR = relative risk (of disease)

- Phase I studies
 - involve small numbers of adult subjects and give preliminary data on safety and immunogenicity
- Phase II studies
 - involve larger numbers and are used to investigate optimal dosing and formulation, and to give further information on immunogenicity and safety
- Phase III studies
 - involve even larger numbers and usually include efficacy trials, which will determine licensing decisions by the regulatory bodies
- Phase IV studies
 - are large-scale epidemiological studies to assess post-licensing effectiveness and safety

What's new?

- Recent vaccine developments
 - Rotavirus
 - Malaria
 - MenB
- Novel routes of administration
 - Intranasal
 - Transdermal
 - Novel adjuvant technology
- New immunological strategies
 - Prime boost (DNA/RNA vaccines)
 - Adolescent/adult boosting

Summary

Time for a break....
(Questions?)