Epidemiology

of infectious diseases

Kolářová M., EPI Spring 2018

EPIDEMIOLOGY

*is the **study*** (scientific, systematic, data-driven)

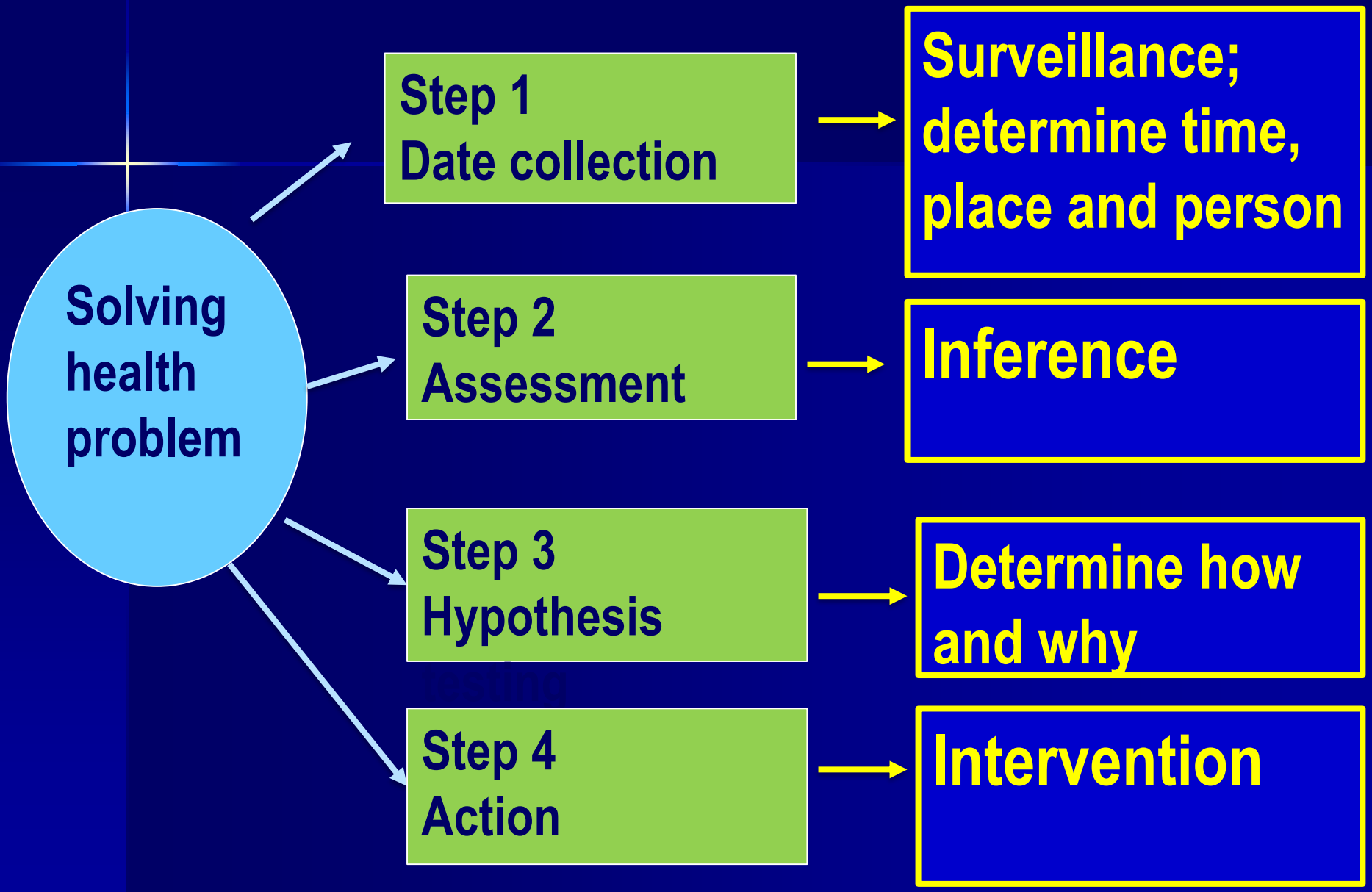
*of the **distribution*** (frequency, pattern)

*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.*


Solving health problem
Step 1 Date collection
Step 2 Assessment
Step 3 Hypothesis
Step 4 Action
Surveillance; determine time, place and person
Inference
Determine how and why
Intervention

Occurrence of Disease

- Sporadic Disease that occurs occasionally in a population.
- Endemic Disease constantly present in a population at all times – **malaria** is present in Africa at all time because of the presence infected mosquitos.
- Epidemic or outbreak Disease occurence among a population that is in excess of what is expected in a given area in a short time – **the Ebola virus** in parts of Africa is in excess of what is expectes for this region.
- Pandemic Disease or condition that spread across world – **HIV/AIDS** is one of the worst global diseases in history.

Disease trends

- **Incidence** - measures the number of new cases over time.

This number measures an individual chances of developing or contracting the disease.

$$\frac{\text{Number of new cases within a specified time period}}{\text{Total number of people in the population}}$$

- **Prevalence** – measures **the total number** of cases of disease in a population.

$$\frac{\text{Total number of diseases individuals}}{\text{Total number of people in the population at a given time}}$$

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

The basic quantitative measurement in epidemiology is a count of the number of persons in the group being studied who have a particular disease.

Epidemiologists arrange their data in various ways, depending on what aspect of the information they want to emphasize.

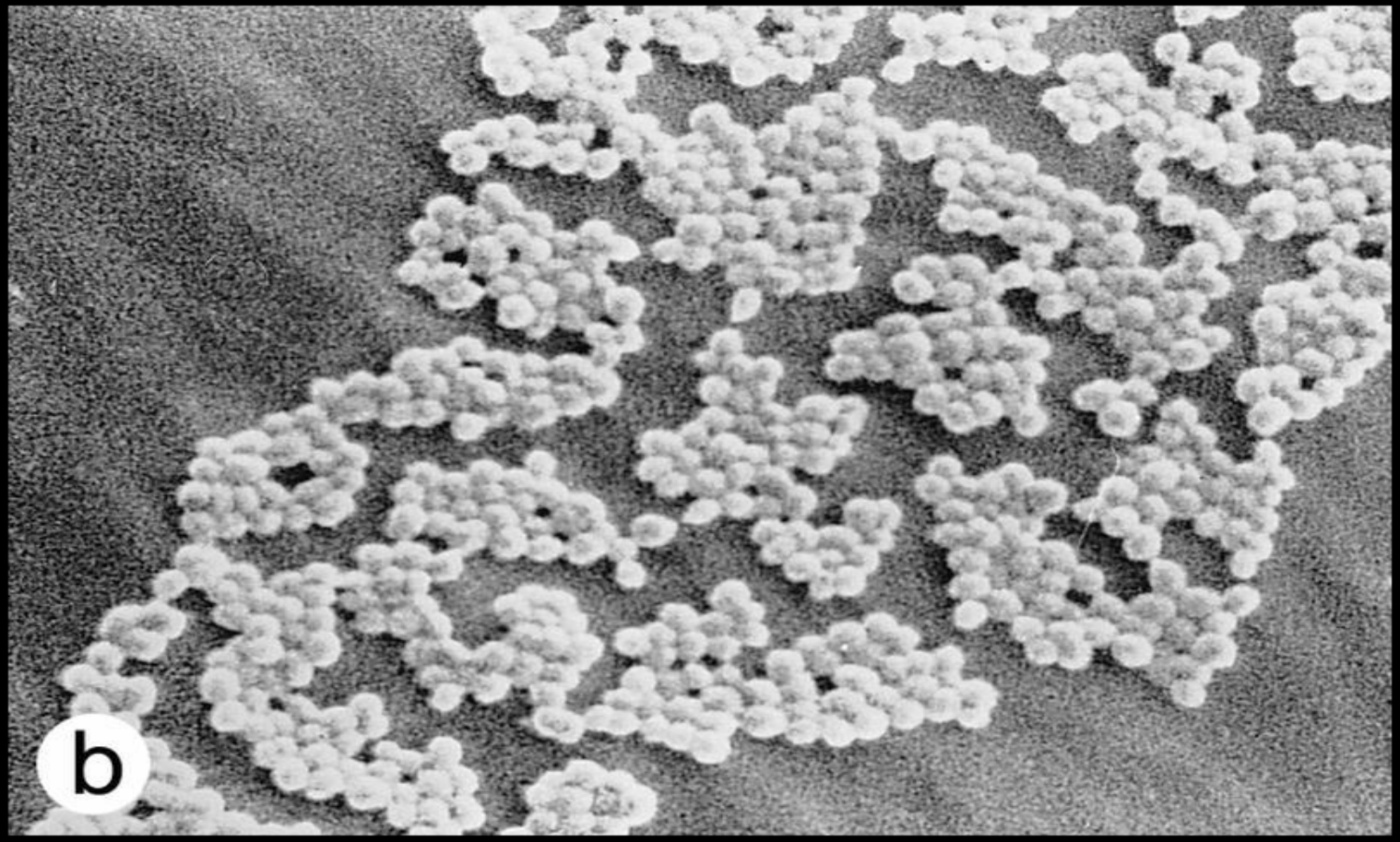
One of the most powerful tools an epidemiologist can use is case reporting: reporting specific diseases to

*** local,**
*** state and**
*** national health authorities,**

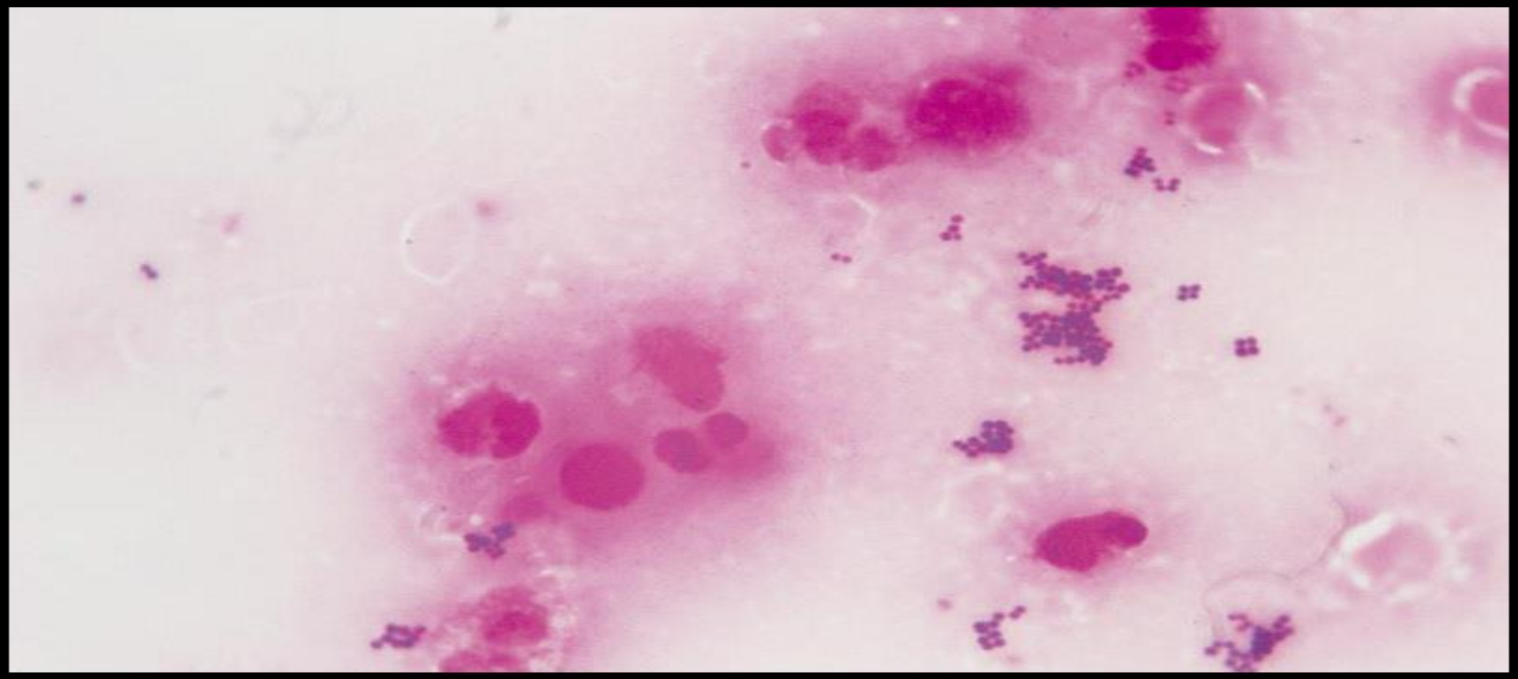
who accumulate the data

Modern infectious disease epidemiology

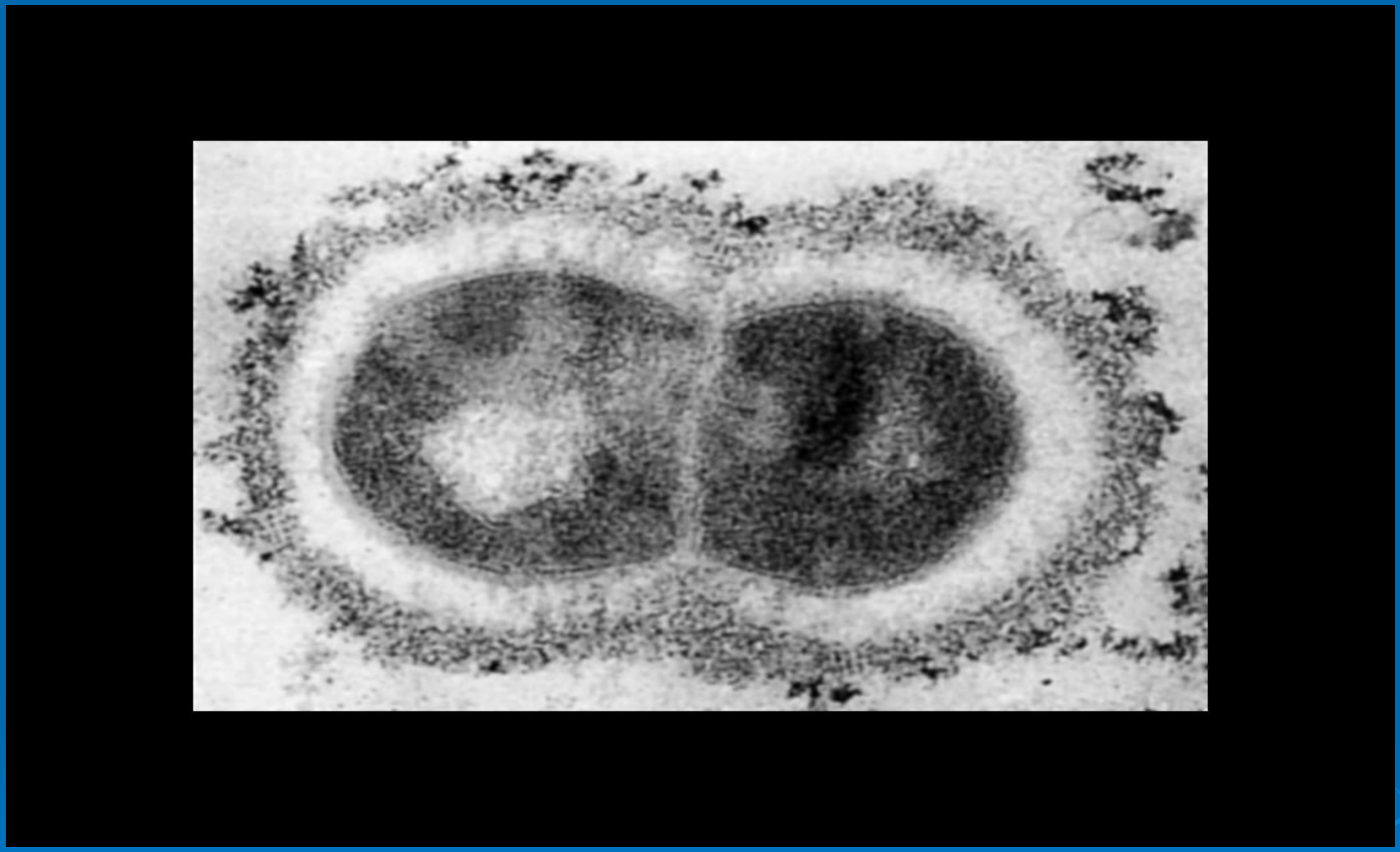
Slime-producing coagulase-negative staphylococci. Scanning electron micrograph of the surface of an intravascular catheter incubated *in vitro* with (a) slime-producing and (b) nonslime-producing strains of *Staphylococcus epidermidis*. With permission from Christensen.[9]



Staphylococcus aureus



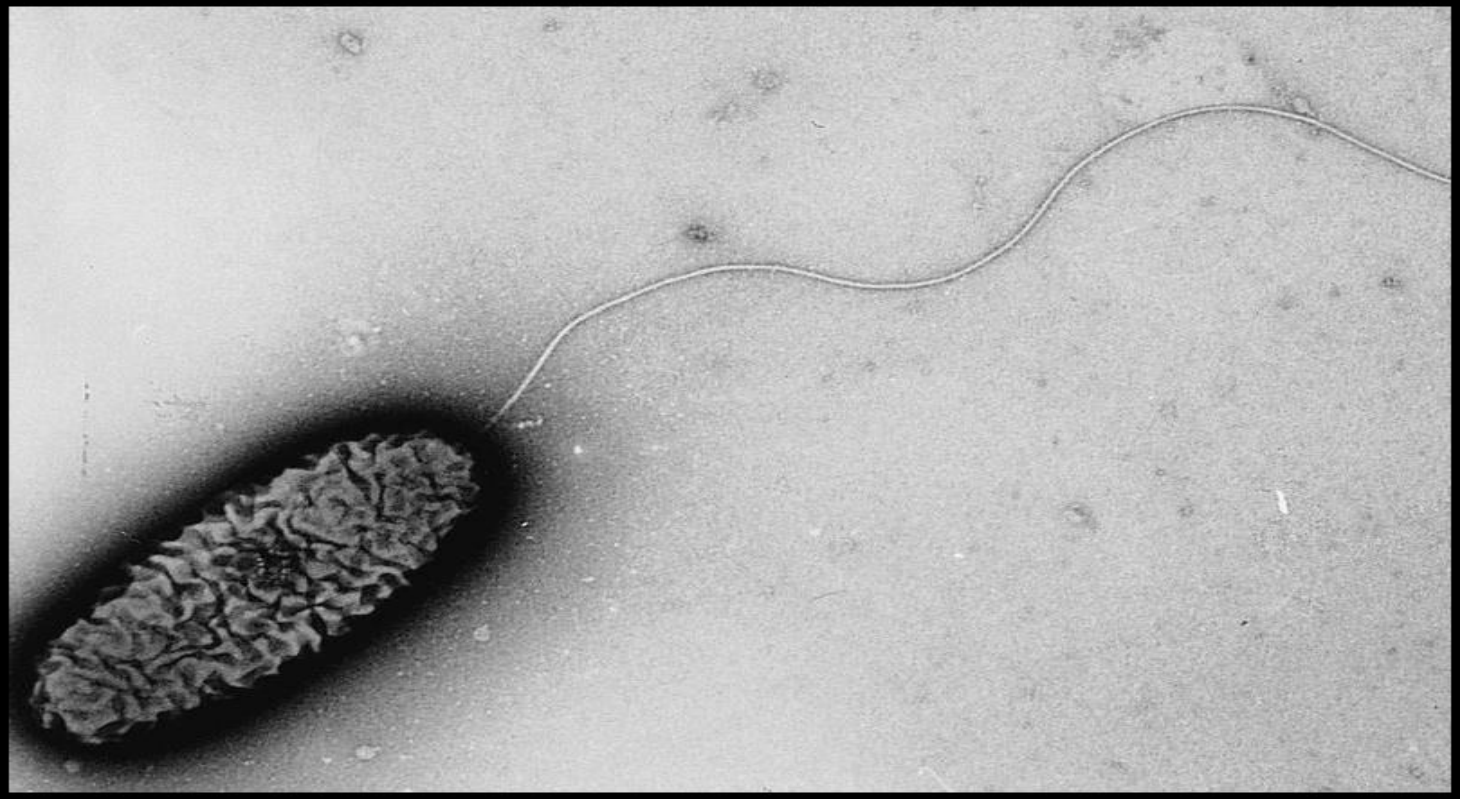
- β-Hemolytic streptococci group A on a blood agar plate. Note the clear b-hemolytic zone.



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

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

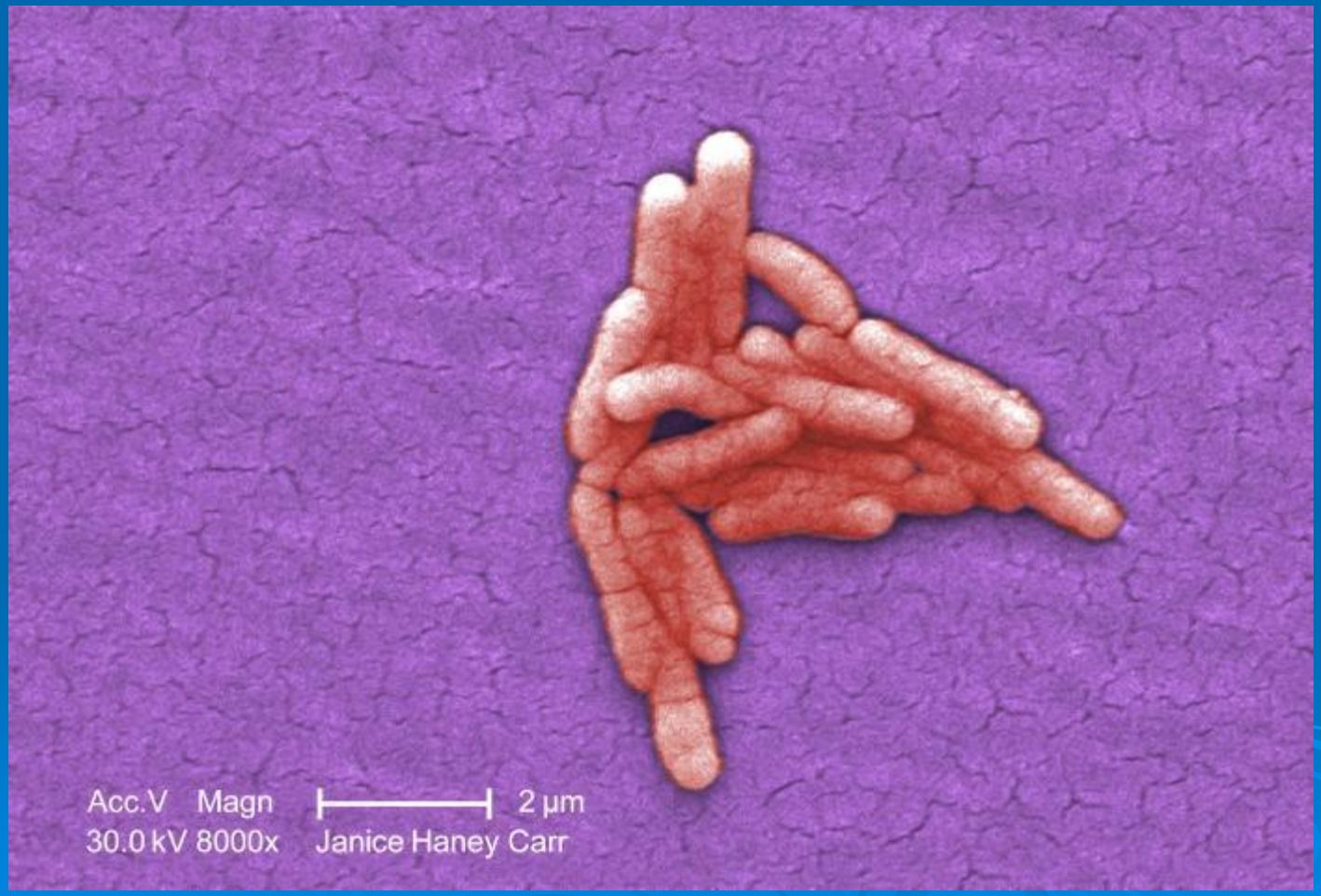
Pseudomonas aeruginosa monotrichous polar flagellum seen on electron microscopy.



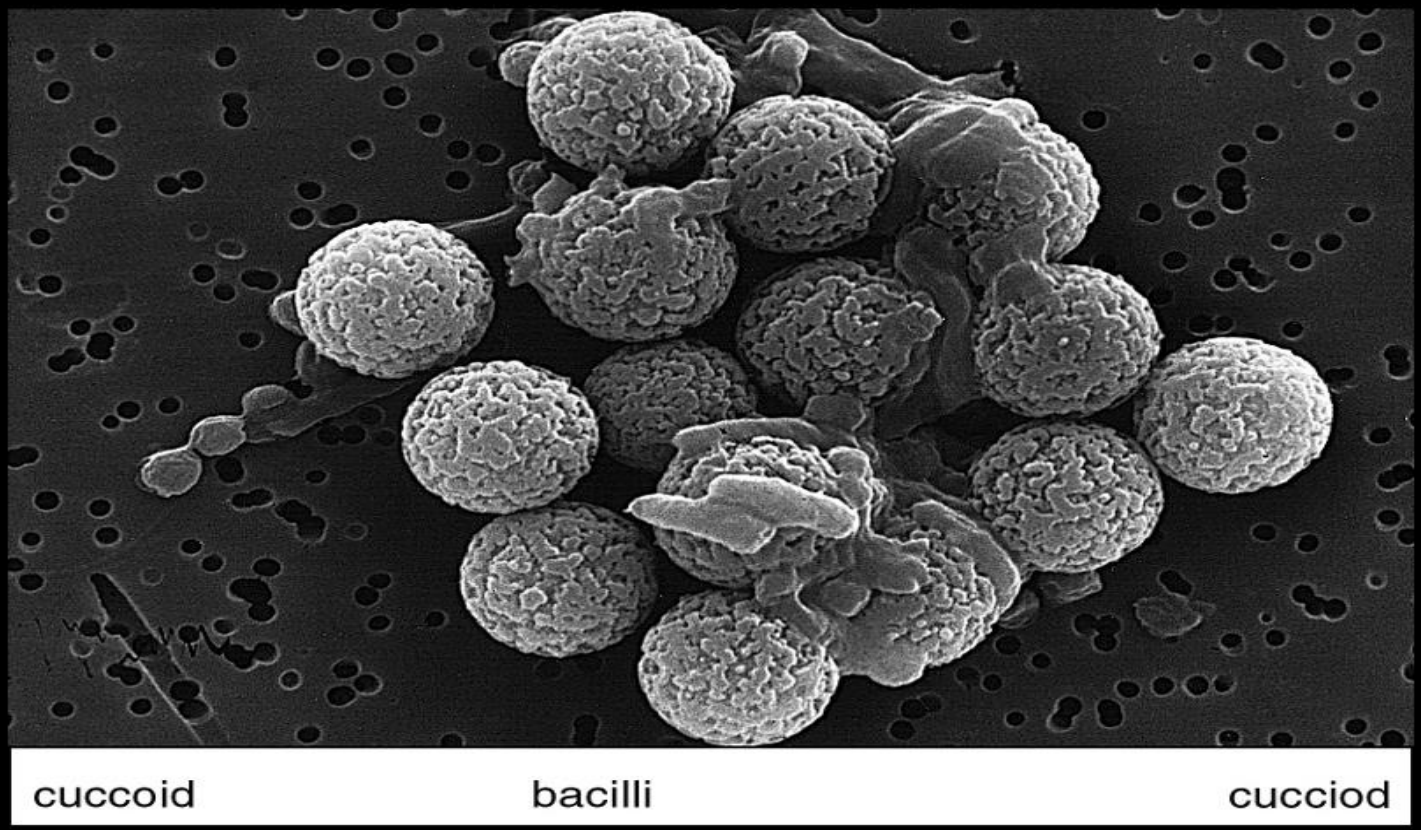
Obtained after an outbreak, this micrograph depicts Gram-positive *Clostridium difficile* bacteria.

Source: CDC

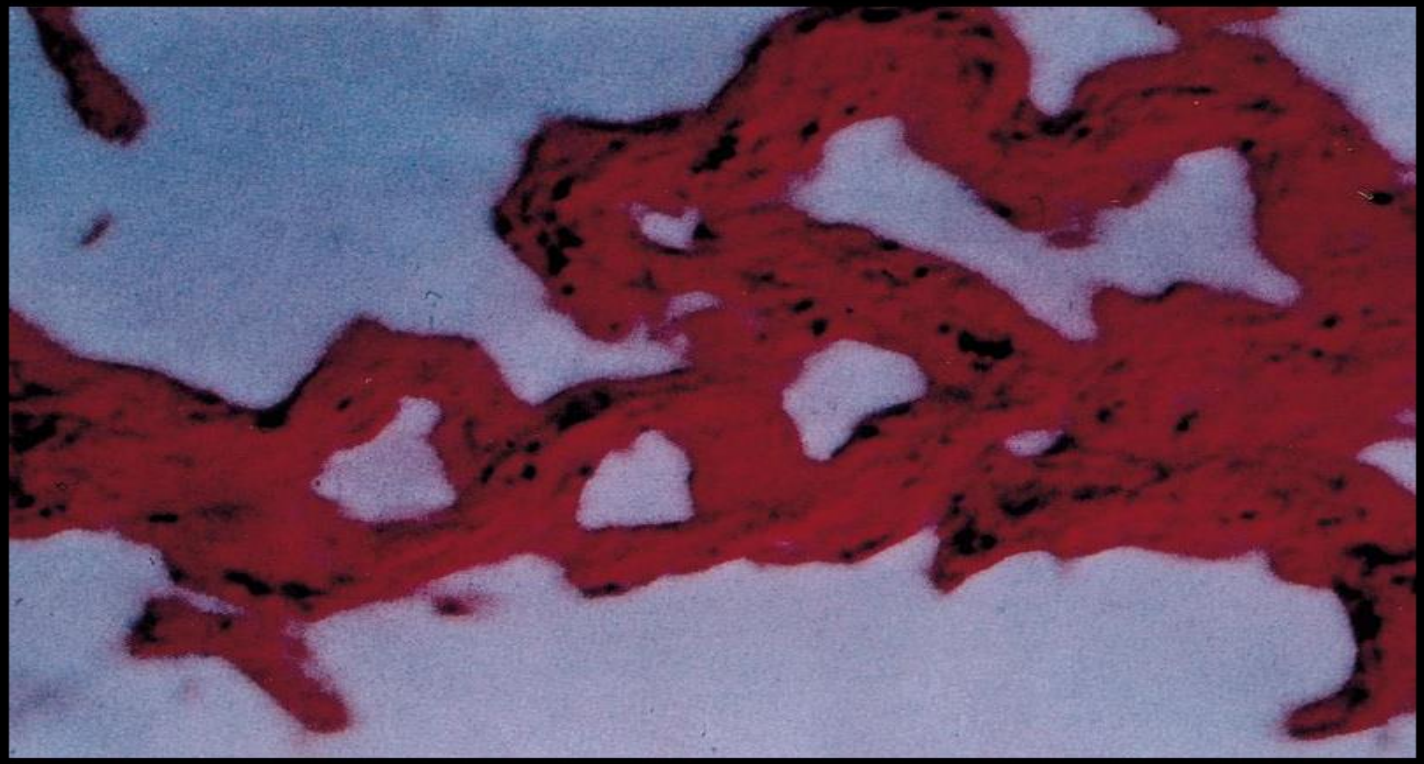
Under a moderately-high magnification of 8000X, this colorized scanning electron micrograph (SEM) revealed the presence of a small grouping of Gram-negative *Salmonella typhimurium* bacteria that had been isolated from a pure culture. See PHIL 10986 for a black and white version of this image.



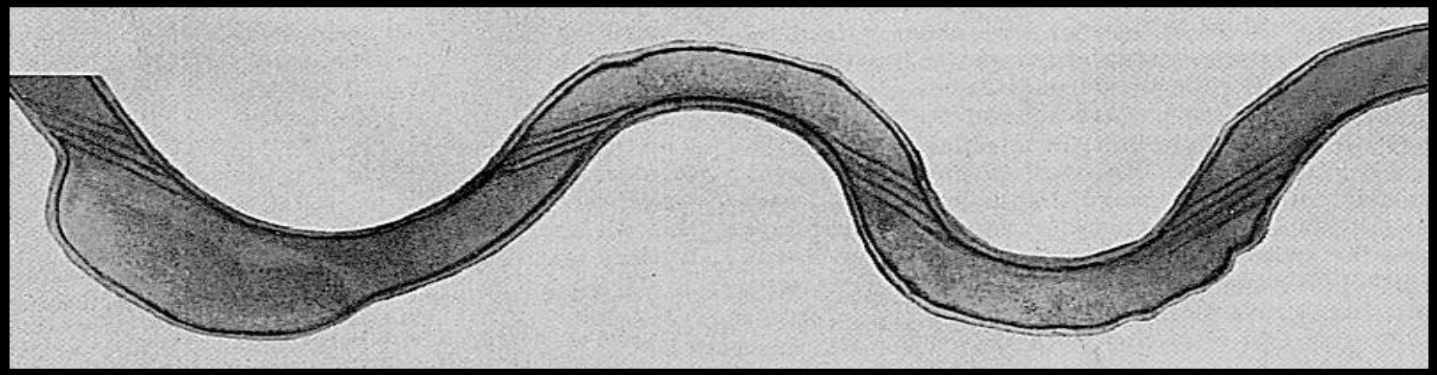
Cultured *Helicobacter pylori* in coccoid and bacilli forms, bound to immunomagnetic beads.



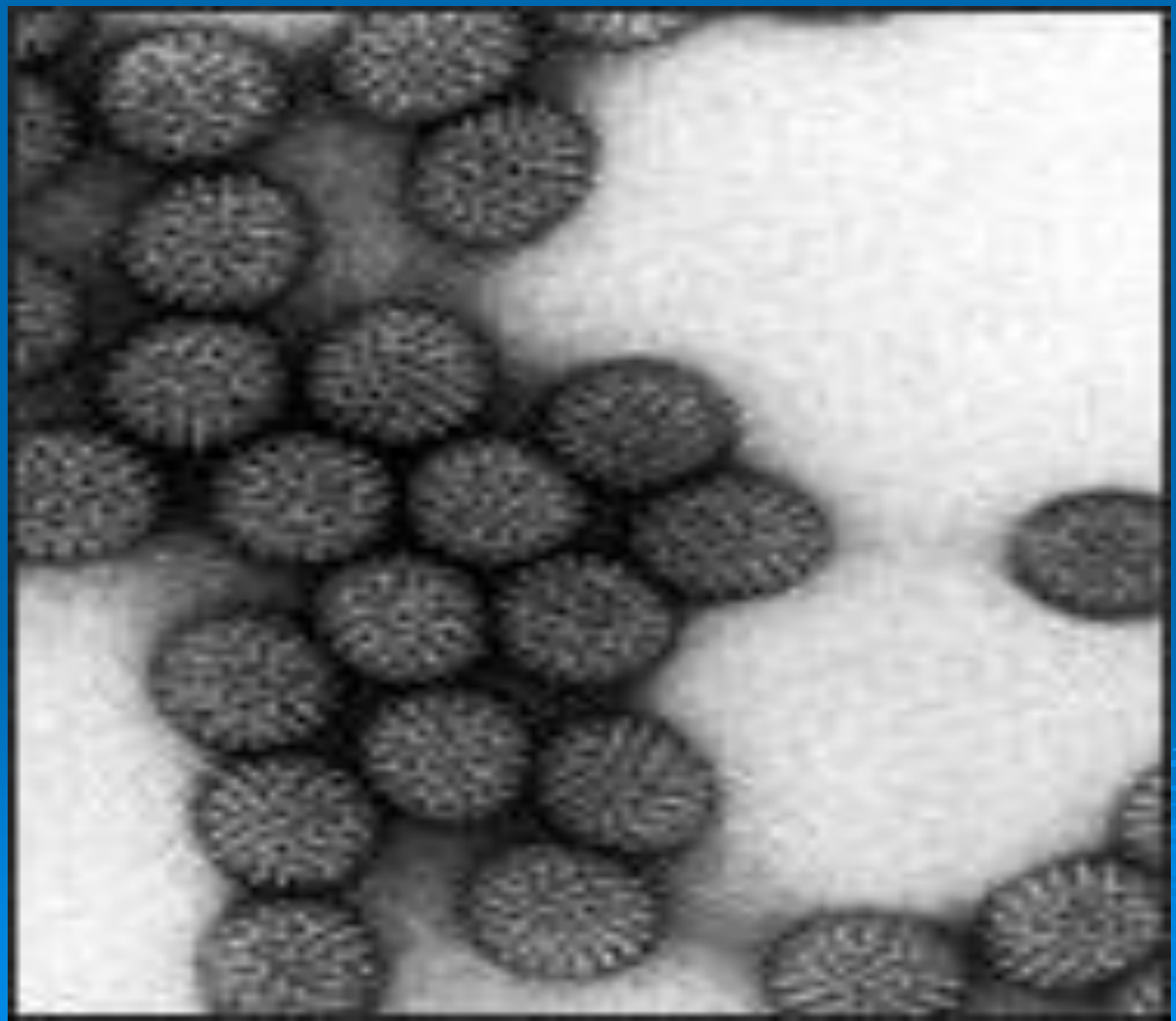
Ziehl-Neelsen stain of 'cords' of *Mycobacterium tuberculosis* isolated from a broth culture. Tubercle bacilli aggregate end to end and side to side to form serpentine cords, especially in broth cultures.



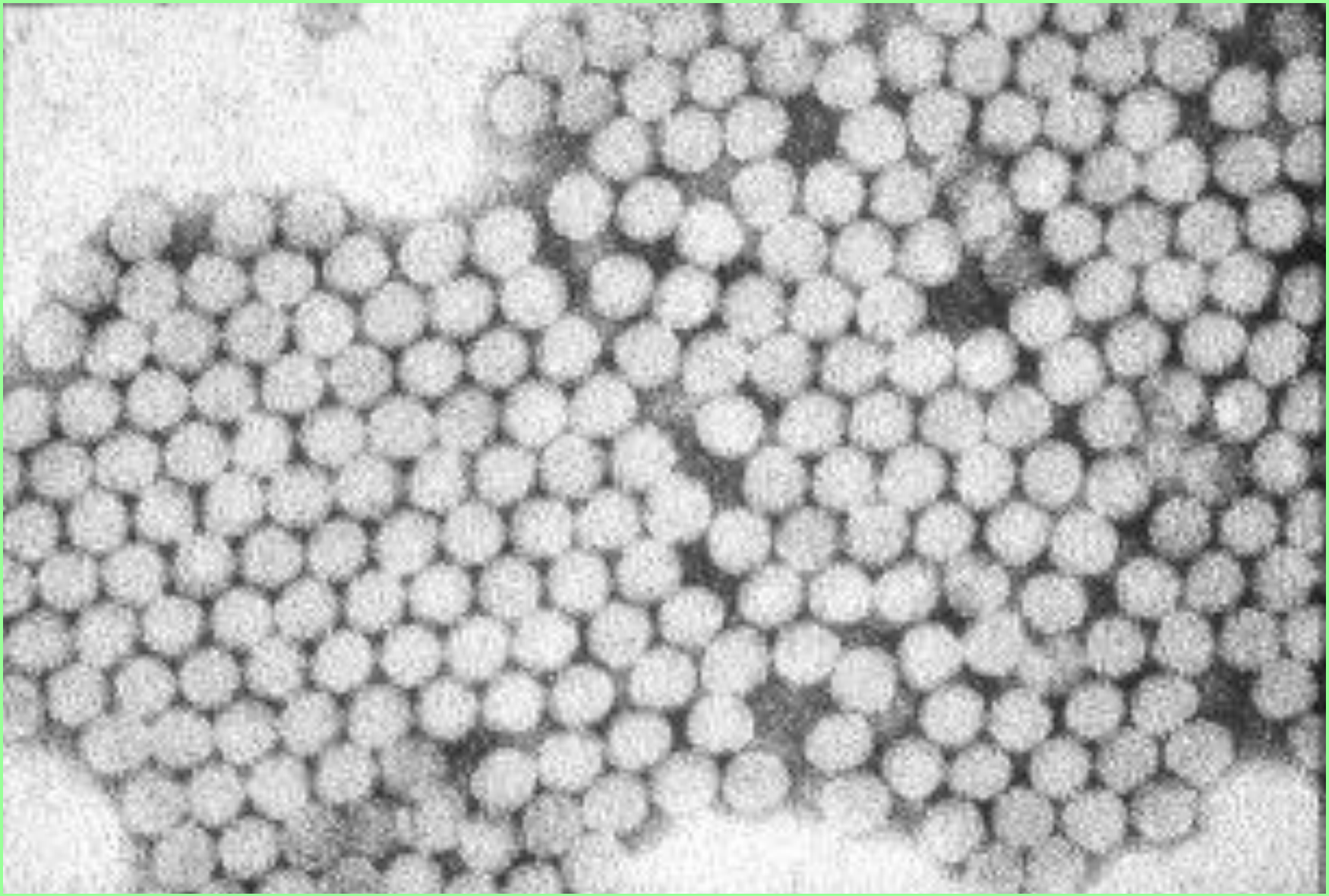
Helical structure of *Treponema pallidum* with the periplasmic flagella.



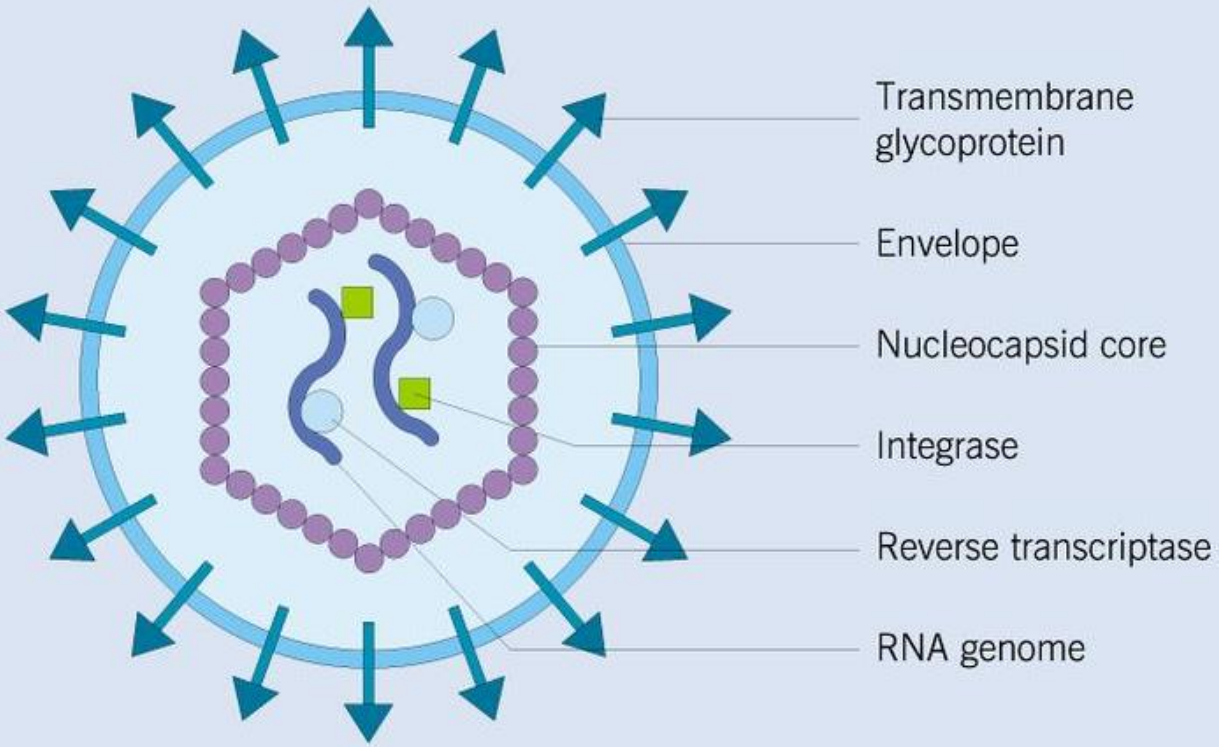
Rotavirus



HEPATITIS A VIRUS



STRUCTURE OF A RETROVIRUS

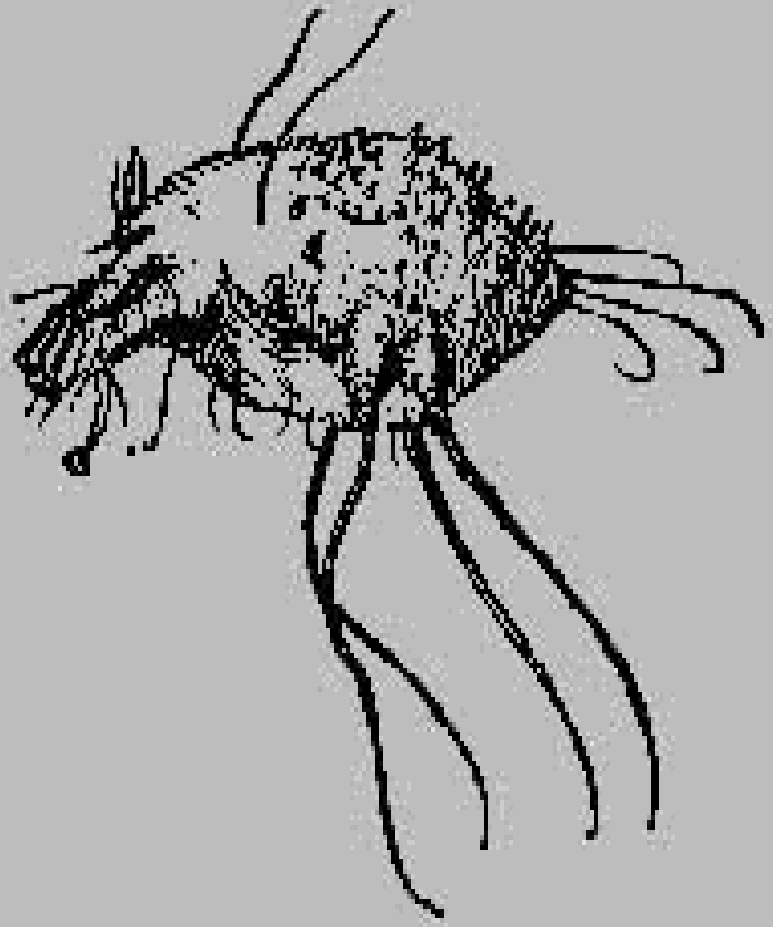


Colonies of *Nocardia asteroides* showing smooth chalky-white appearance.

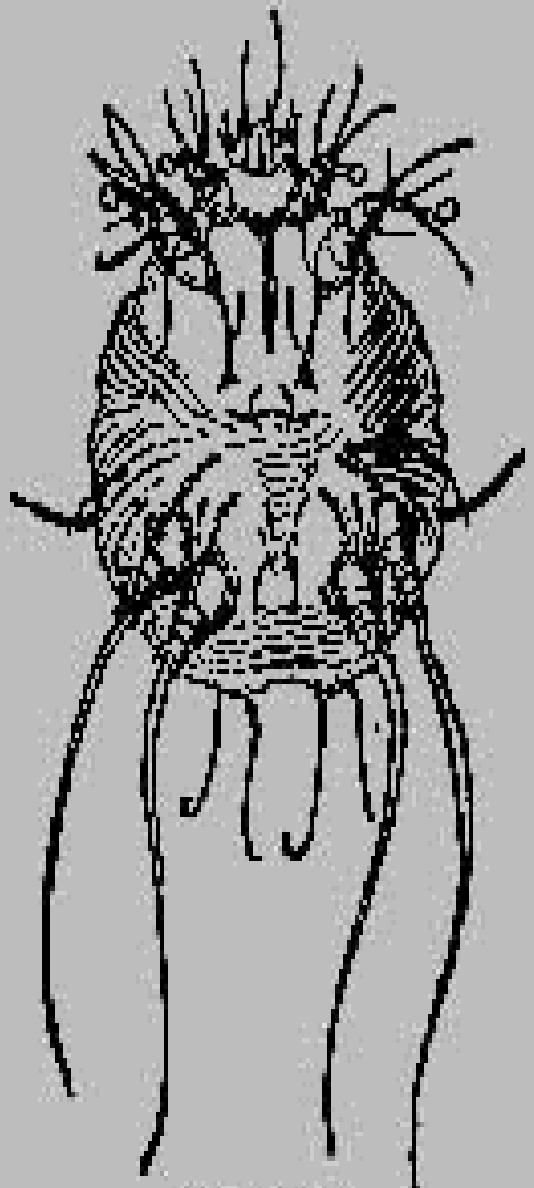
Giemsa stain of blood with *Borellia burgdorferi*.

Hlístice Trichinella spiralis

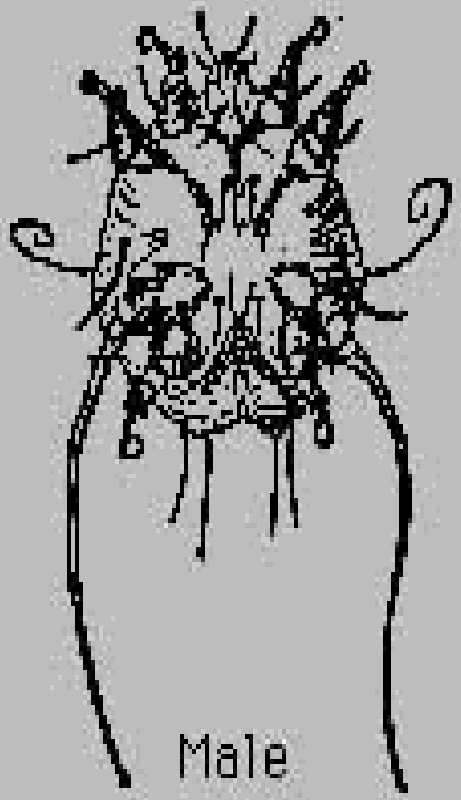
Sarcoptes scabiei



lateral



Female



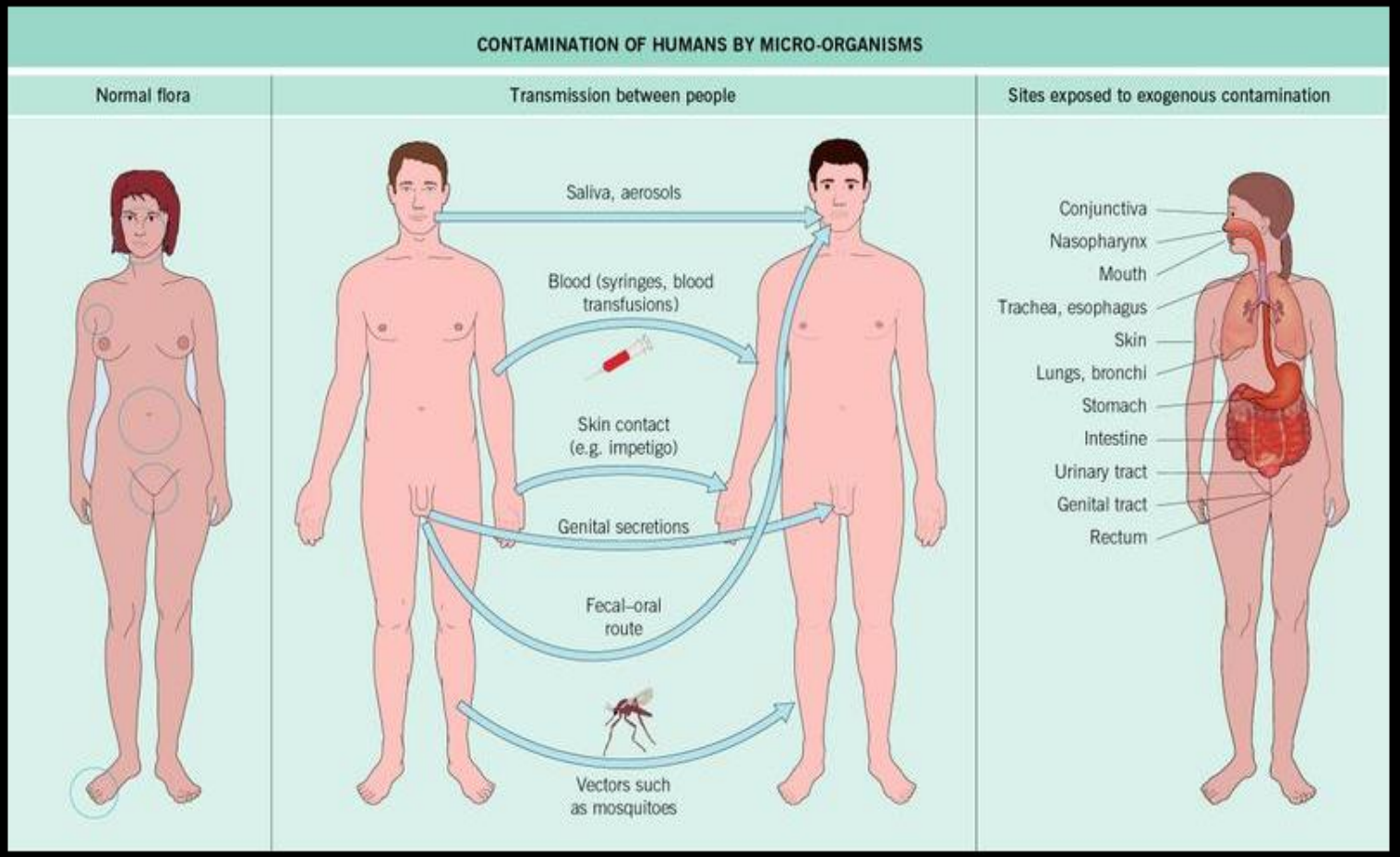
Male

0.4 mm in length

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
Normal flora
Transmission between people
Sites exposed to exogenous contamination
Saliva, aerosols
Blood (syringes, blood transfusions)
Skin contact (e.g. impetigo)
Genital secretions
Fecal–oral route
Vectors such as mosquitoes
Conjunctiva
Nasopharynx
Mouth
Trachea, esophagus
Skin
Lungs, bronchi
Stomach
Intestine
Urinary tract
Genital tract
Rectum

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:

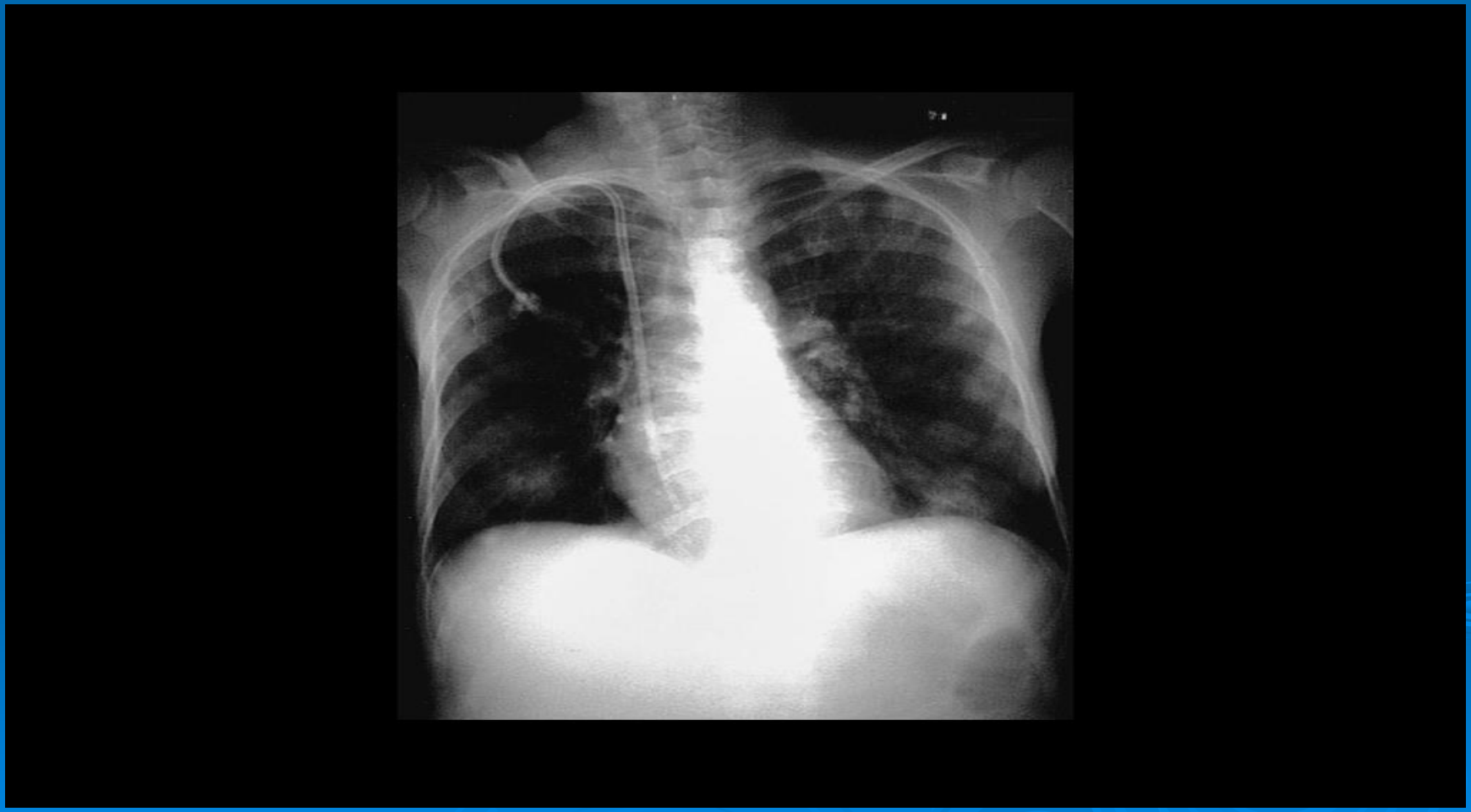
* heat, cold, dryness.

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.

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

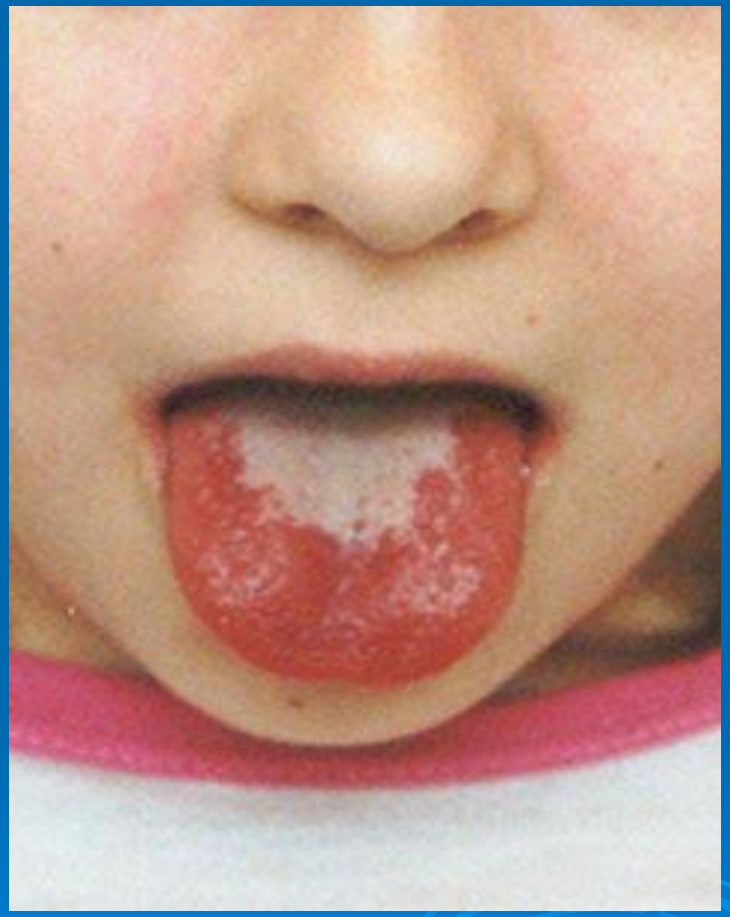
- Impetigo in a child.

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.



Erysipelas. Note the sharp demarcation of the affected skin.

Scarlatina (scarlet fever)



- Necrotizing fasciitis caused by **group A strepococci**. There is only moderate erythema but at surgery there was extensive soft tissue damage.

Varicella (chickenpox)

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

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

Rubella

Parotitis epidemica (mumps)

Scabie

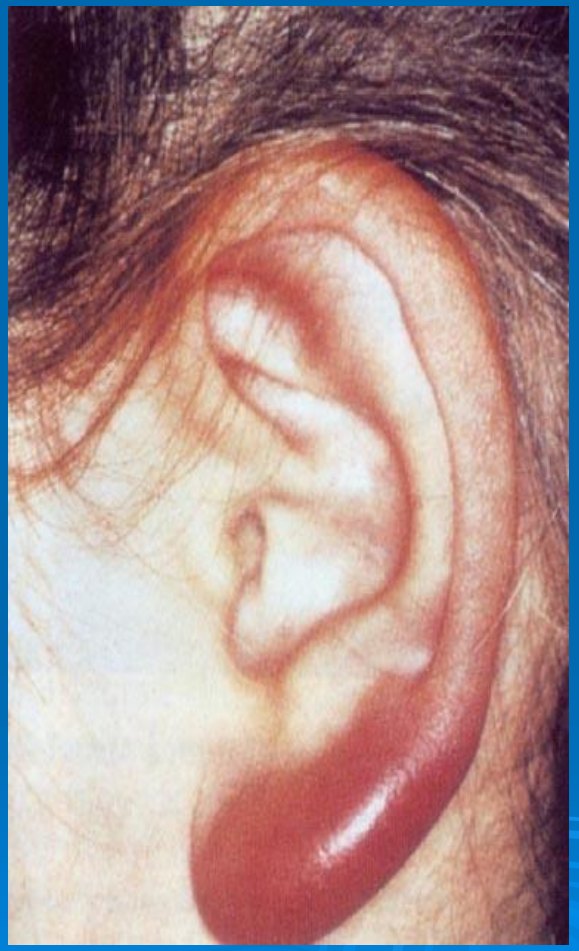
Crusted or Norwegian scabies in a patient who has AIDS.

Primoinfection HIV

Gonococcal urethritis.

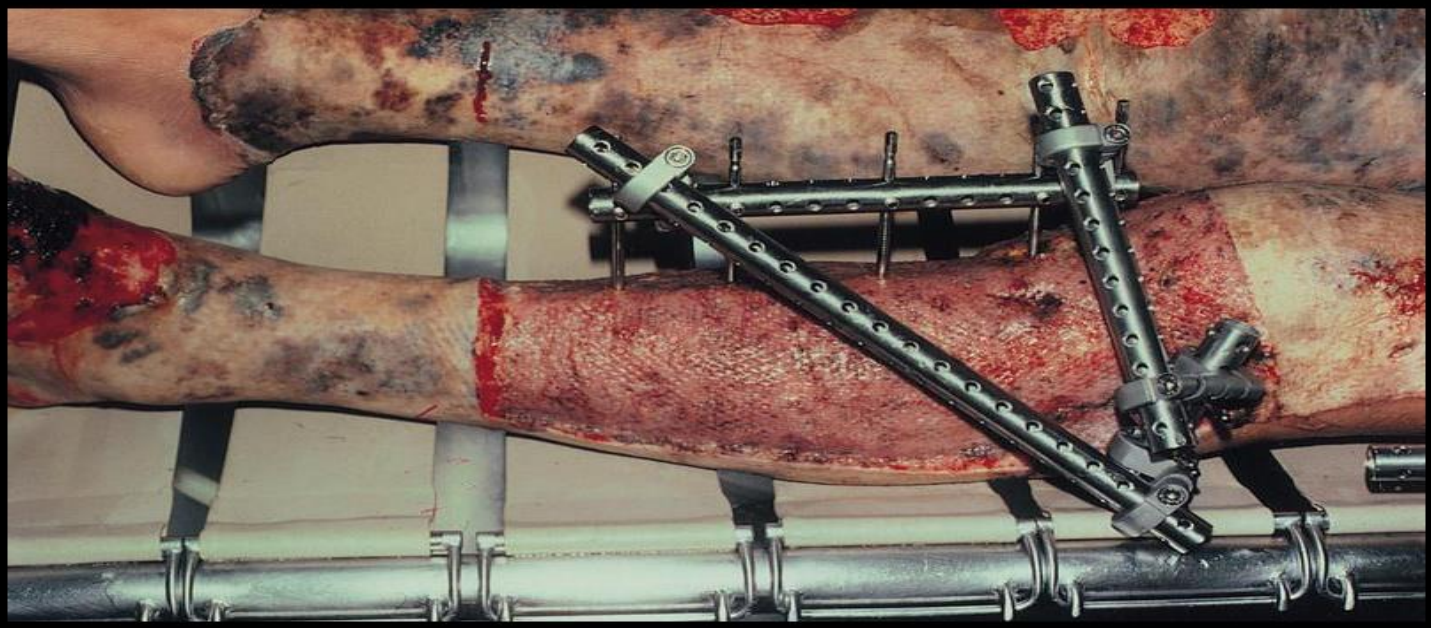
Secondary syphilis with typical skin rash.

Lyme boreliosis (LB)



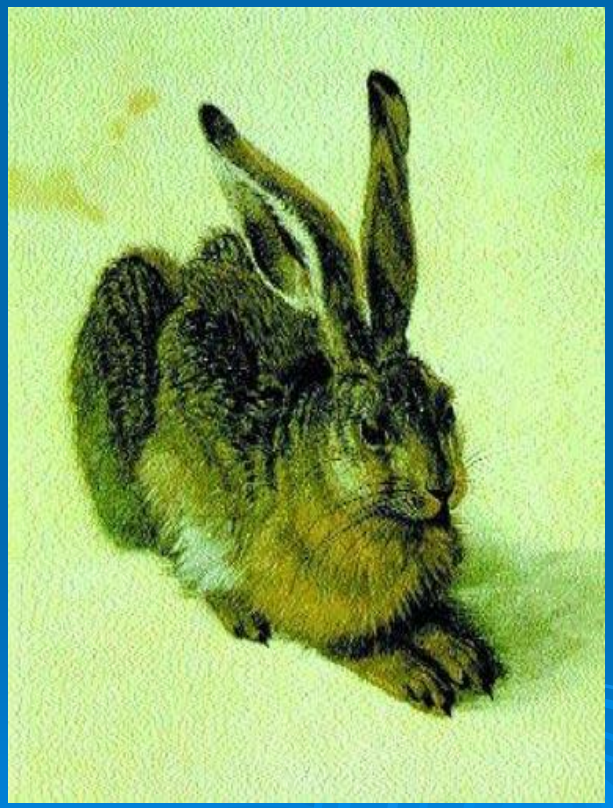
LB - Typical erythema migrans rash.

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



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.

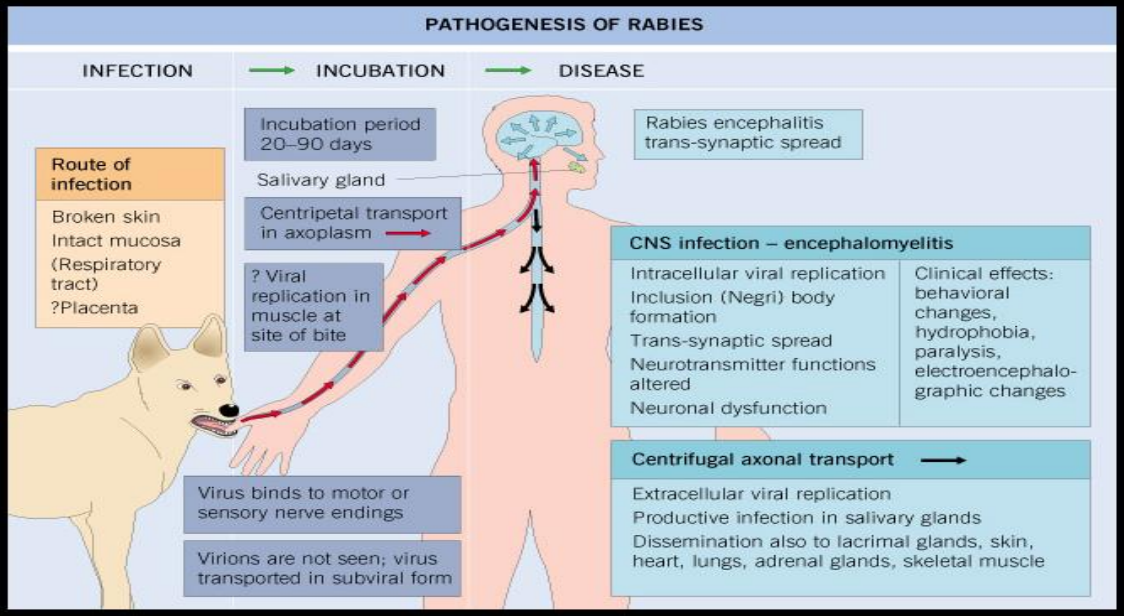
Francisella tularensis



Tularemia

Tularemia

Pathogenesis of rabies.



The chain of infections (epidemic proces)

Infectious diseases result from the interaction of agent, host, and environment (natural, social factors).

More specifically - spreding of infections occurs when:

the agent leaves its reservoirs or host (source) trough a portal of exit, is conveyed by some mode of transmissin and enters trough an appropriate portal of entry to infect a susceptible host.

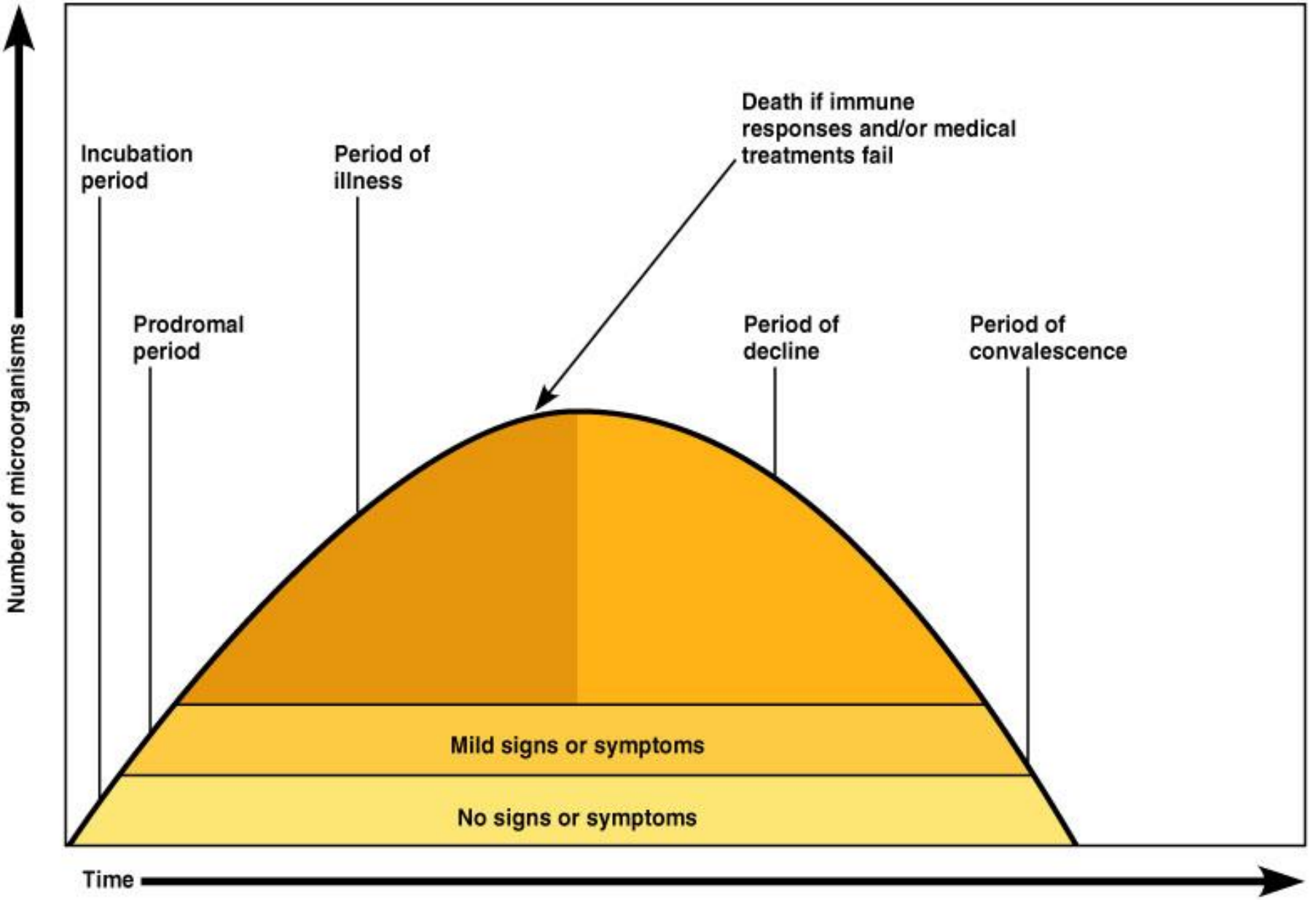
1. the presence of source of infection

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

May be classified as:

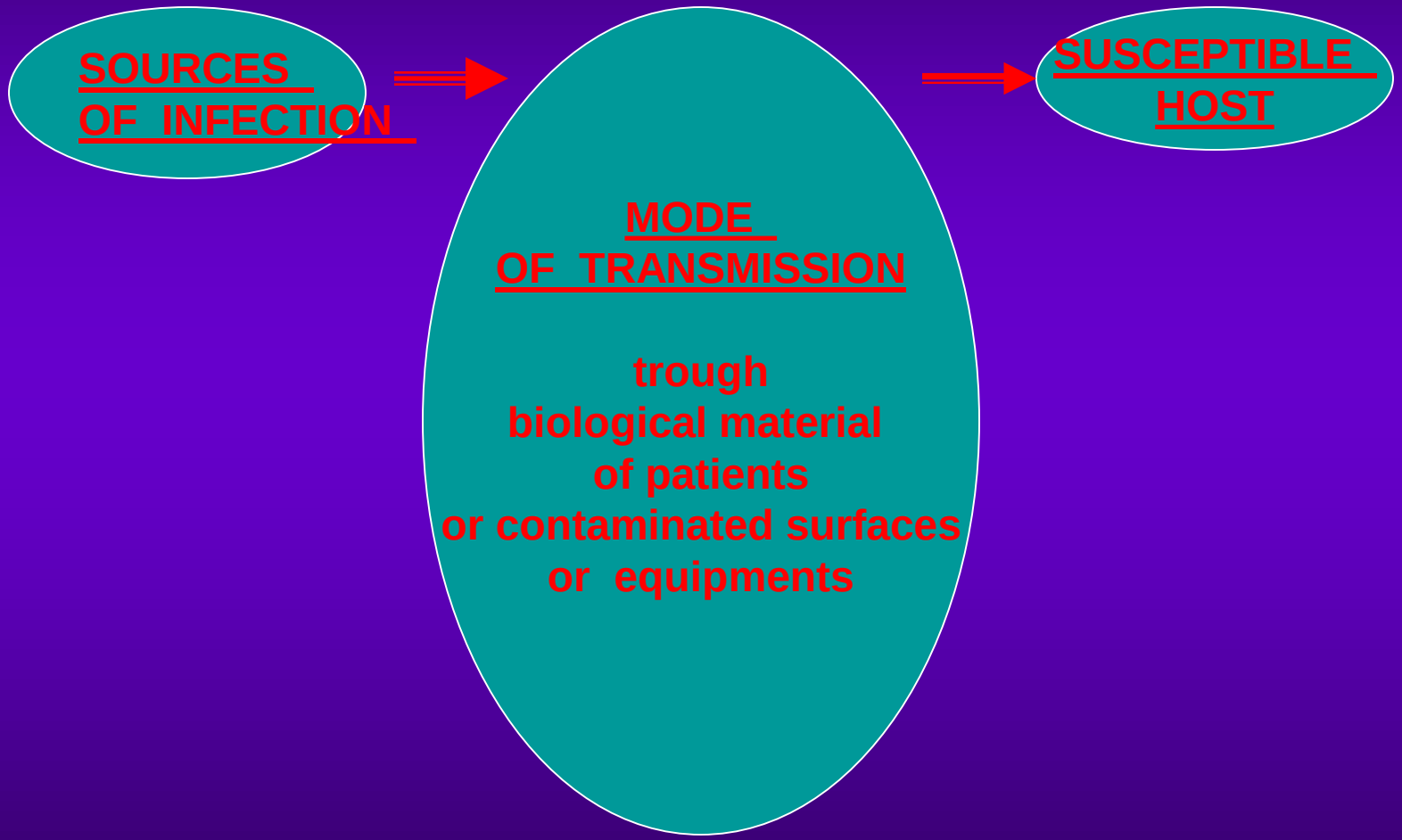
- human - at the ende incubation period,
  if is ill,
  reconvalescent,
  carriers – healthy,
  chronic diseases
- animals - at the ende incubation period,
  if is ill,
  carriers – healthy,
  reconvalescent, chronic

The Stages of a Disease



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.

EPIDEMIC PROCESS IN THE HOSPITAL ENVIRONMENT



Biological materials – their infectivity

1. Causative agens in blood, derivates from blood, plasma

VHB, VHC, VHA (short in the blood), HIV, CMV, rarely EBV,
virus of morbilli (viremie), kandidy-kandidémie,
malárie - (plasmodia can survive in fresh plasma 3 – 5^{o}C - 14 days),
Toxoplasma gondii - (can survive in blood - 56 days)

Biological materials – their infectivity

2. Causative agens in droplets

Adenovirus, coronaviruses, enteroviruses, herpes virus, myxovirus (influenzae), paramyxovirus, RSV, rhinovirus, *Stafylococcus, Streptococcus spp.*, Meningococcus spp., *Haemophilus Influenzae, Neisseria meningitis, Bordetella pertussis, Bordetella parapertussis, Mycoplasma pneumoniae, Pneumocystis carinii,* Kandidy….

Biological materials – their infectivity

3. Causative agents in stool

Enteroviry (VHA, poliomyelitis), VHE, coxsackie viry,
Adenoviry,
Enterobactericeae (*E.coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus spp., Citrobacter, Enterobacter, Serratia* apod)
Listeria monocytogenes, Clostridium perfringens, Clostridium tetani, Pneumocystis carinii

Biological materials – their infectivity

4. Causative agens in URINE :

Virus of measles, parotitis, CMV, VHB, papovavirus, *Listeria monocytogenes, Candidae*

5. LIQUOR

HIV, different causative agents of meningitid

6. Salive

VHB, HIV, CMV, EBV, herpes virus hominis typ 1,2, virus of measles, rubellla

Biological materials – their infectivity

7. TEARS, EYE - SECRET

VHB, HIV, adenoviruses, Enterovirus typ 70, *Coxsackie A 24*, *Staphylococcus aureus*, hemophfilus, pneumokoky, moraxely, chlamydie

8. VAGINA AND CERVIX - SECRET

HIV, VHB, rare VHC, herpes virus hominis typ 1,2, *Streptococcus agalactiae, Neisseria gonorrhoea, Haemophilus Ducreyi, Treponema pallidum, Trichomonas vaginalis, Chlamydia lymfogranulomatosis, Chlamydia trachomatis*

9. EJACULAT

VHB, HIV, rare VHC, CMV,

2. the metod 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)

Tick - Ixodes ricinus

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

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, Fibronection, Cytokines.

Specific immunity

- Humoral immunity
  - Immunoglobulin: IgG, IgM, IgE, IgA, IgD
- Cell mediated immunity

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

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

1. the **presence of rezervoir (source)** of infection

man, animal → at the ende of incubation period
- acute stage
- cariers

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 : a g e , n u t r i t i o n, g e n e t i c s
i m m u n i t y – natural (nonspecific),
- acquired

THE INFECTION

= 1. **source of infection**

.....

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

1. the **presence of rezervoir (source)** of infection

man, animal → at the ende of incubation period
→ acute stage
→ cariers

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….)

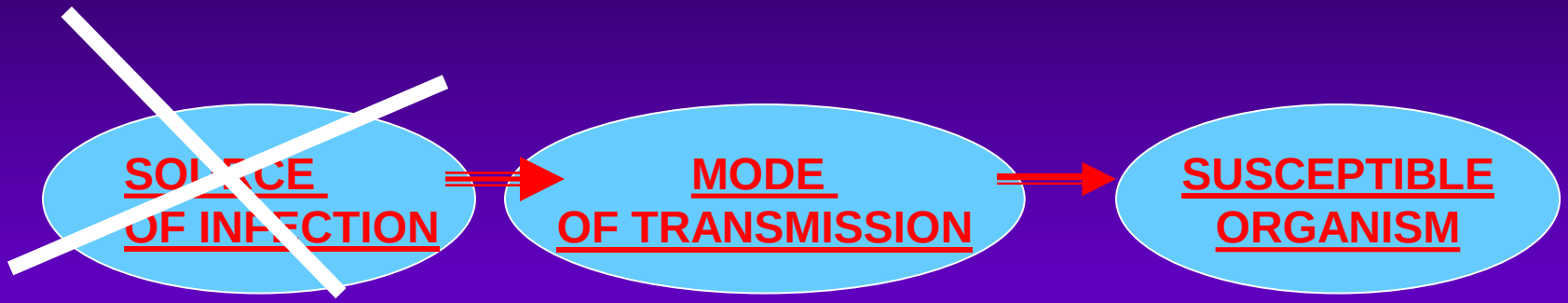
3. the **susceptibility** of the population or its individual members to the organism concerned Host factors : age, nutrition, genetics
immunity – natural (nonspecific),
- acquired

THE INFECTION

= 1. source of infection

.....

Prevention of infectious diseases



Isolation of patients:

- Dpt. of infectious diseases,
- „high degree of isolation“ (ebola)
- at home,
- barriers nursing technique

Prevention of infectious diseases

HANDWASHING, DISINFECTION OF HANDS

LINEN WASHING,

CLEANING

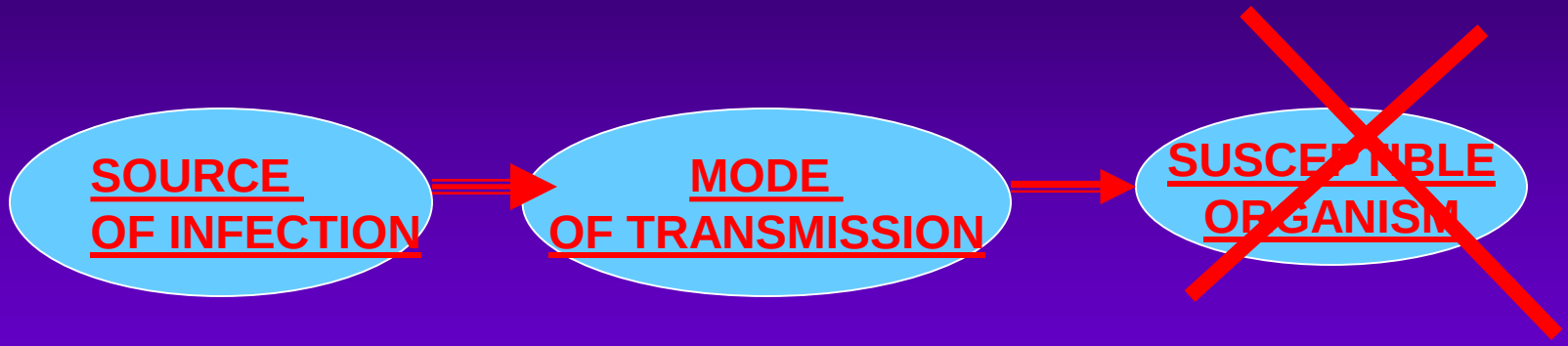
GOOD PREPARING OF FOOD, SAFE WATER……..,

……

DISINFECTION

STERILIZATION

Prevention of infectious diseases



i m m u n i t y

– natural (nonspecific),

- acquired (vaccination)

- **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.

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

„BREAKING THE CHAIN OF INFECTION“

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

In the practical part it is preoccupied with

preventive measures
repressive measures
related to infectious diseases

Preventive anti-epidemic measures

is **a set of measures to prevent the infection** of susceptible individuals:

- **primary** , when *we prevent impact of external risk factors* , or *we will increase the resistance of the individual* (epidemiology)
- **Secondary** prevention is early *to find* (diagnosis), *treatment* and *prevention of further development of the disease* and *complications* (clinical medicine)
- **Tertiary** prevention monitors patients who have overcome the disease

Include:

Increasing hygienic standards of the population - the most important is compliance with sanitary regulations relating to *water supply* , *food* , *manufacturing* and *food handling* , *waste water* , *waste* , *faeces* and so forth.

Vaccination - in order to induce maximum collective immunity.

Evidence and vector control (and the people with them living in the same household) - on the *territory concerned health authorities* must *register for* (eg. Portability typphoid, salmonella, bacillary dysentery and diphtheria); must be under *constant medical supervision* , *regular* microbiologically *examined* or *treated* . Must submit certain *restrictive measures* , always report a change of residence *must not endanger their actions of another person* .

Measures to prevent the introduction of infection into collectives - *entrance examinations* (to work, camp, army, morning filters in nurseries and kindergartens), *prevent the entry into the collective* persons that could be a source of infection (important information too).

Prophylactic desinfection - aims to *reduce the number of pathogens* in the external environment (public buildings, medical facilities, public transport, drinking water, waste water from hospitals, milk pasteurisation).

Border protection - a *system of measures* protecting the borders of the introduction of diseases from foreign **persons** , **materials** , **goods**, **imported animals** . It is, among other things. Persons who come *from countries with endemic or epidemic occurrence of serious communicable diseases* . Such passengers must show a valid vaccination certificate, if you do not or are not vaccinated, subjected to medical supervision, quarantine or vaccination. Quarantine diseases as plaque, yellow fever and cholera. As for the people, not absolute boundaries conserve data. More important is the **protection of imported commodities** , which must be *accompanied by a certificate of health or veterinary authorities about their health* .

Health education - raising awareness of health and culture of the inclusion of basic hygiene and epidemiology in school and extracurricular educational facilities.

Repressive anti-epidemic measures are carried out, if **already established infection**

Early and accurate diagnosis of the disease - is a fundamental prerequisite for initiating rapid and effective punitive measures.

This includes *proper epidemiological history* , *clinical examination* and *laboratory tests* (microbiological, serological, biochemical etc.).

Reporting sick or suspected of being infected - immediately after diagnosis or suspected infectious disease patient reports a *doctor who examined him first* by sending a relevant form epidemiological department *territorially competent health institute* , in the case of highly contagious diseases or epidemic is reported by telephone directly to the ministry health.

Isolation of the sick - is any department patients and convalescent carriers so as to prevent transmission of infection to susceptible individuals. The method determines the *physician or epidemiologist* .

Epidemiological investigation of the outbreak of the disease - carried out immediately (preferably in an interview with the patient), defines the scope of an outbreak of place and time. It is necessary to trace the source of infection and other potentially infected people; collect basic data about patients and their contacts and data (age, gender, onset of disease, residence, profession etc.) to develop epidemic curves and expressing working hypotheses about the sources and routes of transmission.

It's a set of measures that provide **the focus of infection in order to dispose of it as soon as possible** :

active search for infected and suspected infections (possible sources)

quarantine measures for suspected infection **in the form of medical supervision** (regular *investigation* and *observation* after incubation periods since the last case of the disease), *increased medical supervision* (except for watching a ban on certain risky activities), *Quarantine* (isolation within the meaning of the WHO, cholera, plaque, yellow fever)

focal disinfection *routine* around the patient for elimination EA; *final* after transporting or death of the patient,

Active and passive immunization according to the circumstances,

chemoprophylaxis especially antibiotics or antimalarials,

Control of basic hygiene measures , such as *drinking water* , *food* , removal *of garbage* , sewage disposal,

health and educational work is the instruction of persons affected and threatened by means of appropriate behavior.

Monitoring and evaluation of anti-epidemic measures - a day he **performs and evaluates epidemiologist** , if necessary, amend or adapt according to the situation. Efficiency measures are evaluated from a health and economic perspective.

Measures *must be* **viable** , **easily workable** , **understandable** and **effective** .

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.