

# Epidemiology

## of infectious diseases

Kolářová M., EPI Autumn 2018

# EPIDEMIOLOGY

*is the study* (scientific, systematic, data-driven)  
*of the distribution* (frequency, pattern)  
*and determinants* (causes, risk factors)  
*of health-related states or events* (not just diseases)  
*in specified populations* (patient is community,  
individuals viewed collectively),  
*and the application* (since epidemiology is a discipline  
within public health) *of this study to the control of health  
problems.*

In tracking a disease outbreak, epidemiologists may use any or all of three types of investigation:

a) **descriptive** epidemiology

is the collection of all data describing the occurrence of the disease

b) **analytical** epidemiology

attempts to determine the cause of an outbreak

c) **experimental** epidemiology

tests a hypothesis about a disease or disease treatment in a group of people.

# Occurrence of Disease

- **Incidence** - the incidence rate refers to the number of **new cases** of a disease in a given population **over a period of time.**
- **Prevalence** - the prevalence rate refers to the number of **total cases** of a disease in a given population at a specific time.
- **Sporadic disease** Disease that occurs occasionally in a population.
- **Endemic disease** Disease constantly present in a population.
- **Epidemic disease** Disease acquired by many hosts in a given area in a short time.
- **Pandemic disease** Worldwide epidemic.

Epidemiologic investigations are largely mathematical descriptions of persons in groups, rather than individuals.

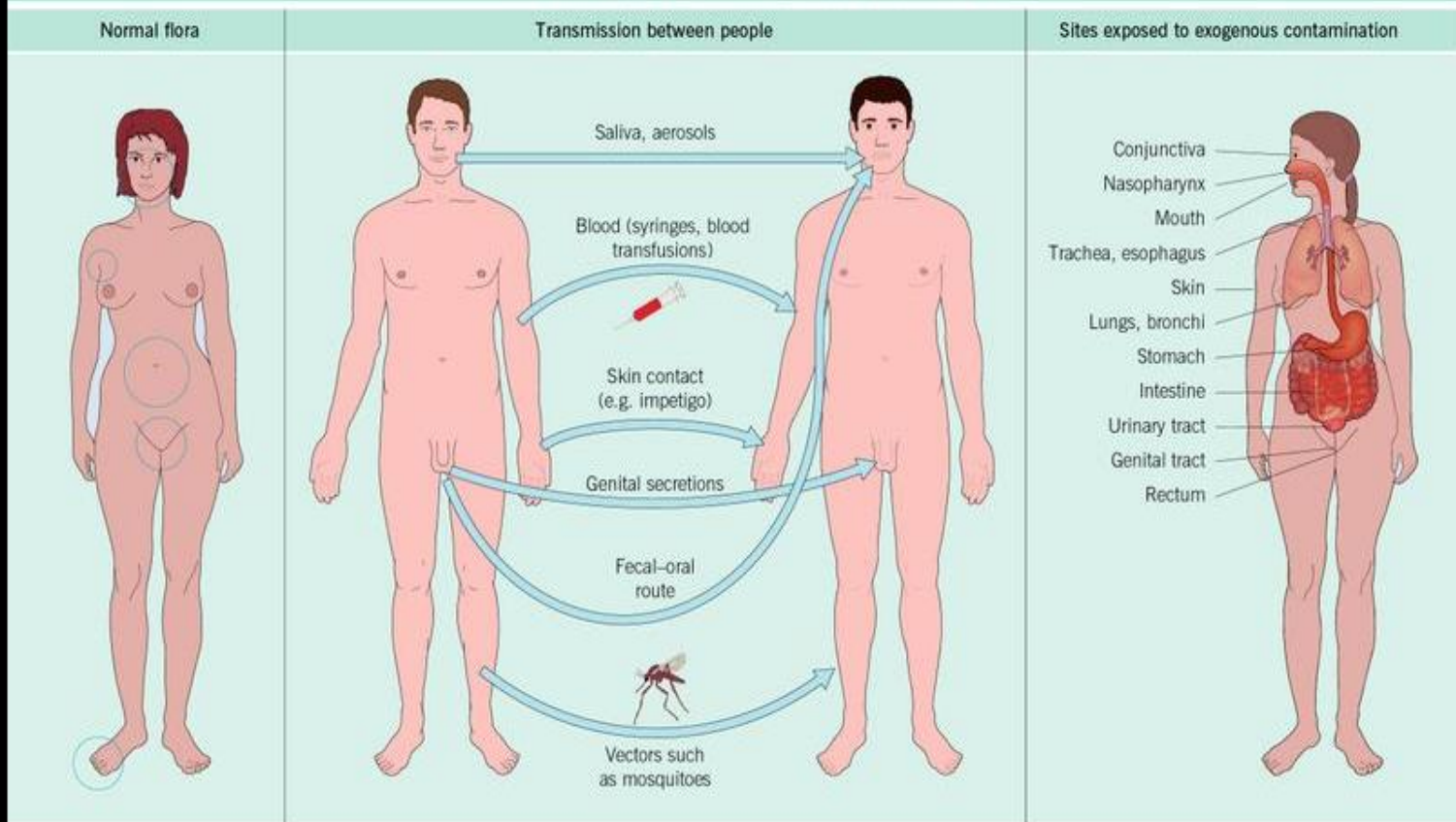
# Modern infectious disease epidemiology

# Colonisation and contamination of humans by micro-organisms.

Many parts of the body are colonized by normal flora, which can be the source of endogenous infection. Large numbers of micro-organisms are found in moist areas of the skin (e.g. the groin, between the toes), the upper respiratory tract, the digestive tract (e.g. the mouth, the nasopharynx), the ileum and large intestine, the anterior parts of the urethra and the vagina.

Other routes are interhuman transmission of infections and exposure to exogenous contamination.

## CONTAMINATION OF HUMANS BY MICRO-ORGANISMS





**the agent of infection** (e.g., particular bacterium or virus),

Organism characteristic:

**infectivity** – capacity to multiply in host

**pathogenicity** – capacity to cause disease in host

**virulence** - pathogenicity in a specific host

**immunogenicity** – capacity to induce specific and lasting immunity in host

**antigenic stability** – can induce long-life immunity

**resistance** - in environment

Organisms vary in their capacity **to survive** in the free state and to withstand adverse environmental conditions, for example:

- \* heat, cold, dryness.

**Sporo-forming organisms**, such as tetanus bacilli which **can survive for years** in a dormant state, have a major advantage over an organisms like the gonococcus which survive for only a very short time outside the human host.

According to classic definition,  
**epidemiology of infectious  
disease**  
in its theoretical part  
**studies the chain of infections  
(epidemic process)**

# 1. the presence of source of infection

is the site or sites in which a disease agent normally lives and reproduces.

May be classified as:

- **human** - at the end incubation period, if is ill, reconvalescent, carriers – healthy, chronic diseases

- **animals** - at the end incubation period, if is ill, carriers – healthy, reconvalescent, chronic

## 2. the method of transmission

### A/ direct contact

touching, kissing or sexual intercourse (Staphylococcus spp.,  
Gonococcus spp., HIV ...),

- **vertical transmission** – from mother to fetus (VHB, VHC, HIV,  
listeria, rubella, cytomegalovirus...)

### B/ indirect contact

- **inhalation of droplets** containing the infectious agents (TBC,  
measles, influenza...)

- **ingestion of food or water** that is contaminated (salmonella,  
giardia, Norwalk virus, VHA....)

- **biological transmission** by insects (malaria, borellia....)

# Routes of transmission

- Air
- Food, Drink or Water
- Direct or indirect contact
  - \* Transplacental
- Insects (Artropods)

Among the important environmental factors that affect an epidemic of infectious diseases are:

poverty, overcrowding, lack of sanitation,

and such uncontrollable factors:  
as the season and climate.

### 3. the susceptibility of the population or its individual member to the organism concerned, and the characteristic of the organism itself.

#### Host factors :

##### Non specific immunity

Barrier action (natural barrier)

##### External barrier:

skin , mucosa

Secretion of skin and mucosa

Accessory organ

Internal barrier: placenta, blood-brain barrier

Phagocytosis

Humoral action :

Complement, Lysozyme, Fibronectin, Cytokines.

##### Specific immunity

Humoral immunity

Immunoglobulin: IgG, IgM, IgE, IgA, IgD

Cell mediated immunity



THE CAUSATIVE AGENT OF INFECTION (bacteria, viruses, fungi, prions, protozoa)

1. the presence of rezervoir (source) of infection

man, animal

- at the end of incubation period
- acute stage
- carriers

2. the way of transmission A/ direct contact

touching, kissing or sexual intercourse (Staphylococcus spp., Gonococcus spp., HIV ...),  
- vertical transmission – from mother to fetus (VHB, VHC, HIV, listeria, rubella, cytomegalovirus...)

B/ indirect contact

- inhalation of droplets containing the infectious agents (TBC, measles, influenza...)
- ingestion of food or water that is contaminated (salmonella, giardia, Norwalk virus, VHA....)
- biological transmission by insects (malaria, borellia....)

3. the susceptibility of the population or its individual members to the organism

concerned Host factors: age, nutrition, genetics  
immunity – natural (nonspecific),  
- acquired

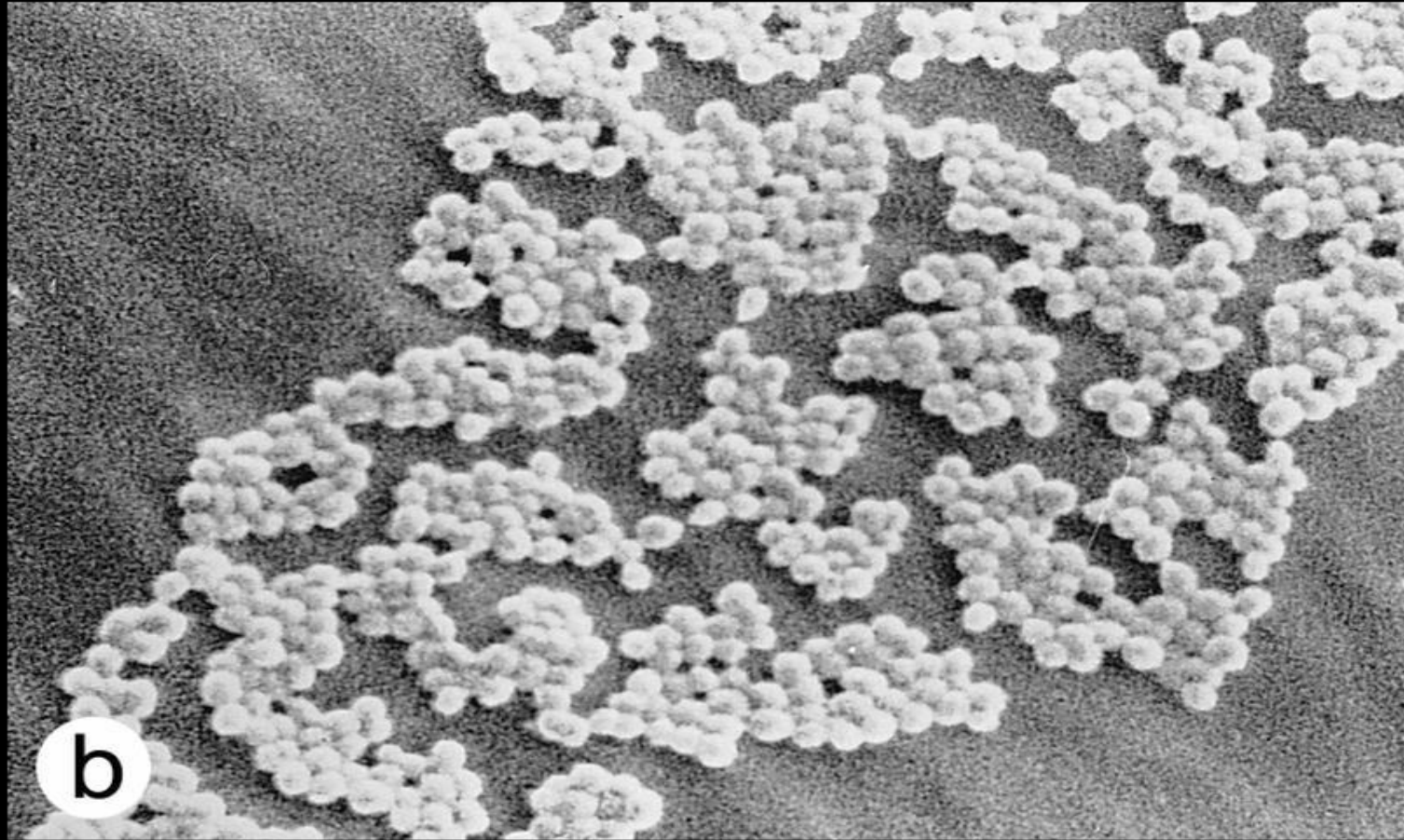
THE INFECTION

= 1. source of infection

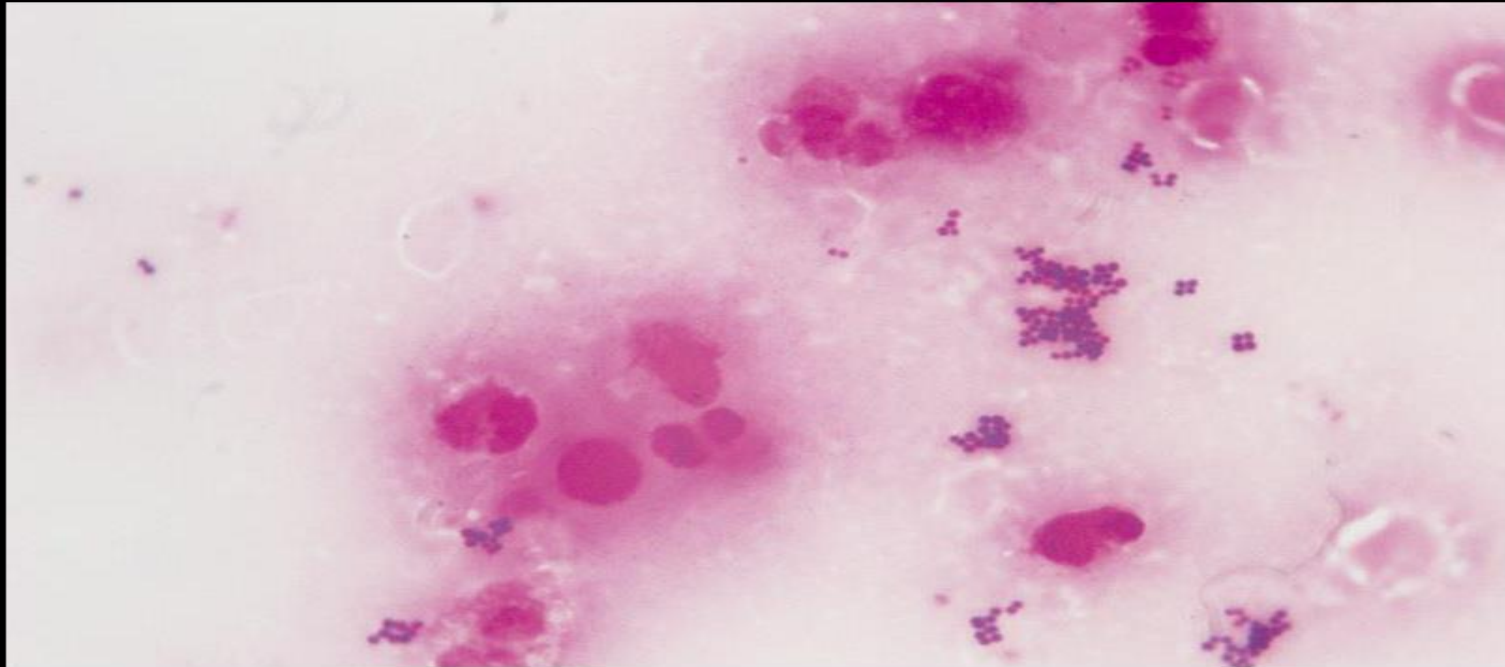
## Main portals of entry

- Respiratory tract
- Gastro-intestinal tract
- Genito-urinary tract
- Direct break through skin
  - \* surgical and wounds
- Direct into blood via needles/catheters

Slime-producing coagulase-negative staphylococci. Scanning electron micrograph of the surface of an intravascular catheter incubated *in vitro* with (a) slime-producing and (b) nonslime-producing strains of *Staphylococcus epidermidis*. With permission from Christensen.<sup>9</sup>



# *Staphylococcus aureus*



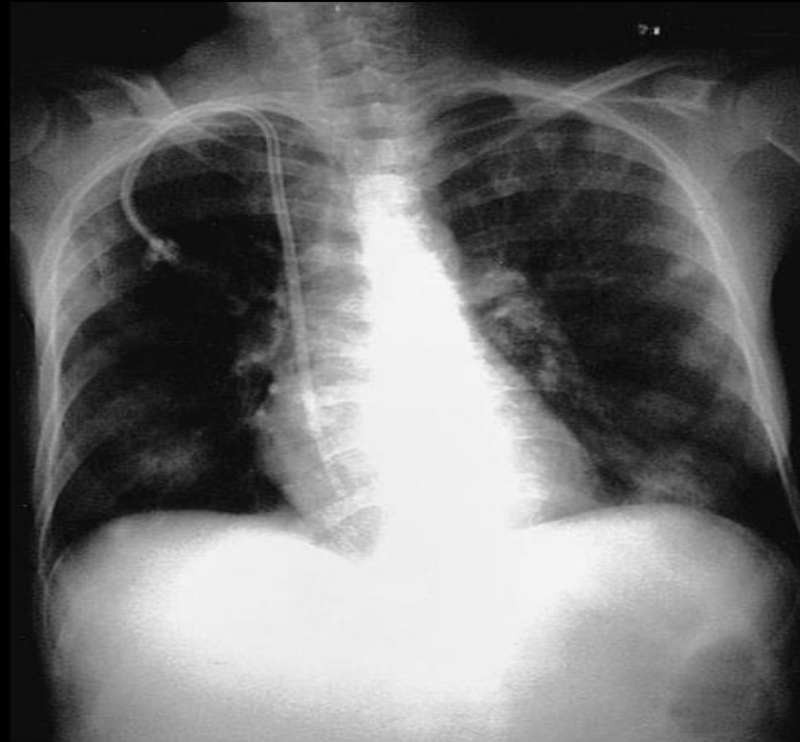
Staphylococcal nasal carriage. This patient had a small staphylococcal abscess beneath the mucosa of the nose, illustrating how *Staphylococcus aureus*, which colonizes the nares, can infect skin and submucosa. Intact mucosa is highly resistant to infection; such infections usually occur as a result of defects in the mucosal membranes or via hair follicles inside the nose.





➤ Impetigo in a child.

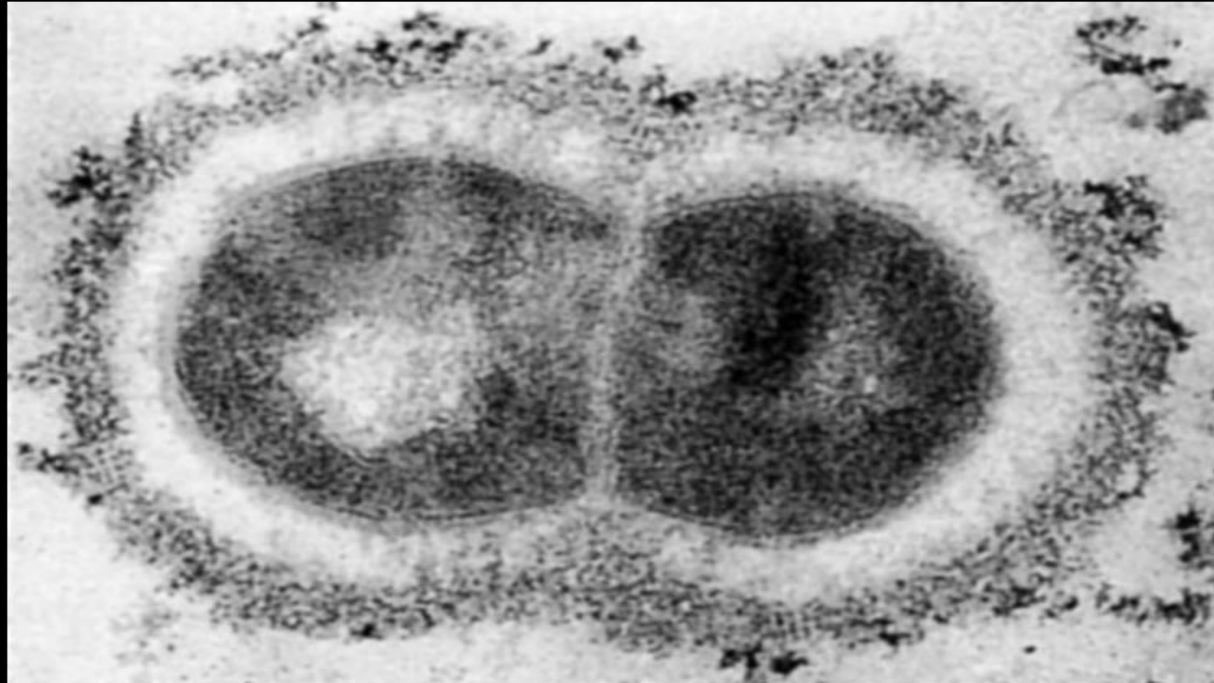
Septic pulmonary emboli. Multiple nodular pulmonary infiltrates secondary to a dialysis catheter-associated infection. The patient presented with high fevers, cough and pleuritic chest pain. *Staphylococcus aureus* was isolated from multiple blood specimens.





- **$\beta$ -Hemolytic streptococci group A** on a blood agar plate. Note the clear  $\beta$ -hemolytic zone.





- Electron microscopy of **group A streptococcus**. The fuzzy M protein layer can be seen protruding from the cell wall..



**Erysipelas.** Note the sharp demarcation of the affected skin.

## Scarlatina (scarlet fever)



Typical rash of **meningococcal septicemia**. Fine erythematous macules and petechiae are present in some areas.



# Varicella (chickenpox)



**Varicella (chickenpox).** Lesions at various stages, including vesicles, can be seen.



**Morbilli (Measles).** A disseminated erythematous rash can be seen over the trunk and arms.



**Rubella.** A pink macular rash can be seen on the forearm.





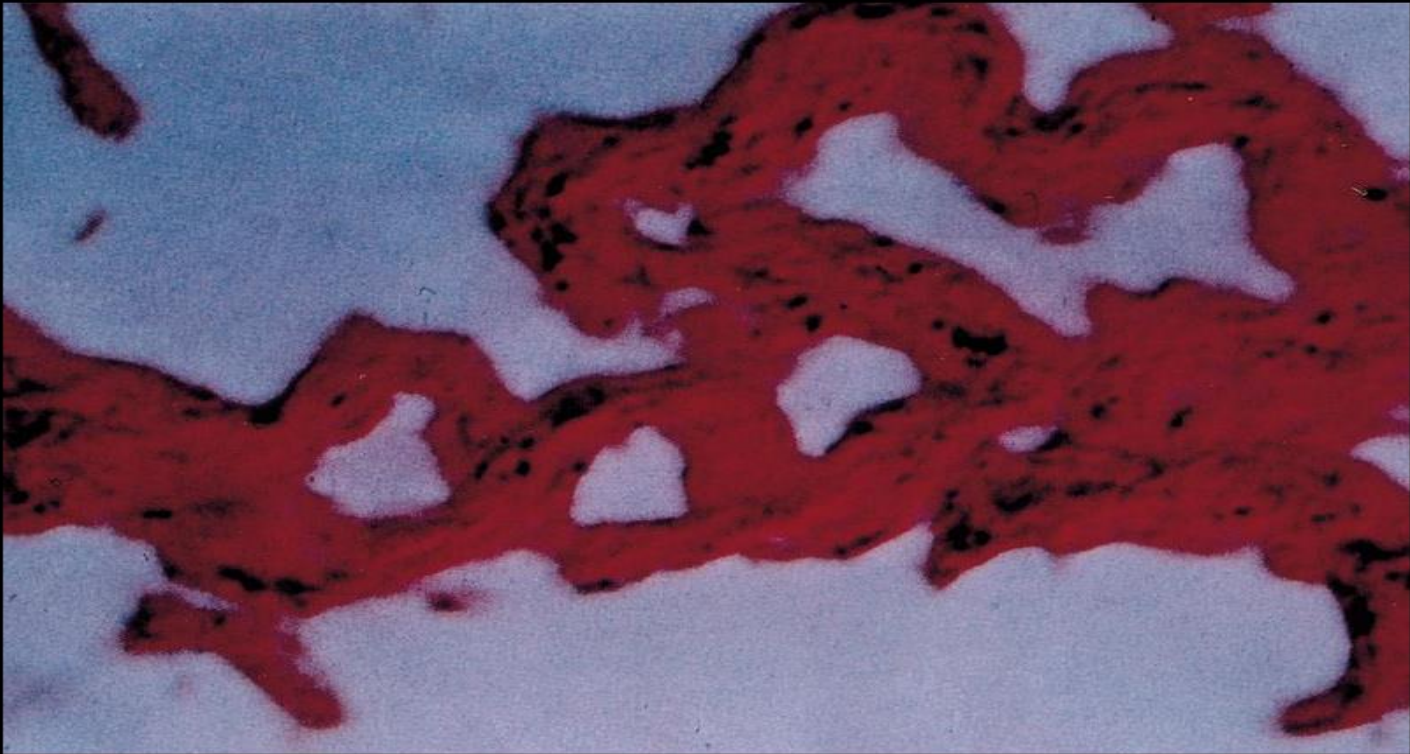
# Rubella



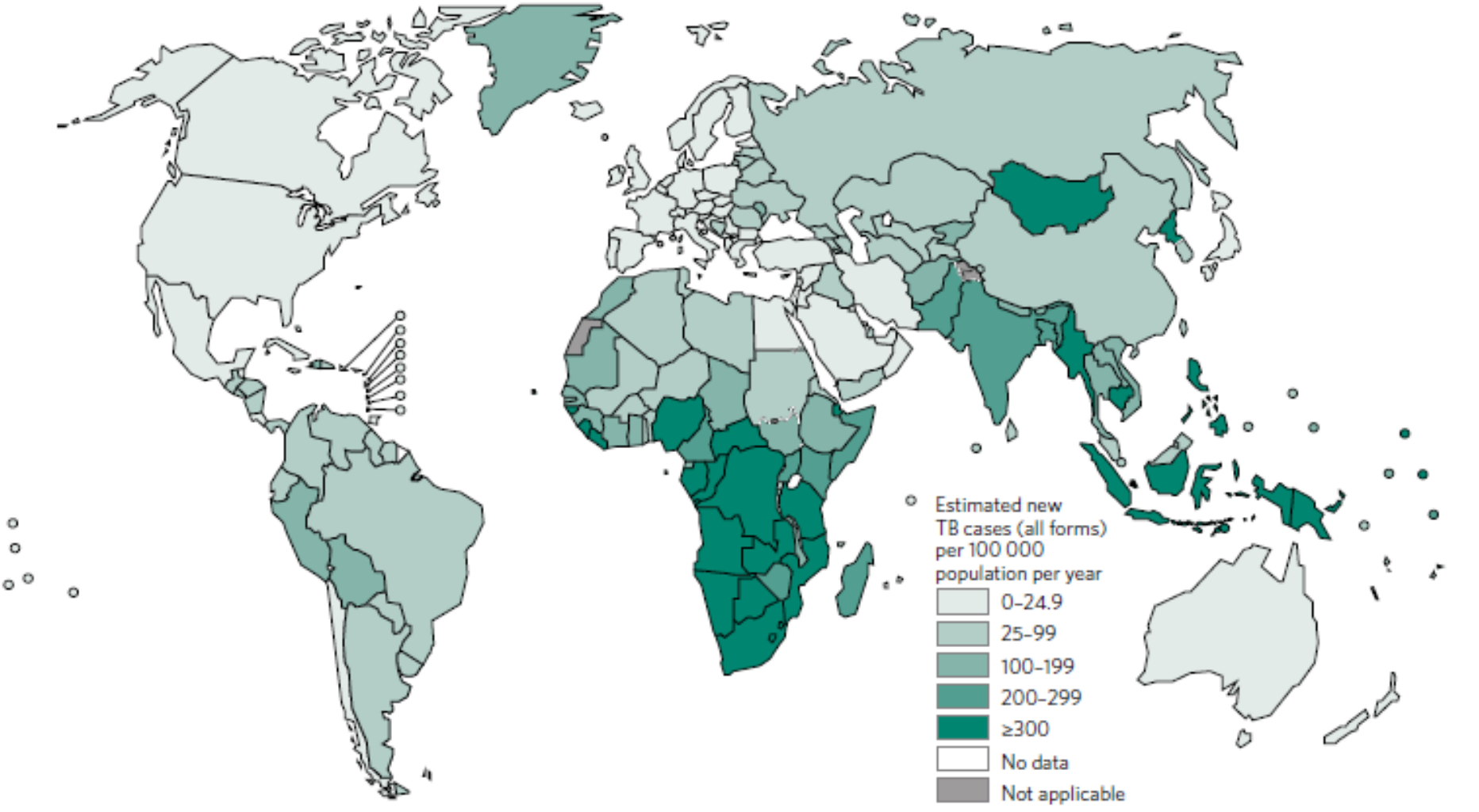
# Parotitis epidemica ( mumps)



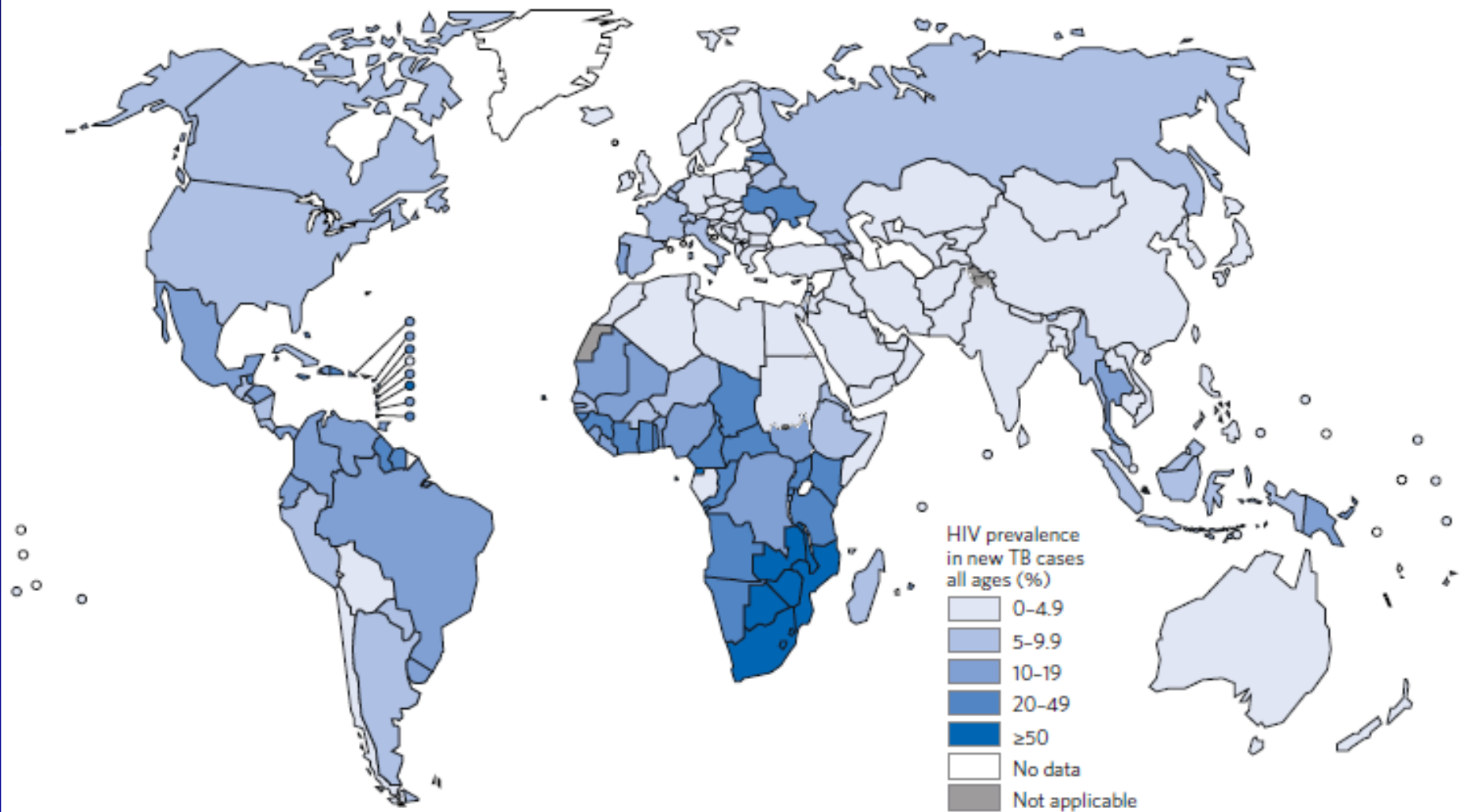
Ziehl-Neelsen stain of 'cords' of *Mycobacterium tuberculosis* isolated from a broth culture. Tubercle bacilli aggregate end to end and side to side to form serpentine cords, especially in broth cultures.



# Estimated TB incidence rates, 2015



## Estimated HIV prevalence in new and relapse TB cases, 2015



If the epidemiology is known, we can interfere with transmission:

## „BREAKING THE CHAIN OF INFECTION“

Different infections have different epidemiologies and thus require different methods of control



- **The distribution of the smallpox rash is usually similar to that shown here. It is most dense on the face, arms and hands, legs and feet. The trunk has fewer pocks than the extremities.**



**Smallpox** is a disfiguring disease. Three out of ten cases may die. It is caused by variola virus. The disease is spread by secretions from the patient's mouth and nose, and by material from pocks or scabs. It is transmitted directly from one person to the next. Close contact with patients, or their clothing or bedding, is thus required for infection. A patient who has developed the distinctive symptoms of smallpox will have been exposed to the virus about two weeks previously.





In the practical part it is preoccupied with

**preventive measures**

**repressive measures**

related to infectious diseases



# The 14 steps of an epidemic investigation

1. Confirm the existence of an epidemic.
2. Verify the diagnosis.
3. Develop a case definition.
4. Develop a case report form.
5. Count the cases (i.e., an approximate analysis).
6. Orient the data (i.e., time, place, and person).
7. Analyze the data (e.g., agent, transmission, and host).
8. Develop a hypothesis.
9. Test the hypothesis.
10. Plan and implement control and prevention measures.
11. Evaluate the implemented measures.
12. Establish or improve the public health surveillance.
13. Write a report.
14. Plan and conduct additional studies.

# 1. Respiratory tract infections

- Influenza
- Avian influenza and other animal influenzas
- Legionnaires' disease
- Severe acute respiratory syndrome (SARS)
- Tuberculosis

# 2. Sexually transmitted infections, including HIV and blood-borne viruses

- ❖ *Chlamydia trachomatis* infection
- ❖ Gonorrhoea
- ❖ Hepatitis B virus infection
- ❖ Hepatitis C virus infection
- ❖ HIV/AIDS
- ❖ Syphilis

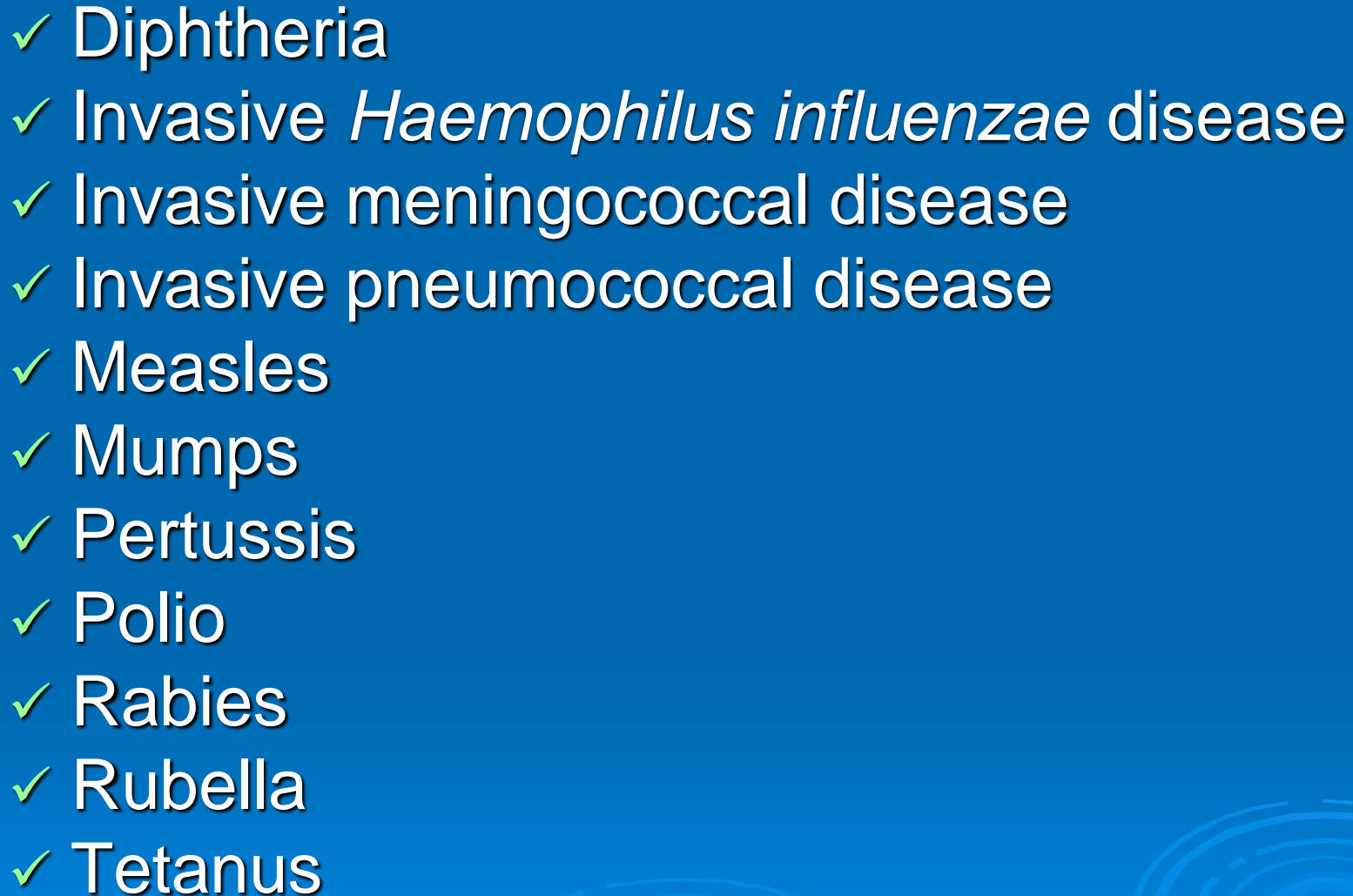
### 3. Food- and waterborne diseases and zoonoses

- Anthrax
- Botulism
- Brucellosis
- Campylobacteriosis
- Cholera
- Cryptosporidiosis
- Echinococcosis (hydatid disease)
- Shiga toxin/verocytotoxin-producing *Escherichia coli* (STEC/VTEC) infection
- Giardiasis
- Hepatitis A
- Leptospirosis
- Listeriosis
- Salmonellosis
- Shigellosis
- Toxoplasmosis (congenital)
- Trichinellosis
- Tularaemia
- Typhoid/paratyphoid fever
- Variant Creutzfeldt–Jakob disease (vCJD)
- Yersiniosis


## 4. Emerging and vector-borne diseases

- ❑ Malaria
- ❑ Plague (*Yersinia pestis* infection)
- ❑ Q fever
- ❑ Smallpox
- ❑ Viral haemorrhagic fevers
- ❑ Hantavirus
- ❑ Crimean–Congo haemorrhagic fever
- ❑ Dengue fever
- ❑ Rift Valley fever
- ❑ Ebola and Marburg virus
- ❑ Lassa fever
- ❑ Chikungunya fever
- ❑ West Nile fever
- ❑ Yellow fever

## 5. Vaccine-preventable diseases

- ✓ Diphtheria
  - ✓ Invasive *Haemophilus influenzae* disease
  - ✓ Invasive meningococcal disease
  - ✓ Invasive pneumococcal disease
  - ✓ Measles
  - ✓ Mumps
  - ✓ Pertussis
  - ✓ Polio
  - ✓ Rabies
  - ✓ Rubella
  - ✓ Tetanus
- 

## 6. Antimicrobial-resistant pathogens and healthcare-associated infections

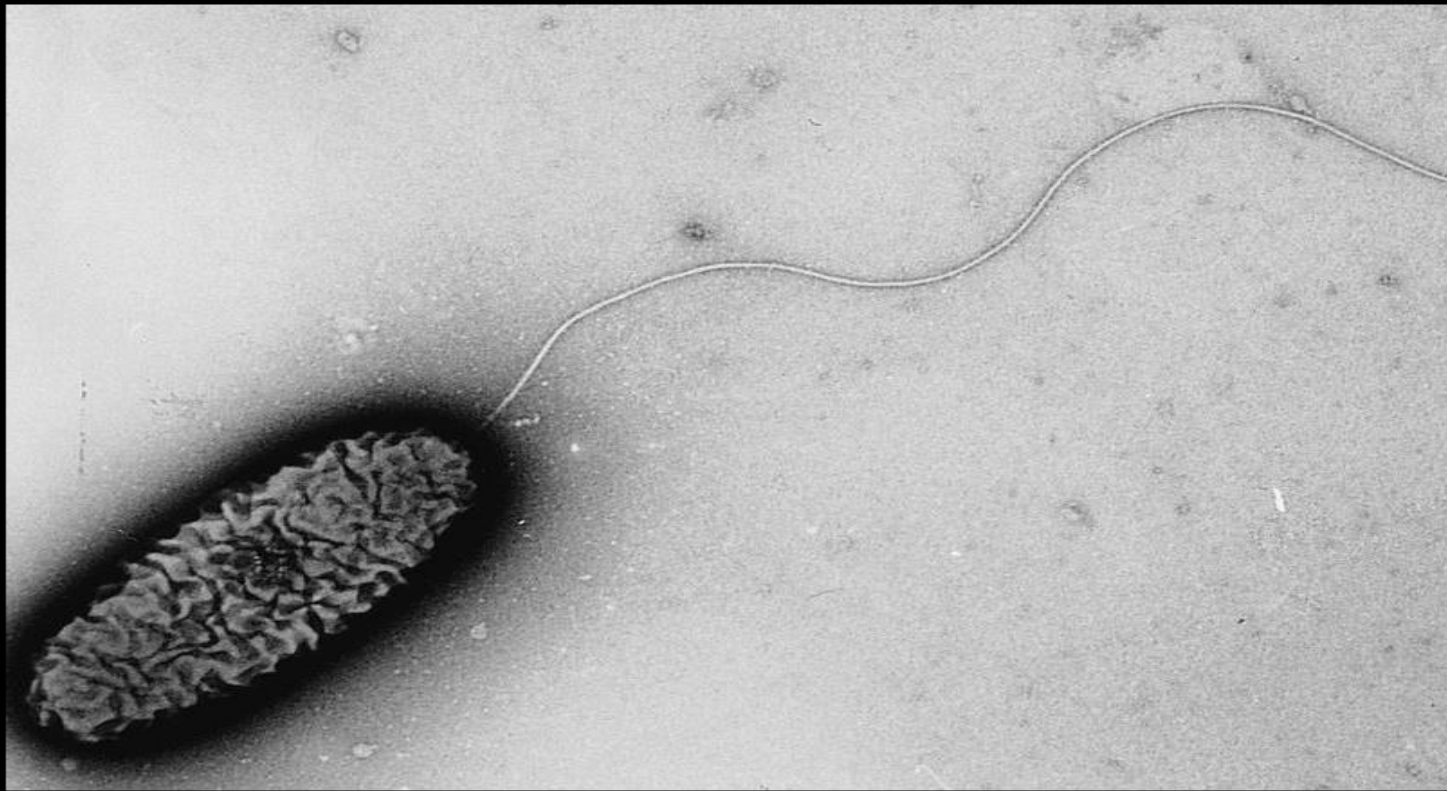
- Antimicrobial resistance
  - Antimicrobial consumption
  - Healthcare-associated infections - HAI
- 

Mixed culture of two morphotypes of Enterobacteriaceae on blood agar plate (*Escherichia coli* and *Salmonella* spp.).





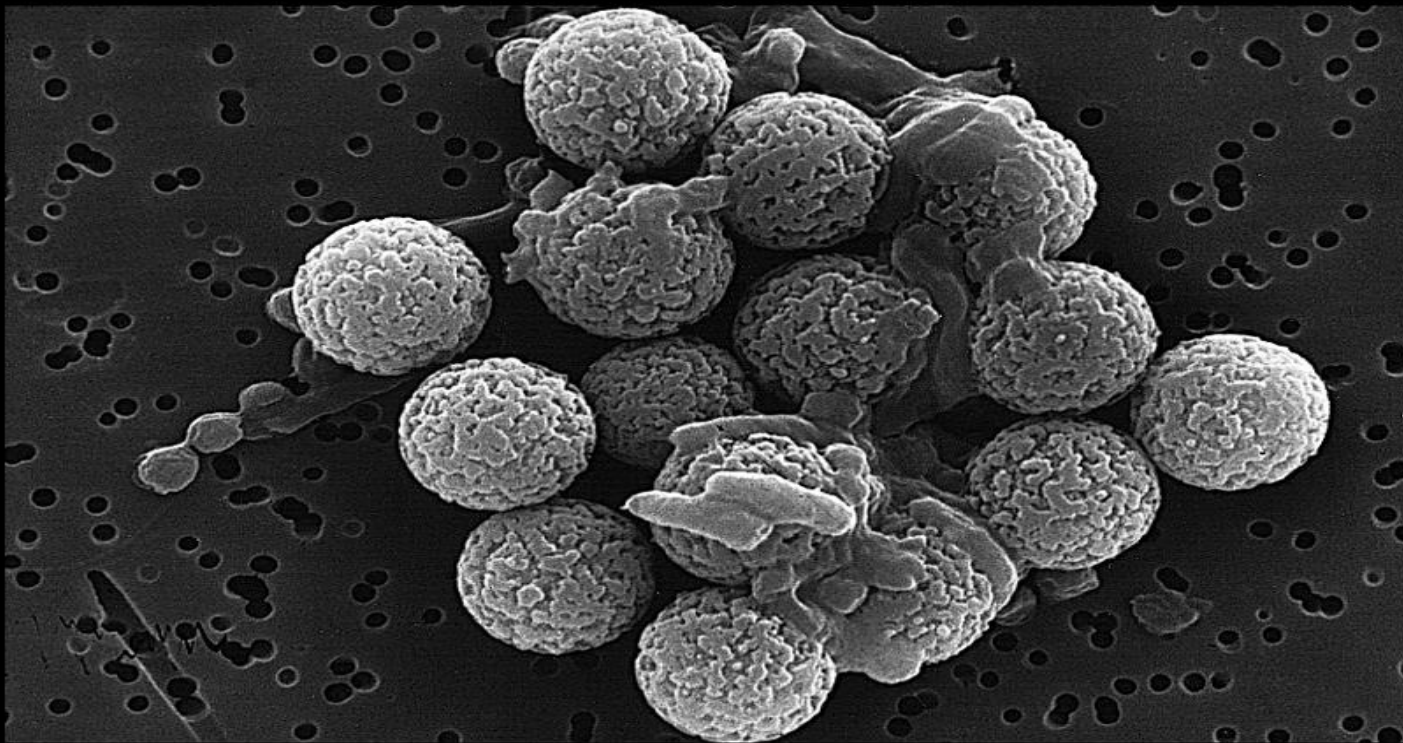
***Pseudomonas aeruginosa*** monotrichous polar flagellum  
seen on electron microscopy.



Burned leg that has been superinfected with *Pseudomonas aeruginosa*.



Cultured *Helicobacter pylori* in coccoid and bacilli forms, bound to immunomagnetic beads.



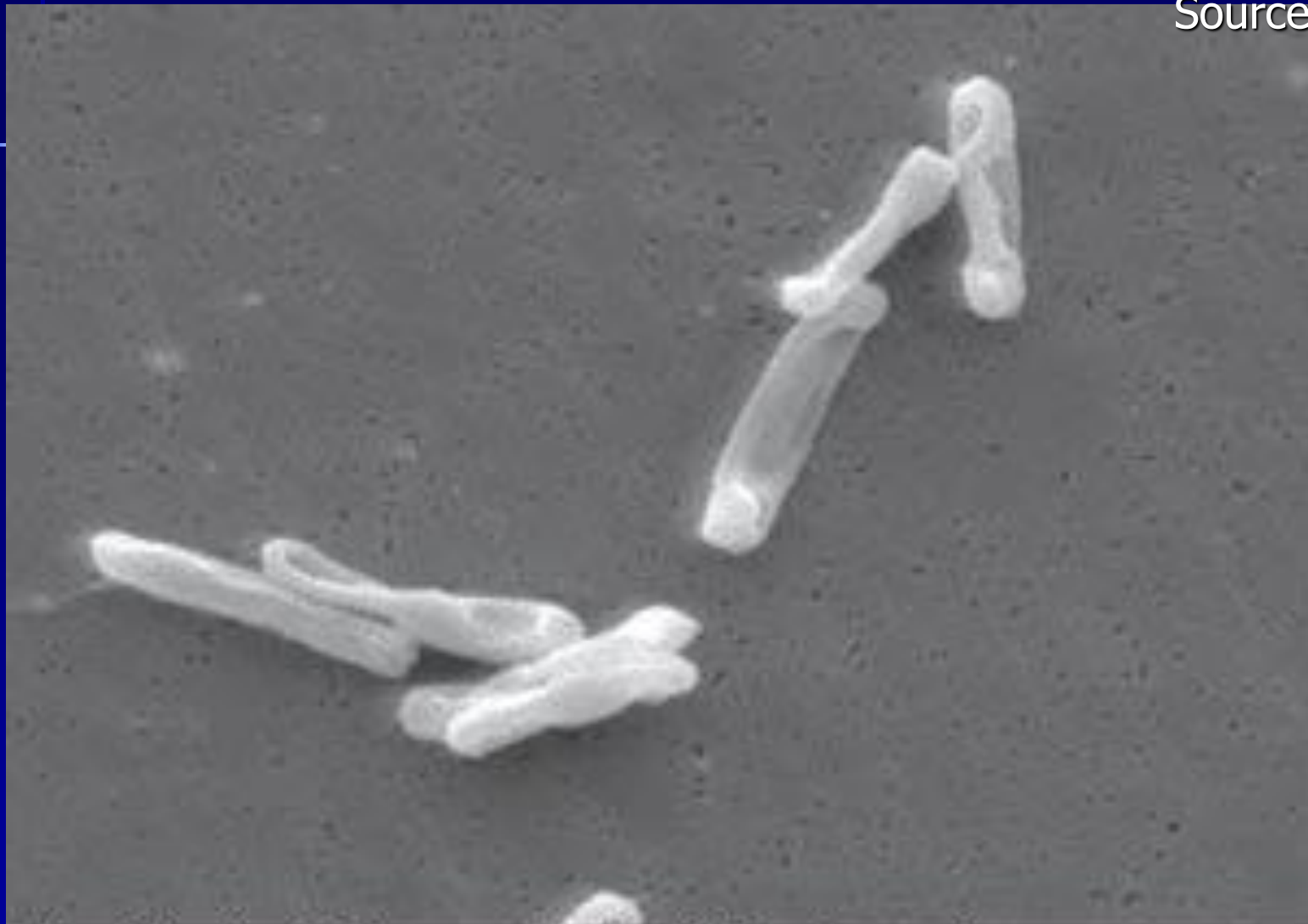
coccoid

bacilli

coccoid

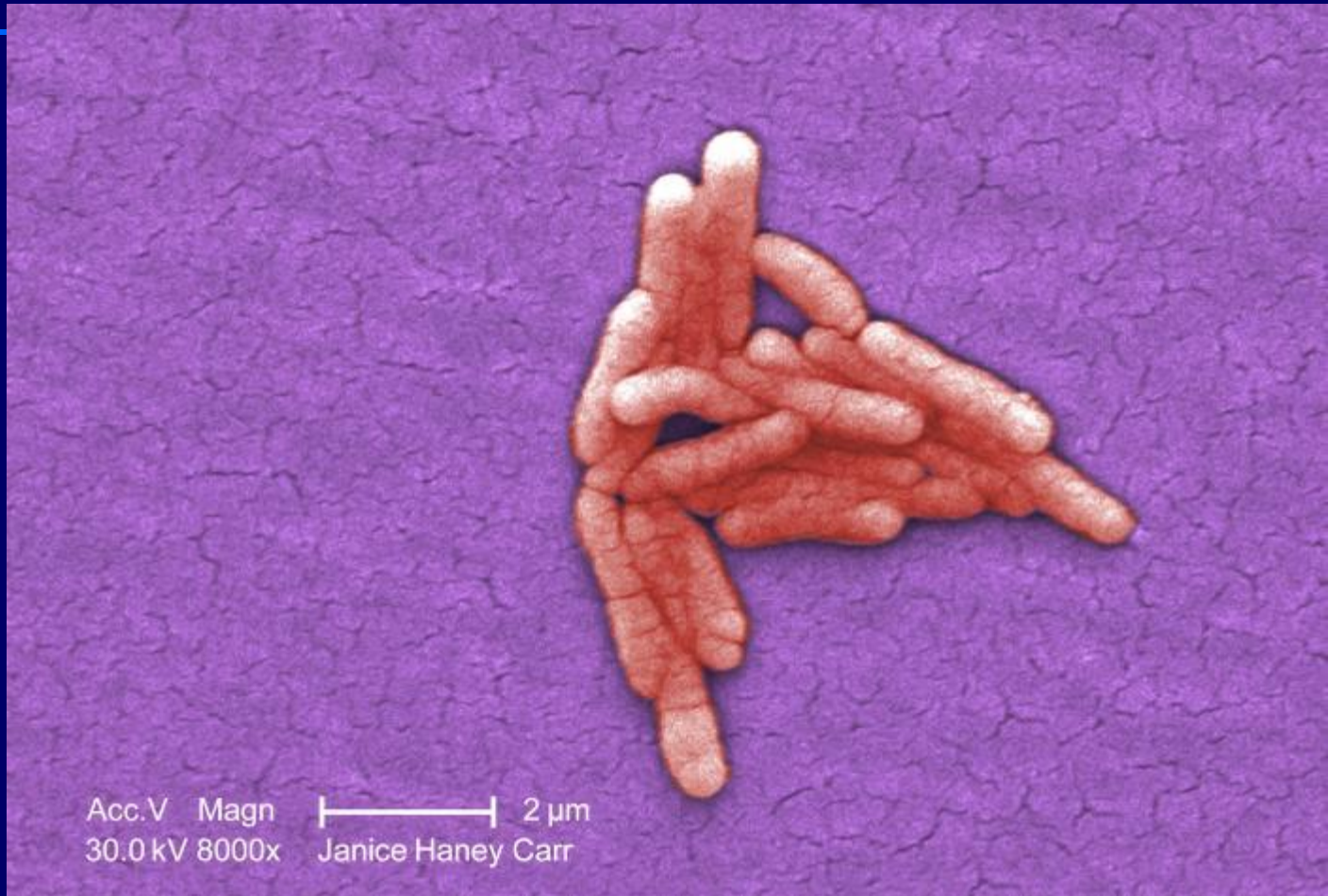
Obtained after an outbreak, this micrograph depicts Gram-positive *Clostridium difficile* bacteria.

Source: CDC

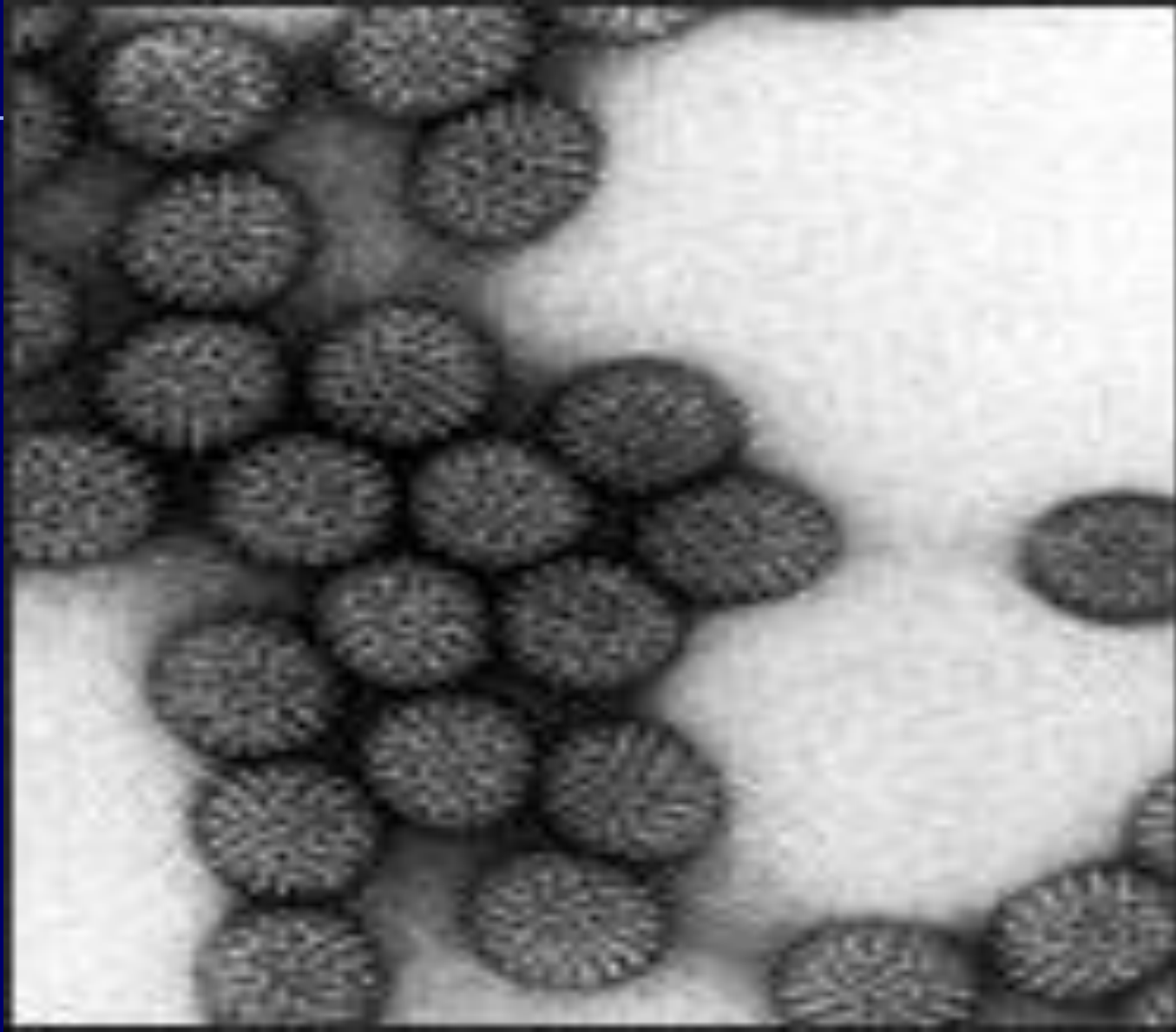


Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	3.0	4753x	SE	33.8	1

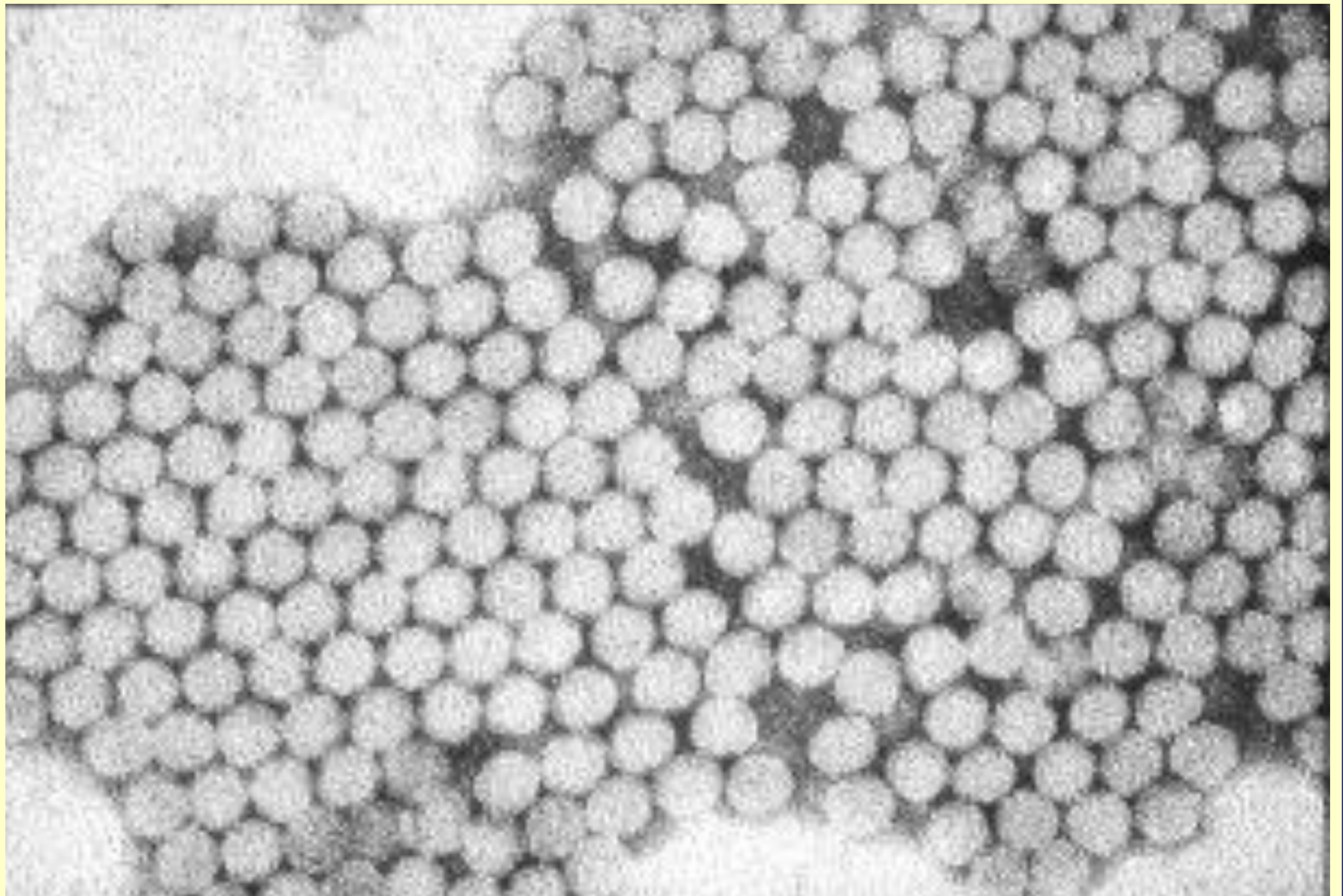
Under a moderately-high magnification of 8000X, this colorized scanning electron micrograph (SEM) revealed the presence of a small grouping of Gram-negative *Salmonella typhimurium* bacteria that had been isolated from a pure culture. See PHIL 10986 for a black and white version of this image.



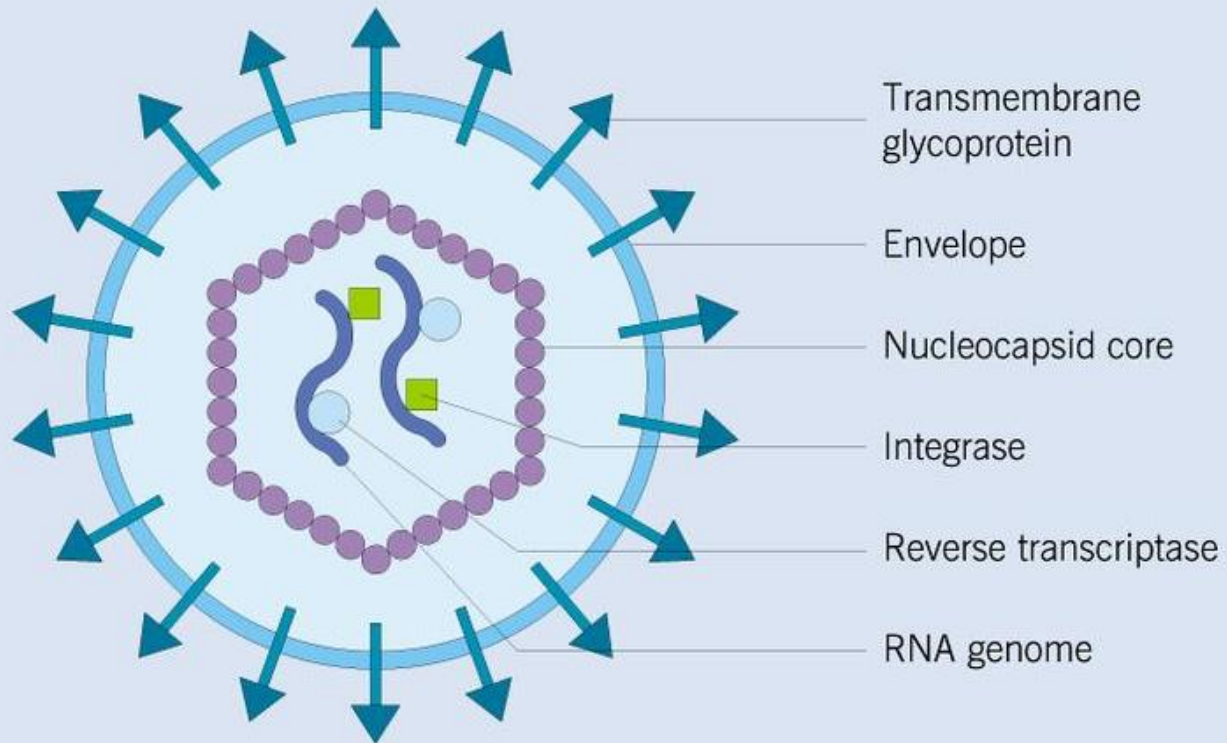
# Rotavirus



# HEPATITIS A VIRUS



## STRUCTURE OF A RETROVIRUS

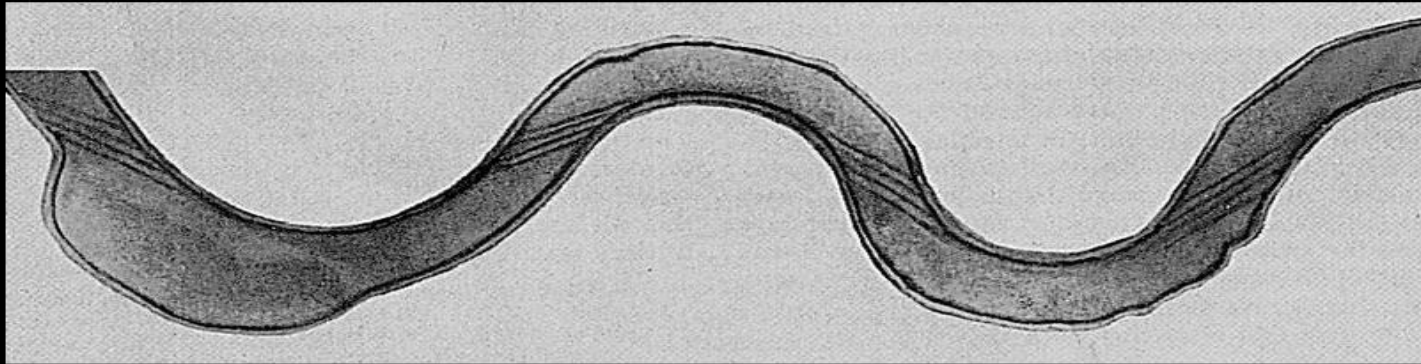




# Primoinfection HIV



Helical structure of *Treponema pallidum* with the periplasmic flagella.



Secondary **syphilis** with typical skin rash.



## Gonococcal urethritis.



Colonies of *Nocardia asteroides* showing smooth chalky-white appearance.

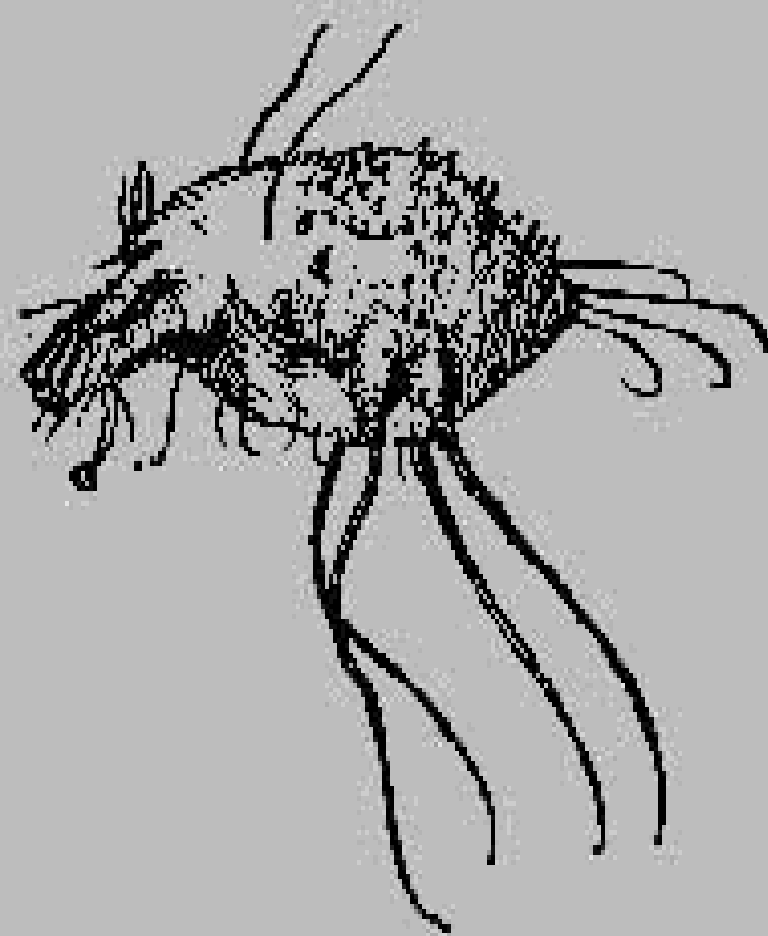


Primary cutaneous **nocardial infection** is characteristically painless, localized and slowly progressive. (a) There is marked swelling and erythema in this child's finger. (b) However, because the finger was painless the child was not brought to medical attention until the infection had progressed to involve the entire finger.

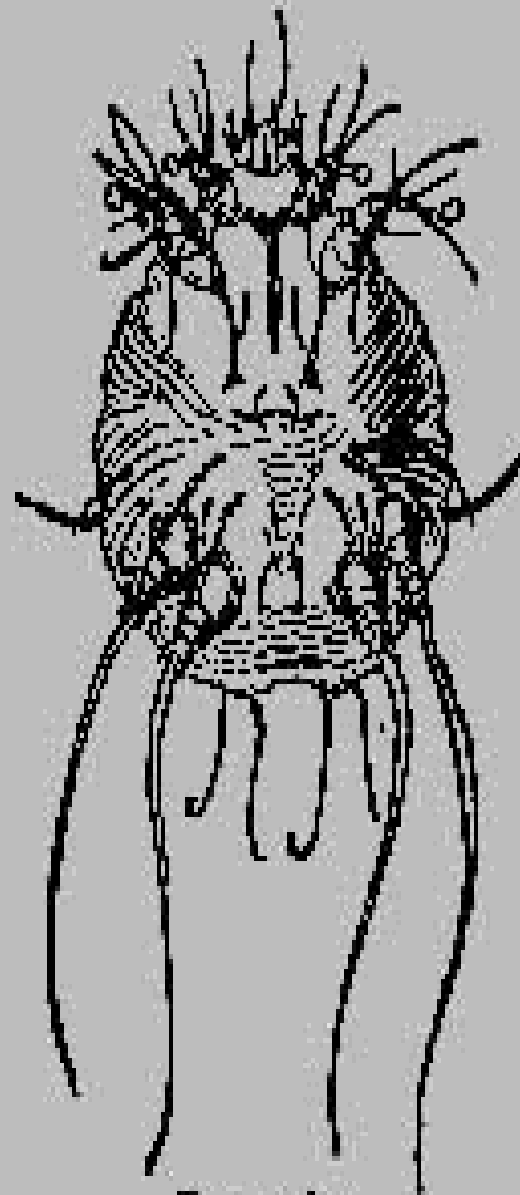


# Sarcoptes scabiei

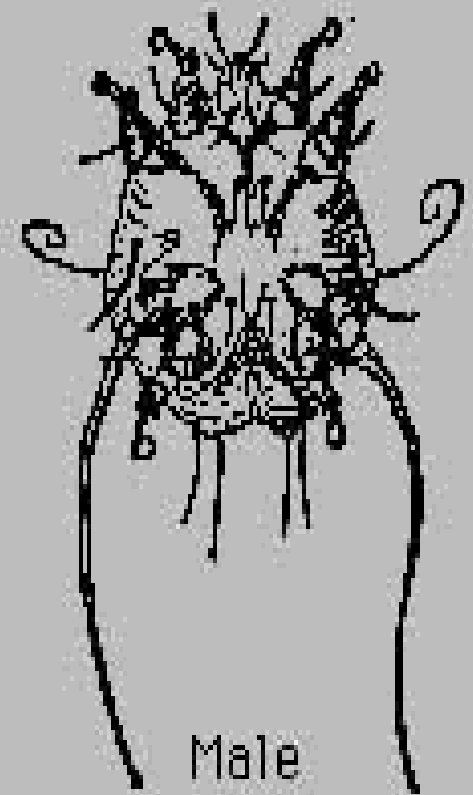




lateral



Female



Male

0.4 mm in length



# Scabies



Crusted or **Norwegian scabies** in a patient who has AIDS.



Giemsa stain of blood with *Borellia burgdorferi*.



# Tick - *Ixodes ricinus*



# Lyme boreliosis (LB)



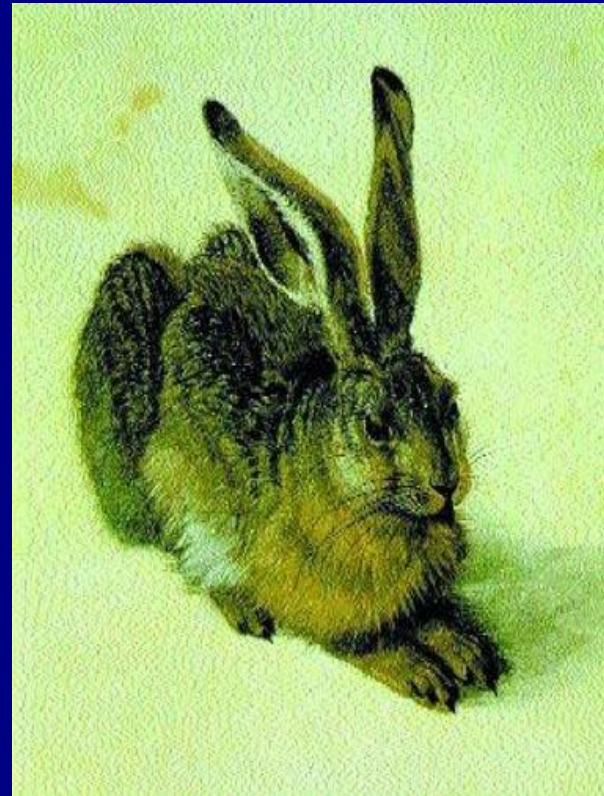
LB - Typical **erythema migrans** rash.



A blood-engorged female *Aedes albopictus* mosquito feeding on a human host.



# Francisella tularensis





# Tularemia



# Tularemia



## Hístice *Trichinella spiralis*



# Pathogenesis of rabies.

