

# Medically important bacteria

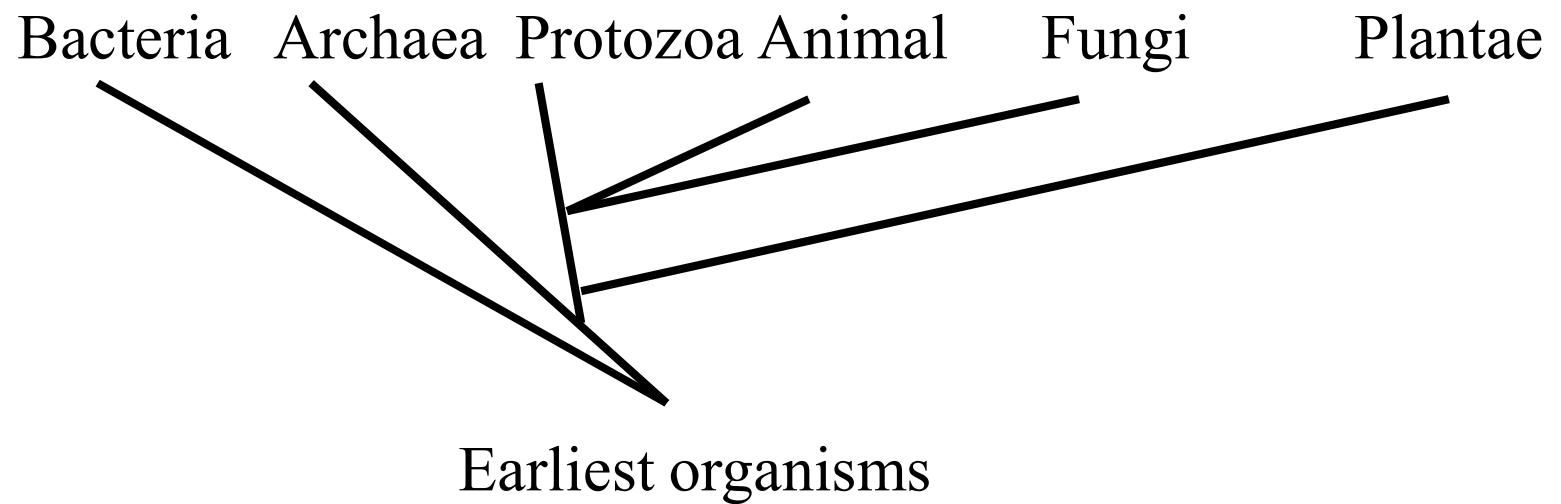
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## Learning objectives:

- Basic approaches for identification
- Common bacterial infections and transmission routes
- Simple classification of medically important bacteria
- Some key examples of medically important bacteria

# Objective 1: Classification

# Prokaryotes & Eukaryotes



## Prokaryotic Cell Structure

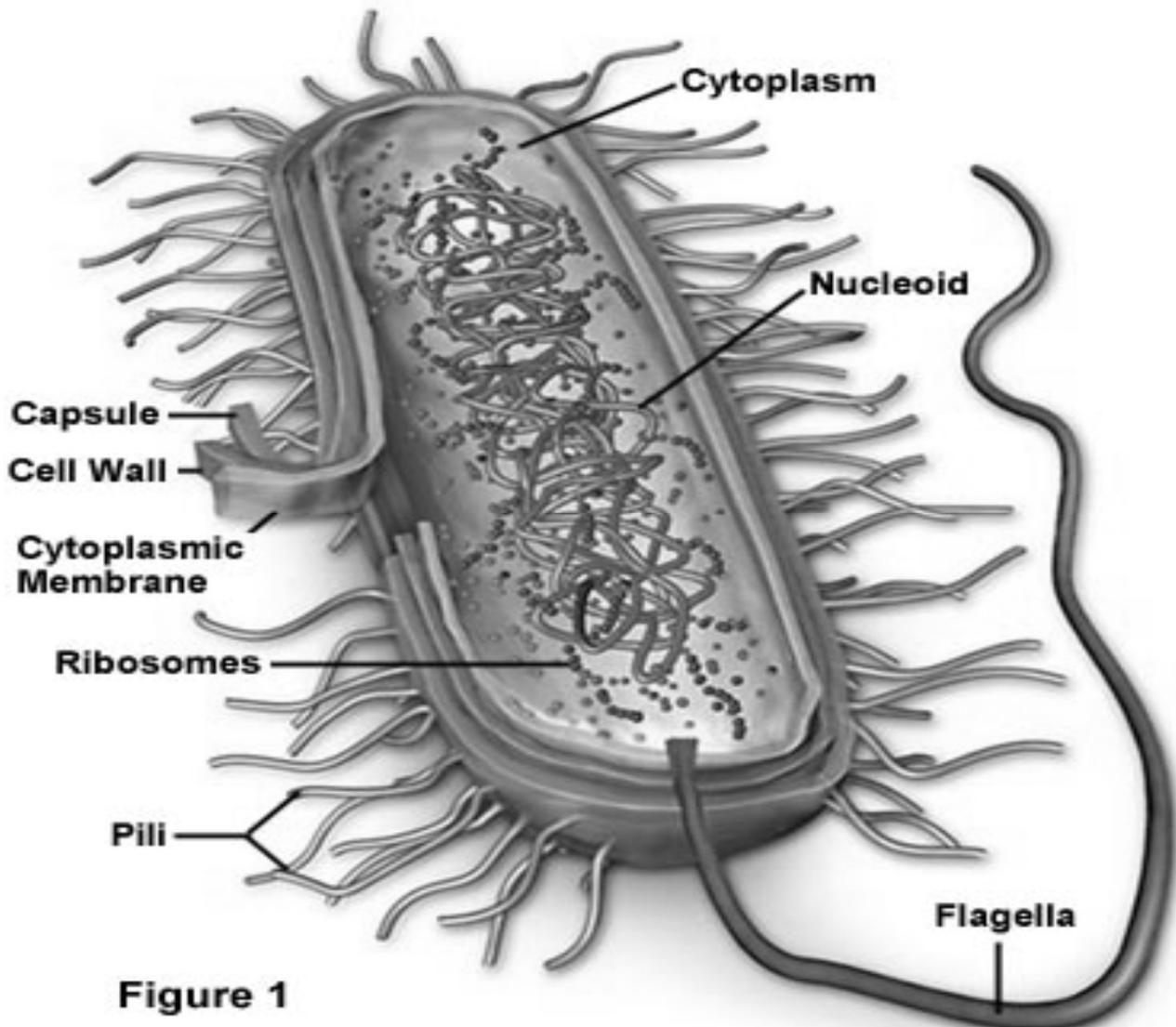


Figure 1

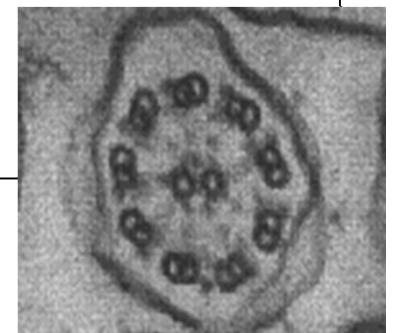
# Prokaryotes & Eukaryotes (II)

## Prokaryotes

- no membrane-enclosed nucleus
- a single chromosome
- may contain extrachromosomal elements (Plasmids)
- no mitochondria or chloroplasts
- mostly asexual reproduction- by binary fission (no mitosis and meiosis)
- transfer of genetic information by conjugation, transduction & transformation
- plasma membrane is a phospholipid bilayer but contains no cholesterol or other steroids
- flagella consist of one protein, flagellin
- contain 70S ribosomes
- peptidoglycan cell walls (eubacteria only)

## Eukaryotes

- membrane-enclosed nucleus
- >1 chromosomes, may contain more than 1 copies for each chromosome
- Plasmid only find in yeast
- contain membrane-bounded organelles
- cell divide by mitosis
- transfer of genetic information during sexual reproduction, e.g. meiosis
- plasma membrane is a phospholipid bilyaer, contains steroids or cholesterol
- flagella have a complex structure with 9+2 microtubular arrangement
- contain 80S ribosomes in cytoplasm, but contain 70S ribosomes in mitochondria and chloroplast
- polysaccharide cell walls



# Characters used in bacterial identification

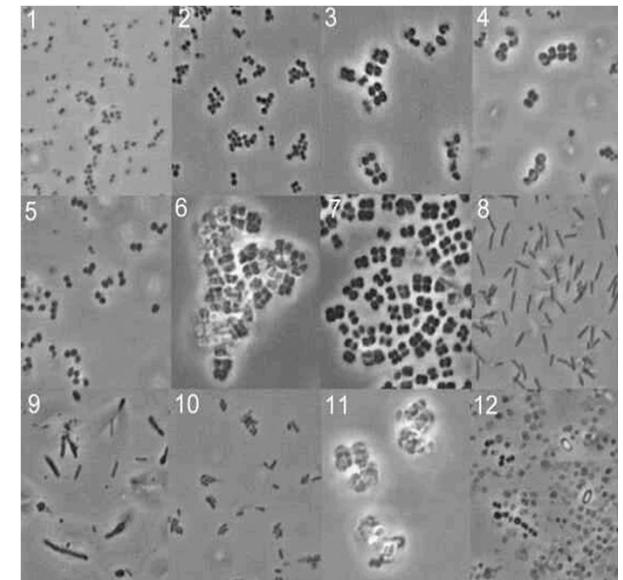
## • Colony morphology

Size- large or small?

Edge- round, lobate, irregular, etc?

Color?

Elevation- flat, convex, domed?



## • Cell shape, size & structure

coccus (spherical), bacillus (straight rod), spirillum (helically curved rods) & pleomorphic?  
special structure, e.g. endospore, flagella?

## • Cell arrangement

in pair, form chains, hypha, or no arrangement at all?

## • Staining reaction

Gram stain- Gram positive → blue/violet, Gram negative → red

Acid fast stain (Ziehl-Neelsen stain)- Acid-fast → red, Non acid fast → blue      Mycobacteria

Shape	Examples
Rod-shaped (bacilli)	<i>Escherichia coli</i>
Bacilli with tapered ends (fusiform bacilli)	<i>Fusobacterium nucleatum</i>
Spherical (cocci)	<i>Staphylococcus aureus</i>
Kidney-shape cocci (vibrios)	<i>Vibrio cholerae</i>
Spiral (spirilla)	<i>Spirillum volutans</i>
Flexible spirilla (spirochaetes)	<i>Treponema pallidum</i>
Fucus-like threads (hyphae)	<i>Strptomyces albus</i>
Irregular (pleomorphic)	<i>Mycoplasma pneumoniae</i>
Group	
Pairs	<i>Neisseria gonorrhoeae</i>
Palisades	<i>Corynebacterium diphtheriae</i>
Clusters	<i>Staphylococcus aureus</i>
Chains	<i>Streptococci pneumoniae</i>

# Characters used in bacterial identification (II)

- **Chemical contents**

chemical contents of the cells (e.g. sulfur granules)

- **Growth characteristic**

nutritional requirements and physical conditions required for growth

- **Biochemical test**

measure various aspects of bacterial metabolism, e.g. C and N sources the bacteria can use, end products of their metabolic processes, enzymes produce for these processes

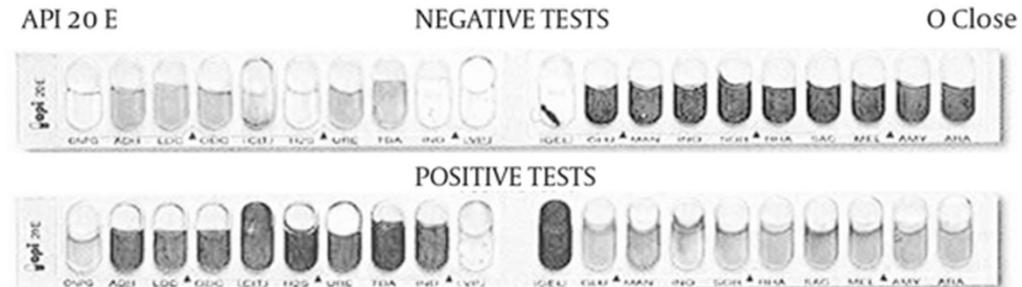
- **Immunological test**

antigens of the cell, distinctive for certain kinds of microbiology

- **Genetic test**

DNA sequence (homology) and DNA base content

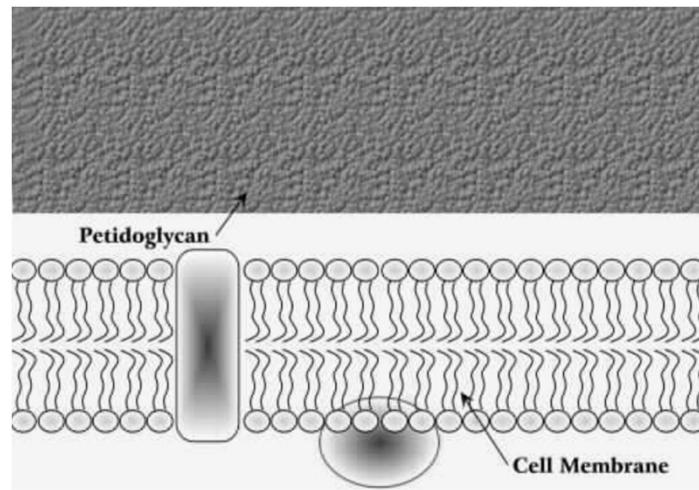
Ribosomal sequencing



**Figure 1.** Negative and positive test results on API 20E test.

# Cell wall

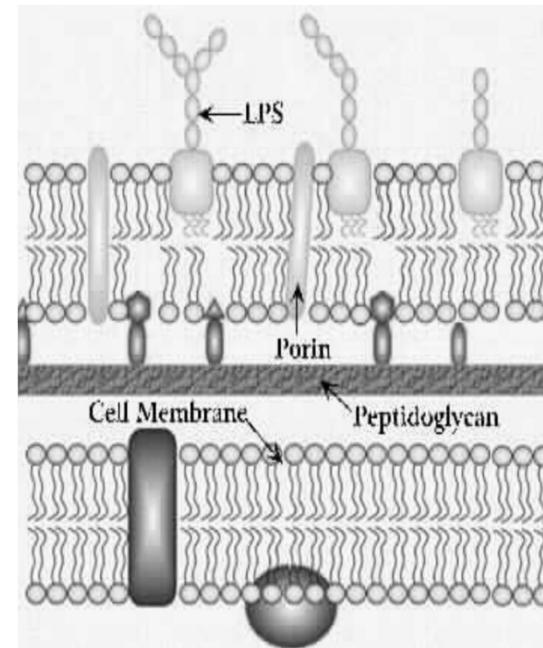
- protects protoplast (cell without cell wall & capsule) from mechanical damage, osmotic lysis
- determines the shape of a cell
- Gram stain



## Gram positive

A thick wall (about 30-100 nm)  
mainly composed of multilayered  
peptidoglycan (polysaccharides +  
protein)

contains large amounts of teichoic  
acid (polymer of ribitol)



## Gram negative

A relatively thin cell wall (20-30 nm),  
contains one or multiple layers of  
peptidoglycan

- Objective 2: Common bacterial infections and transmission routes

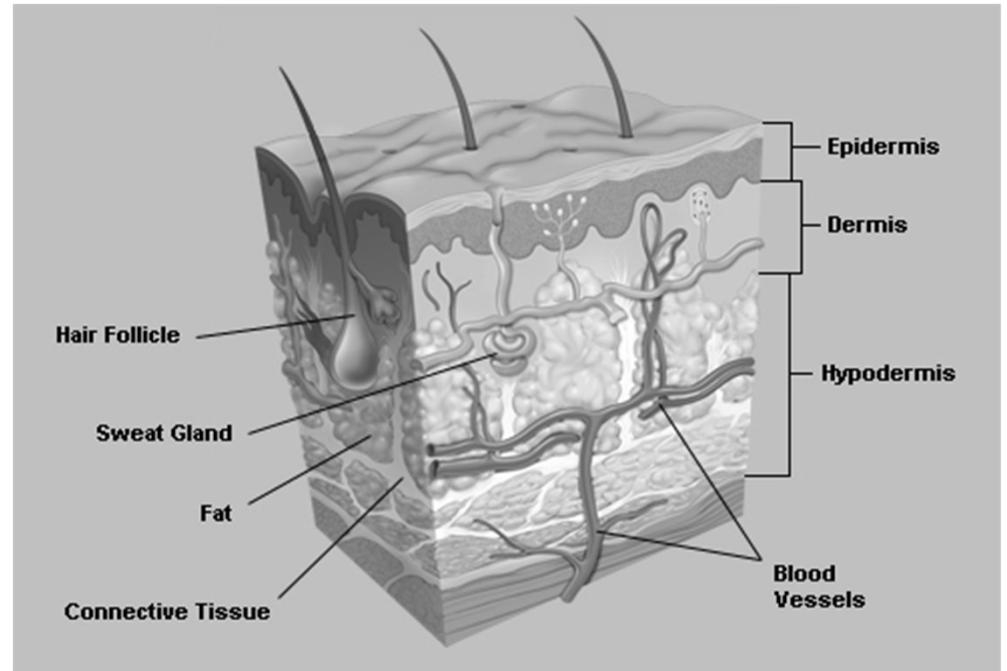
# Skin infections

Bacterial infections:

- Impetigo
- Scarlet fever
- Folliculitis, boils
- Acne
- Anthrax
- Leprosy

Burn and Wound infections:

- Burns
- Wound and surgical infections
- Infections caused by bites



# Eye infections

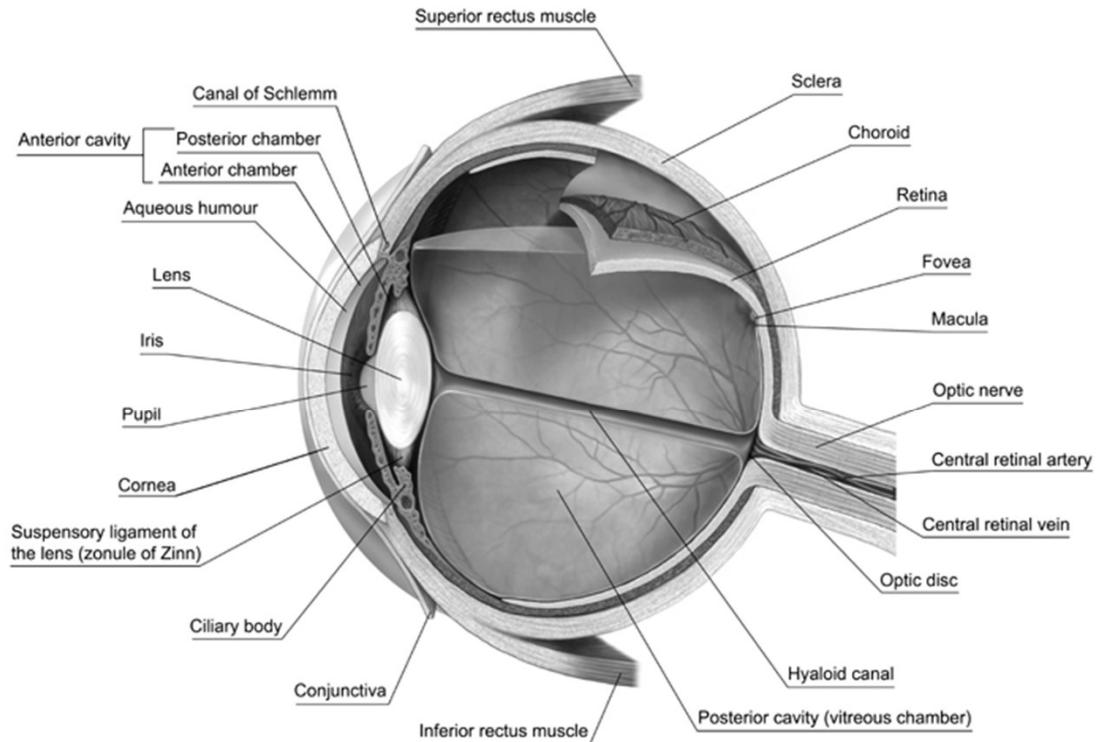
Bacterial infections:

Bacterial conjunctivitis

Chlamydial (inclusion) conjunctivitis

Trachoma

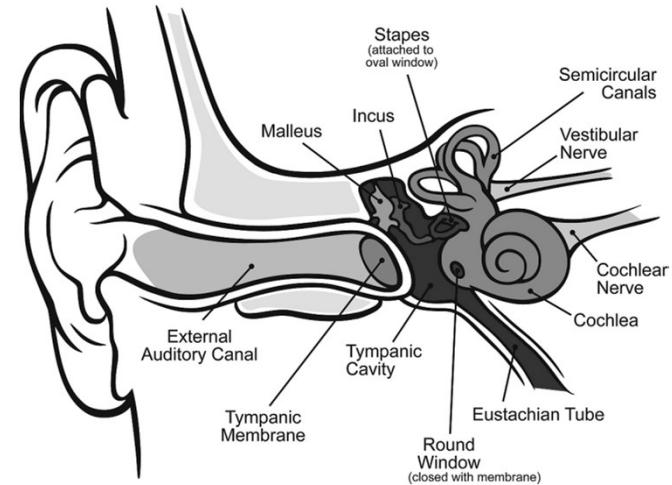
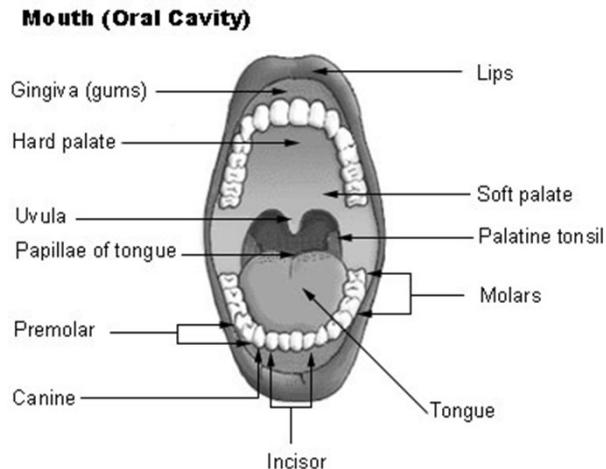
Gonococcal conjunctivitis



# Infectious diseases of the mouth and ear

Ulceration  
Dental plaque  
Dental caries  
Gingivitis

Otitis media  
Otitis externa



# Common respiratory tract infections

## Pneumonia

Bacterial infections:

Diphtheria

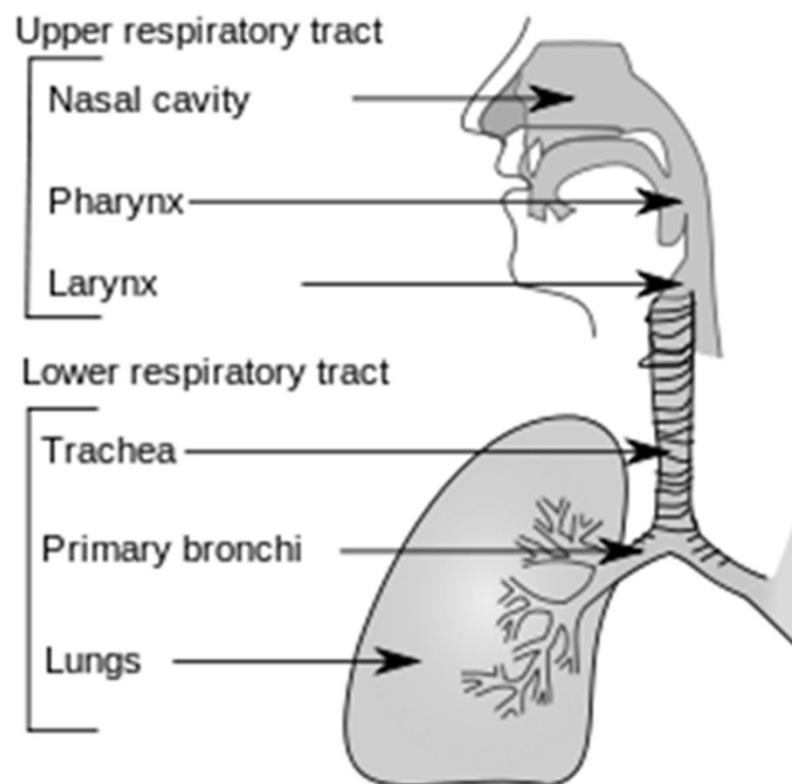
Legionellosis

Mycoplasmal pneumonia

Streptococcal pharyngitis

Tuberculosis

Whooping cough



# Gastrointestinal infections

Bacterial gastrointestinal infections:

Bacterial gastritis

Campylobacter gastroenteritis

Cholera

Enterovirulent *E. coli*

Enterohemorrhagic *E. coli*

Enterotoxigenic *E. coli*

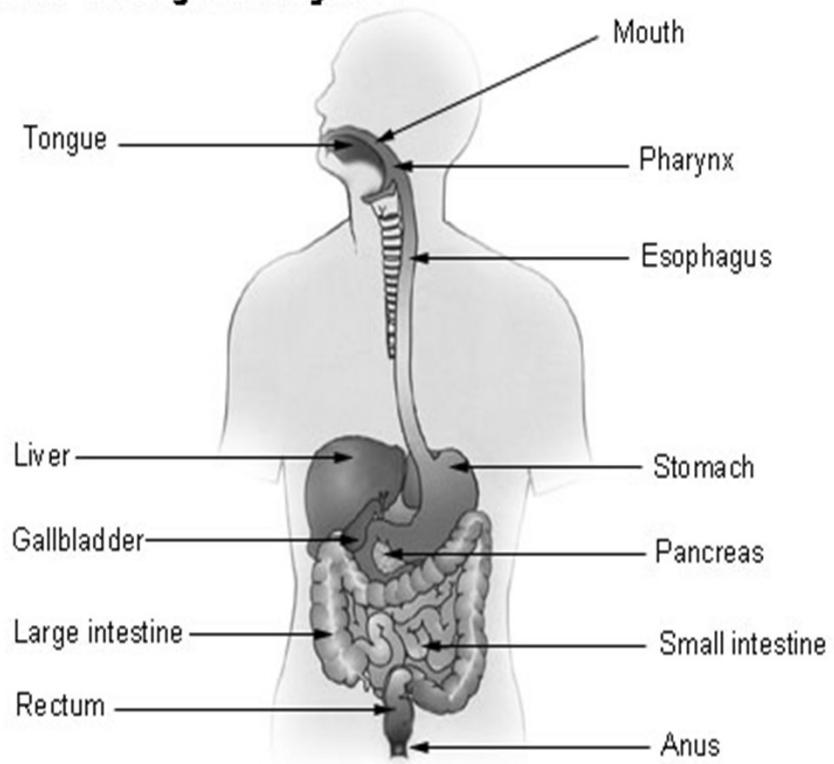
Salmonellosis

Typhoid

Shigellosis

*H. pylori*, a carcinogen

**Organs of the Digestive System**



# Foodborne intoxication

Toxins produced by bacteria

Botulism

Clostridium perfringens food poisoning

Staphylococcal food poisoning

## **Botulism Symptoms**

If you have recently developed the following symptoms, go to the hospital now:

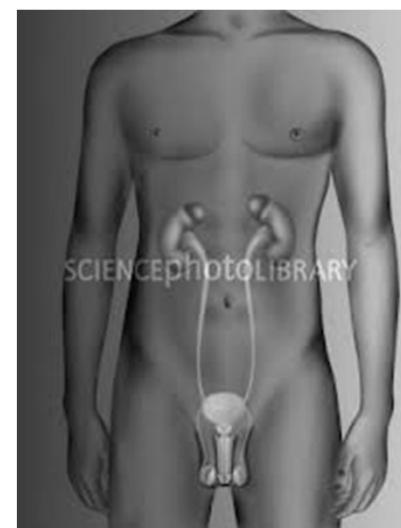
- Double Vision • Difficulty Swallowing
- Blurred Vision • Dry Mouth
- Droopy Eyelids • Muscle Weakness  
(Starts in shoulders and descends through body)
- Slurred Speech



# Infectious diseases of the gastro-urinary tract

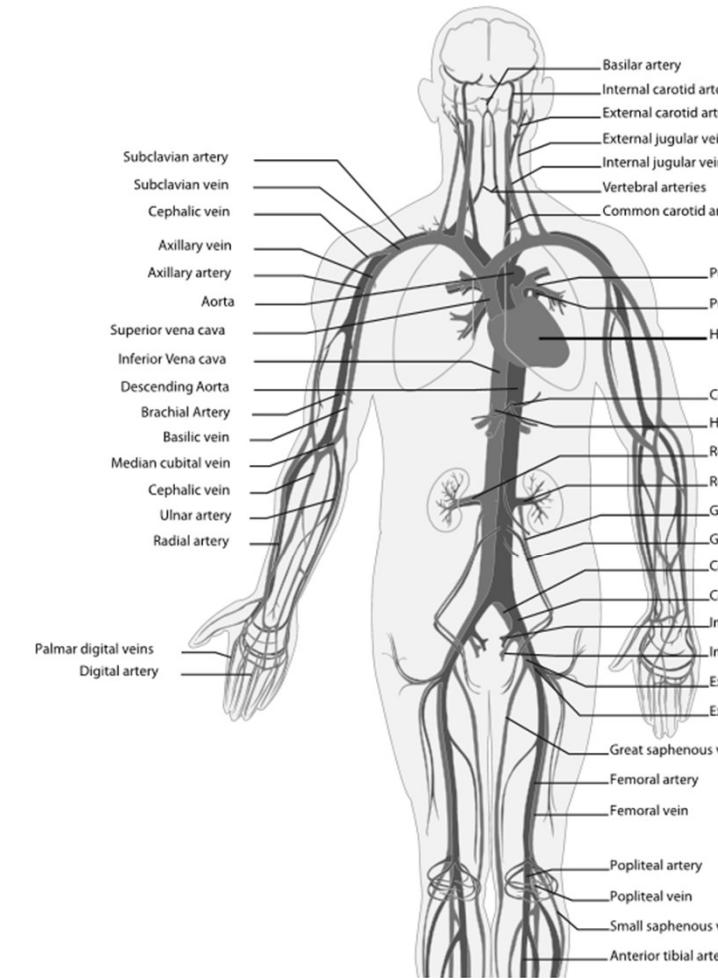
Sexually transmitted diseases

Genital Chlamydia  
Gonorrhea  
Syphilis



# Infectious diseases of the circulation system

Bacterial infections:  
Lyme disease  
Plaque  
Tularemia



Vector-borne diseases

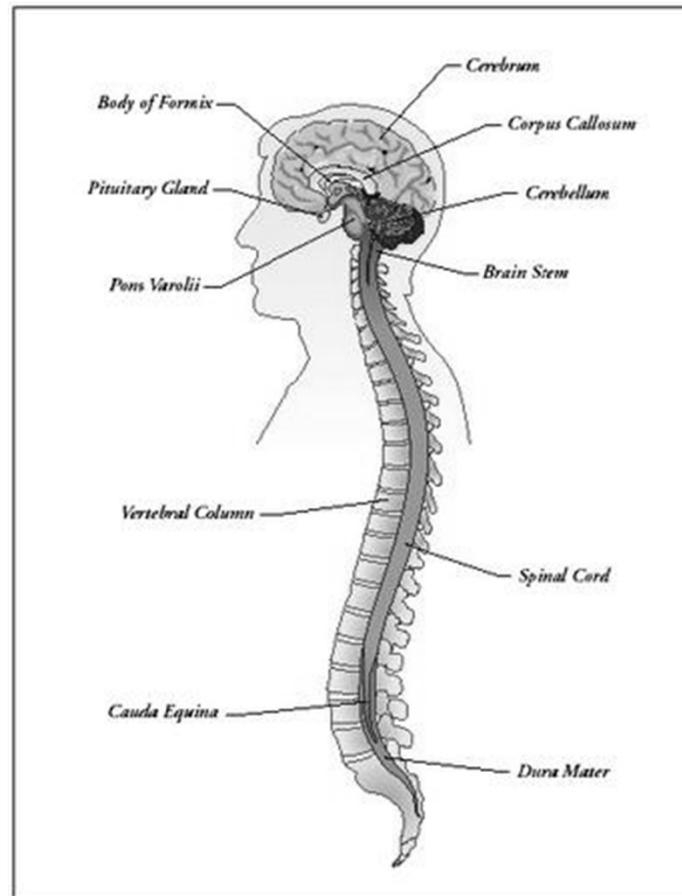
# Central nervous system infections

Bacterial infections:

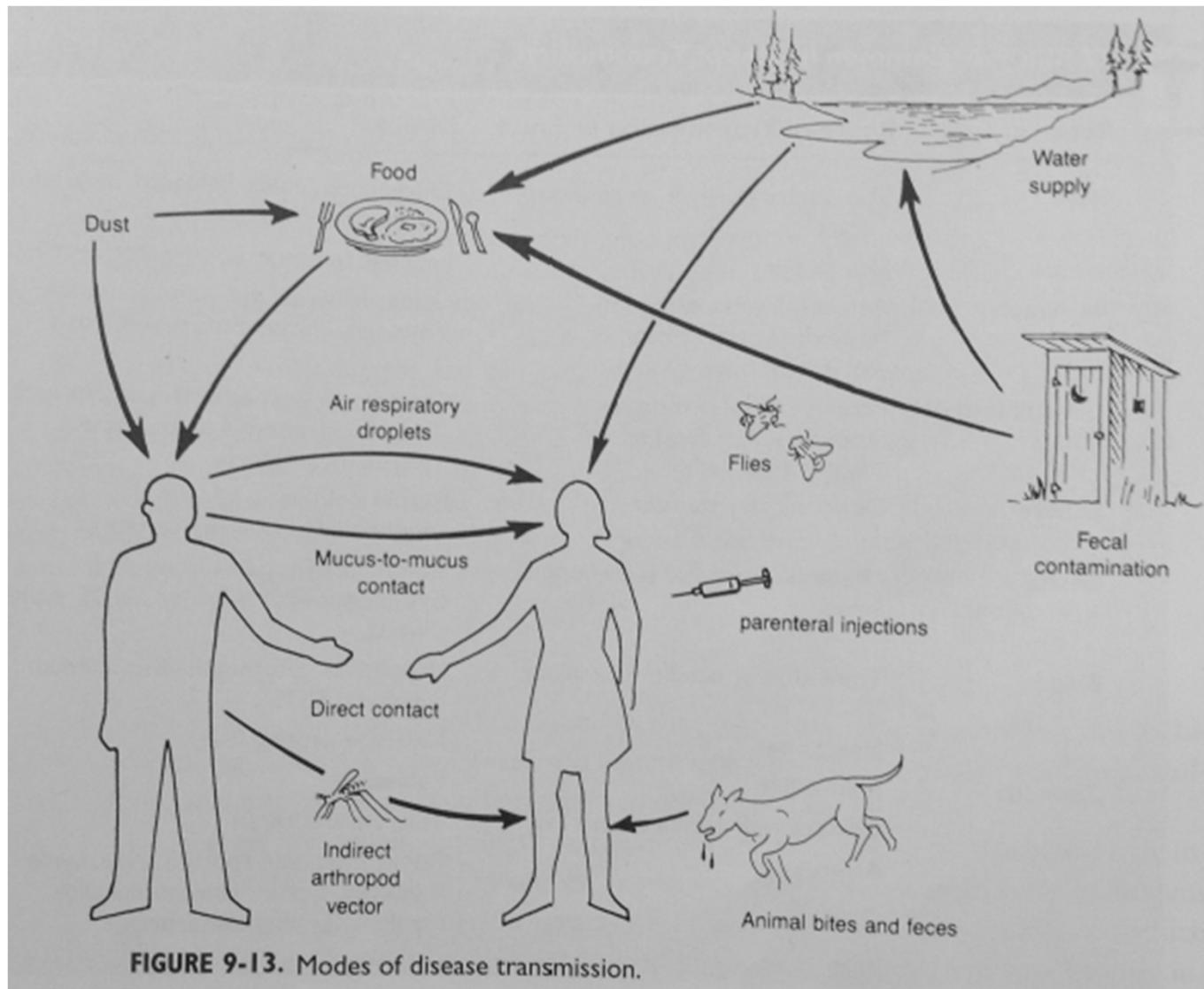
Bacterial meningitis

Botulism

Tetanus



# Transmission routes



- Objective 3: Simple classification of medically important bacteria

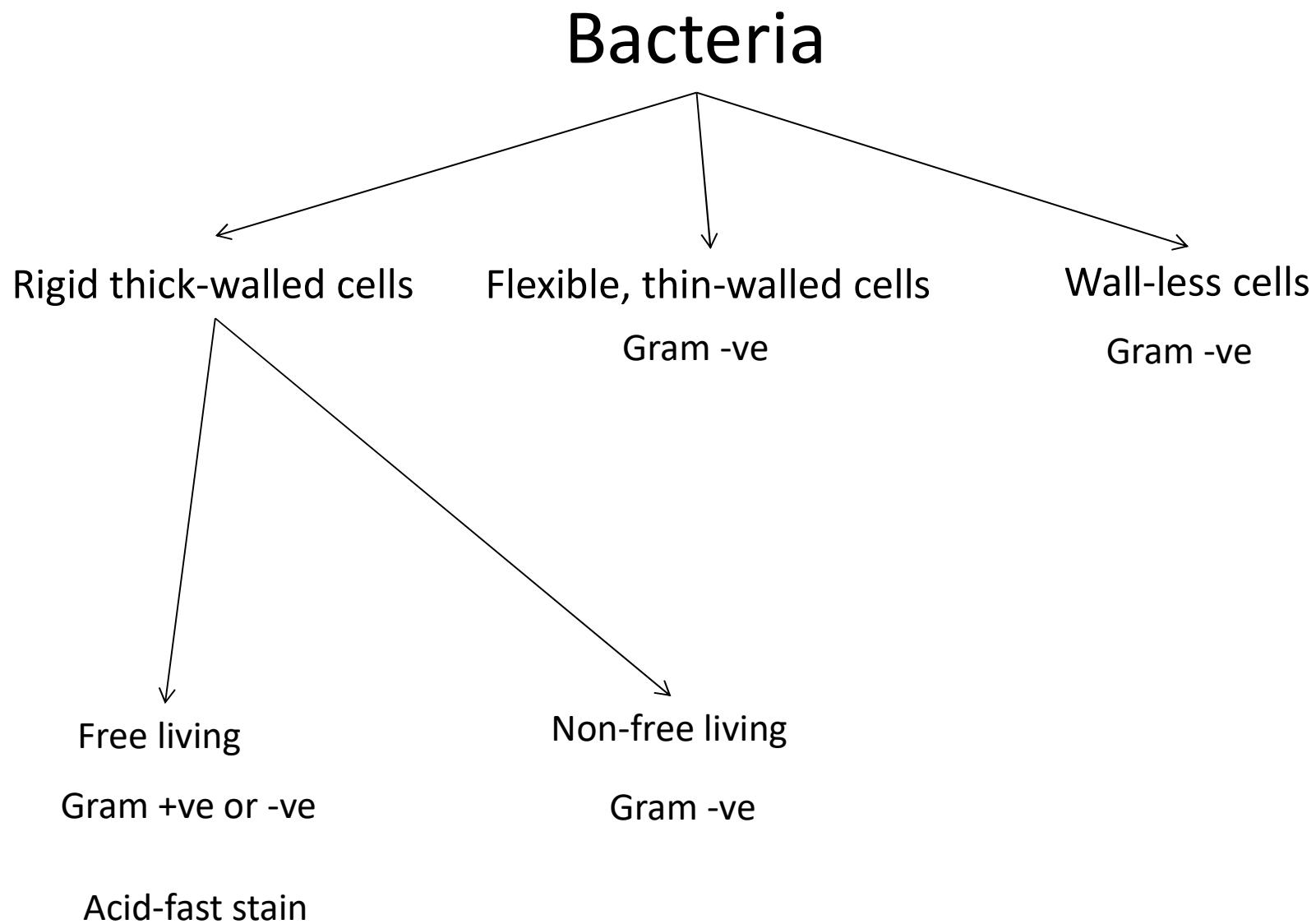
# Medically important bacteria

<u>Bacterial pathogen</u>	<u>Disease(s)</u>	<u>Transmission</u>
<b>Gram-negative bacteria</b>		
<i>Coliforms</i> (e.g. <i>E. coli</i> , <i>Enterobacter</i> )	Gastroenteritis, urinary tract infections, neonatal meningitis	F W E
<i>Salmonella enterica</i>	Gastroenteritis	F W
<i>Salmonella typhi</i>	Typhoid fever	F W
<i>Shigella dysenteriae</i>	Bacillary dysentery	F W
<i>Yersina pestis</i>	Bubonic plague	IV
<i>Pseudomonas aeruginosa</i>	Opportunistic infections, swimmer's ear, hot tub itch, cellulitis, pneumonia, more	S W C HA E
<i>Vibrio cholerae</i>	Asiatic cholera	W
<i>Bordetella pertussis</i>	Whooping cough	RC
<i>Haemophilus influenzae</i>	Meningitis, pneumonia, sinusitis	RC
<i>Helicobacter pylori</i>	Gastric and duodenal ulcers	F?
<i>Campylobacter jejuni</i>	Gastroenteritis	F W
<i>Neisseria gonorrhoeae</i>	Gonorrhea	S C
<i>Neisseria meningitidis</i>	Meningococcemia and meningitis	R C E
<i>Brucella abortus</i>	Undulant fever	IA M
<i>Bacteroides fragilis</i>	Anaerobic infections	E
<b>Gram-positive bacteria</b>		
<i>Staphylococcus aureus</i>	Food poisoning, wound infections, toxic shock syndrome, more	F C E HA IA
<i>Streptococcus pyogenes</i> (Group A strep)	Strep throat, scarlet fever, mastitis, necrotizing fasciitis, more	C
<i>Streptococcus pneumoniae</i>	Pneumonia, otitis media, meningitis	RC E
<i>Bacillus anthracis</i>	Anthrax	S IA
<i>Bacillus cereus</i>	Food poisoning	F
<i>Clostridium tetani</i>	Tetanus	S
<i>Clostridium perfringens</i>	Food poisoning, gas gangrene, uterine infections	F S E
<i>Clostridium botulinum</i>	Botulism, infant botulism	F
<i>Clostridium difficile</i>	Antibiotic-associated diarrhea, pseudomembranous colitis	C HA E
<i>Corynebacterium diphtheriae</i>	Diphtheria	RC
<i>Listeria monocytogenes</i>	Listeriosis	F
<b>Not typed by Gram stain</b>		
<i>Mycobacterium tuberculosis</i>	TB (tuberculosis)	RC M
<i>Mycobacterium leprae</i>	Leprosy	C
<i>Chlamydia trachomatis</i>	Chlamydia, lymphogranuloma venereum, trachoma	SC C
<i>Chlamydia pneumoniae</i>	Pneumonia	RC
<i>Mycoplasma pneumoniae</i>	Atypical pneumonia	RC
Rickettsias	Rickettsiosis: typhus, RMSF	IV
<i>Treponema pallidum</i>	Syphilis	SC
<i>Borrelia burgdorferi</i>	Lyme disease	IV

## KEY TO TRANSMISSION.

C = Contact  
 E = Endogenous  
 F = Food borne  
 HA = Hospital Acquired  
 IA = Infected Animal  
 IV = Insect Vector  
 M = Milk  
 RC = Respiratory Contact  
 SC = Sexual Contact  
 S = Soil  
 W = Water

## A simple classification of bacteria of medical importance

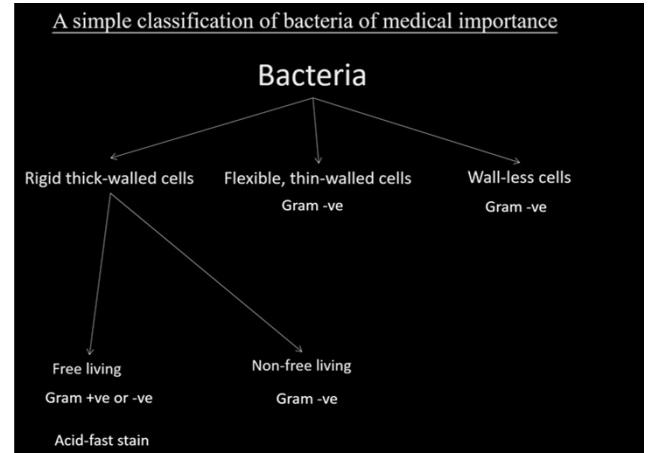


**Objective 4: Some key examples of medically important bacteria**

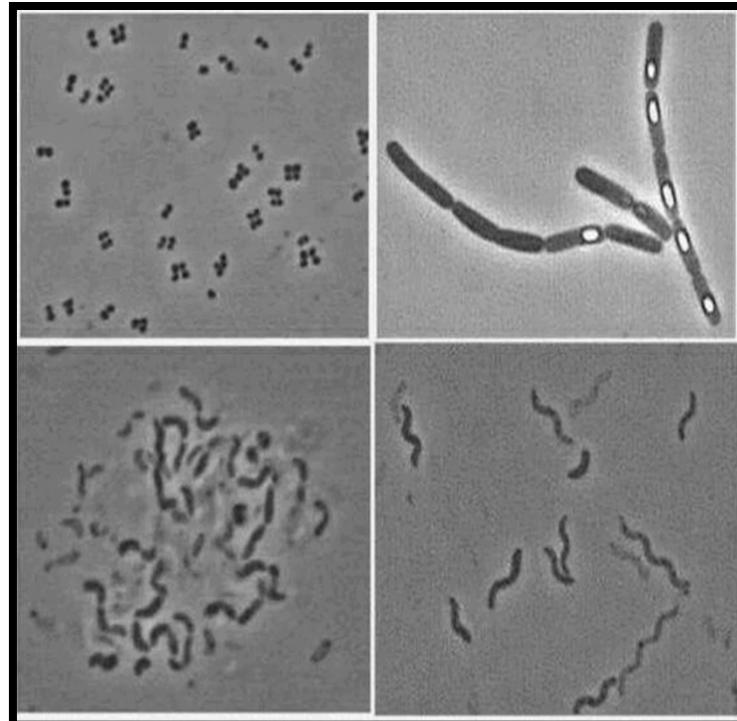
# Free-living bacteria (I)

Eubacterium (True bacteria)

- medically important bacteria
- classified according to their shape



Cocci, spherical shaped  
Gram positive/negative  
e.g. *Streptococcus*



Vibrios, comma-shaped  
Gram negative  
e.g. *Vibrio*

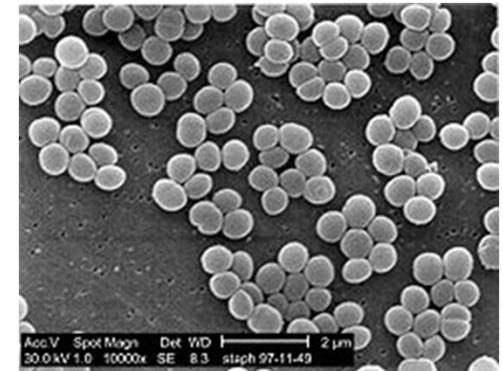
Bacilli, rod-shaped  
Gram positive/negative  
e.g. *Bacillus*

Spirilla, spiral-shaped  
Gram negative  
e.g. *Spirillum*

## Some medically important eubacteria

### *Staphylococcus spp*

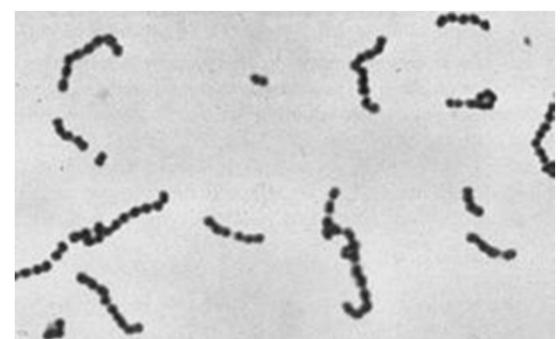
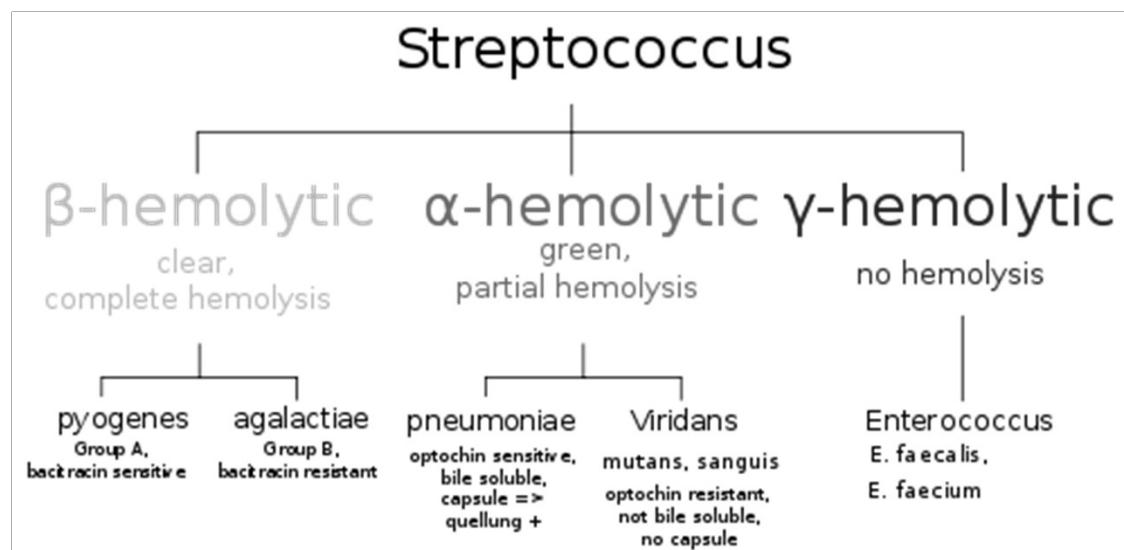
- Staphylococci (Staph): clustered gram-positive beta-hemolytic bacteria.
- Coagulase-negative Staph (CoNS): >30 species, 15 of which are human pathogens. *S. epidermidis*, *S. saprophyticus* (*novobiocin resistant*), *S. haemolyticus*, *S. lugdunensis*, & *S. schleiferi* are most commonly isolated.
- *S. aureus* (SA) is coagulase positive.
- Many of these are common flora and cause opportunistic infections.
- SA produces several toxins, including enterotoxins, epidermolytic toxins, & toxic shock syndrome toxins (TSST)
- Methicillin resistance: >80% of CoNS, and an increasing number of both hospital acquired & community acquired SA (MRSA) have emerged.



## Some medically important eubacteria

### *Streptococcus spp*

- Gram positive cocci, Facultative anaerobes
- Divided into three groups by the type of hemolysis on blood agar: α, β and γ hemolytic
- Also divided into serological groups of A-V
- Commonly found as commensal species in the upper respiratory tract
- Asymptomatic carrier status
- Produces a range of toxins (especially *Streptococcus pyogenes*)



## Some medically important eubacteria

### Coliform bacteria

- Rod-shaped Gram-negative bacteria
- Typical genera include:  
*Citrobacter*,  
*Enterobacter*  
*Escherichia*  
*Hafnia*  
*Klebsiella*  
*Serratia*
- GI infection, urinary tract infection, nosocomial infection

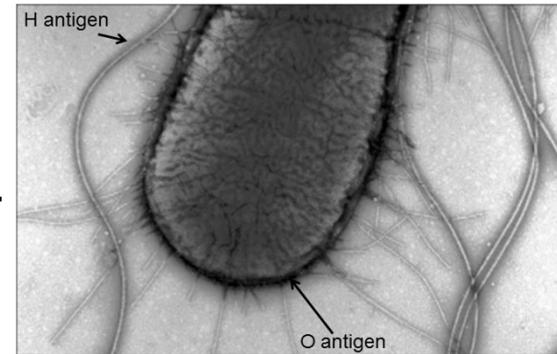


Figure 1. Electron micrograph of an *E. coli* O157 isolate from the 1996 Central Scotland outbreak. Magnification ×50 000.

# Coliforms are the cause of many nosocomial infections

TABLE 26-2 Frequency of Selected Pathogens Causing Nosocomial Infections \*

Organism	PERCENTAGE OF INFECTIONS AT SITE					
	Urinary Tract	Surgical Site	Primary Bloodstream	Pneumonias	Other	All Sites
<i>E. coli</i>	25	8	5	4	4	12
<i>Klebsiella</i>	8	4	5	9	4	6
<i>Enterobacter</i>	5	7	4	11	4	6
<i>Serratia marcescens</i>	1	1	1	3	1	1
<i>Citrobacter</i>	2	1	1	1	1	1
<i>Proteus mirabilis</i>	5	3	1	2	2	3
	[46]	[24]	[17]	[30]	[16]	[29]
<i>Pseudomonas aeruginosa</i>	11	8	3	16	6	9
<i>Staphylococcus aureus</i>	2	19	16	20	17	12
Coagulase-negative Staph	4	14	31	2	14	11
<i>Enterococcus</i>	16	12	9	2	5	10
<i>Candida albicans</i>	8	3	5	5	5	5
Other pathogens	13	20	19	25	37	24
% of All Isolates	36.0	16.7	13.4	12.6	21.3	100

\* Data from NNIS System for 1990 through 1992. Emori, T.G., and R.P. Gaynes. 1993. An overview of nosocomial infections, including the role of the microbiology laboratory. Clin. Microbiol. Rev. 6:428-442.

## *Salmonella* and *Shigella*:

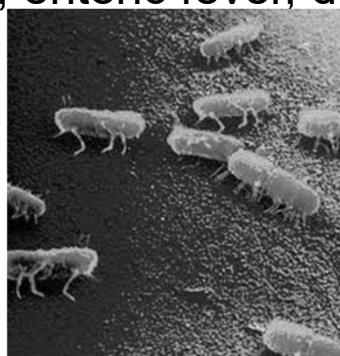
- Gram negative bacilli, Facultative anaerobes

### Salmonella

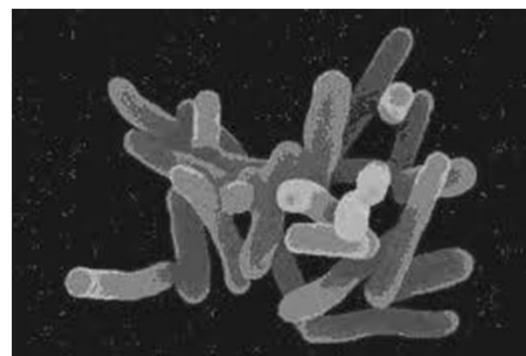
- Salmonella species involved in gastroenteritis are usually of animal origin, enteric fever species are transmitted horizontally via the oral-fecal route with no known animal reservoirs
- Only 2 species: *Salmonella enterica* and *Salmonella bongori* but >2000 variants differentiated by surface antigens (serovars)
- Grouped serologically into serogroups and sub divided into serotypes
- But conventionally, species status given to these serovars as more useful clinically

### Shigella

- Very low infective dose
- Potent Shiga toxins and other enterotoxins
- GI infection, enteric fever, dysentery



Salmonella  
(flagellated)



Shigella  
(non-motile )

# *Campylobacter* and *Helicobacter*:

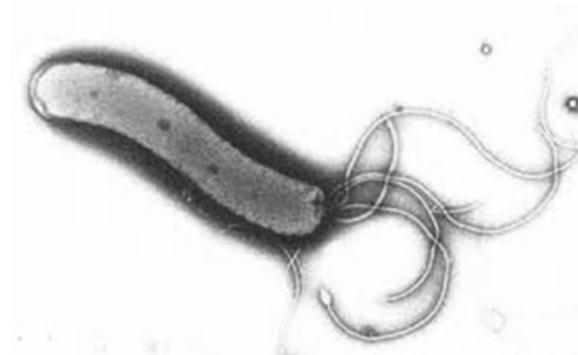
*Campylobacter* ('twisted bacteria')

- Gram negative bacilli
- Microaerobic (require reduced oxygen)
- Usually of animal origin, especially in poultry



*Helicobacter*:

- Gram negative curved or spiral bacilli
  - Human reservoirs
  - Grouping/typing still not clear
- 
- *Campylobacter jejuni* & *Campylobacter coli*: Acute gastroenteritis, with implications in Guillain-Barré syndrome
  - *Helicobacter pylori*: Chronic superficial gastritis (stomach inflammation). Associated with peptic ulcer disease



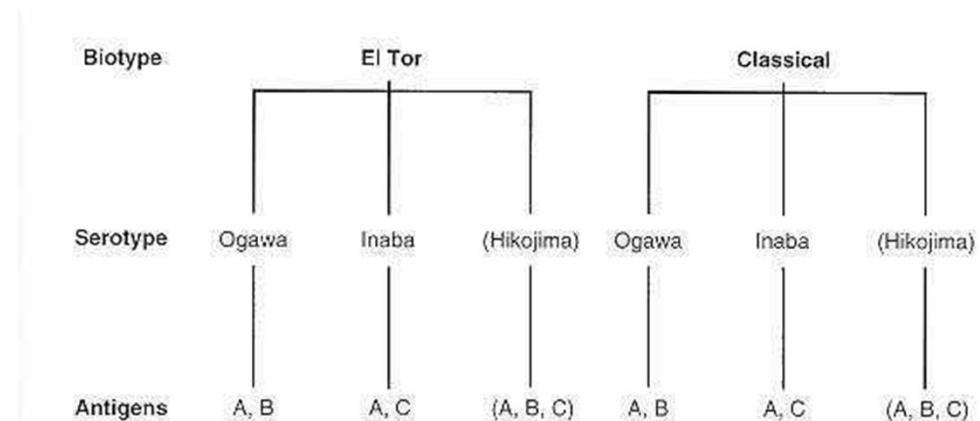
# *Vibrio spp*

- Gram negative curved bacilli
- Reservoirs in contaminated water and marine life (filter feeders)
- Transmission: oral fecal for cholera and contact for wound infection
- Pathogenesis through enterotoxin causing large volume watery diarrhea
- 2 main serogroups: O-1 and O-139
- O-1 further divided into 2 biotypes (by phenotypic traits): Classic and El Tor and 2 serotypes (by antigenic markers) : Inaja and Ogawa
- *Vibrio cholerae*: *Cholera*
- *Vibrio parahemolyticus*: *Wound infection & Gastroenteritis*



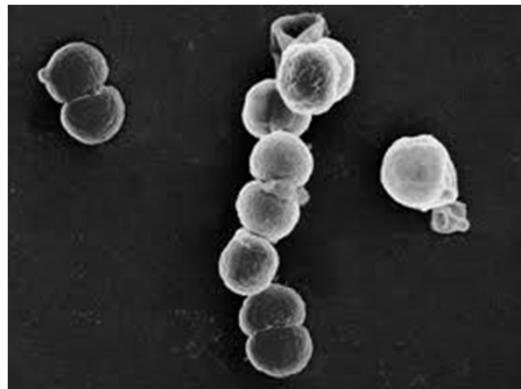
*Vibrio cholerae*

*Hemolysin +ve*      *Hemolysin -ve*



# Neisseriaceae

- Gram negative cocci
- Includes the genera *Neisseria*, *Moraxella*, *Kingella*, and *Eikenella*
- Only *Neisseria* is significant: *Neisseria gonorrhoeae* and *Neisseria meningitidis*
- Gonorrhea: carrier can be asymptomatic but still highly infectious through sexual contacts
- The human nasopharynx is the only known reservoir for *Neisseria meningitidis* and it can be spread through droplets
- Only about 1% of *Neisseria meningitidis* carrier goes onto developing meningitis
- *Moraxella*, *Kingella*, and *Eikenella* are only associated with opportunistic infections



## *Bacillus* and *Clostridium*:

- Bacillaceae family, Gram positive bacilli, Facultative anaerobes
- Spore-forming and spores can survive extreme environments
- Bacilli are commonly found in the environment, and *Bacillus anthracis* usually associated with herbivores
- Thermophilic *Bacillus stearothermophilus* is used to test heat sterilization processes
- Clostridiaceae family, Gram positive rod-shaped, spore-forming bacteria, Facultative anaerobes
- Clostridia are found in the environment as well as intestines of humans and animals
- Diseases through exotoxins
- Anthrax, Tetanus, Botulism



Clostridium botulinum

**BOTOX®**  
Cosmetic  
*Botulinum Toxin Type A*

### Botulism poisoning

#### Source of trouble

Low-acid foods that were improperly canned.

#### Trouble signs

- Clear liquids turned milky
- Cracked jars
- Loose or dented lids
- Swollen or dented cans
- An "off" odor



Home canned foods

#### Prevention

- Examine all canned foods before cooking
- Cook and reheat foods thoroughly
- Keep cooked foods hot (above 140 degrees) or cold (below 40 degrees)

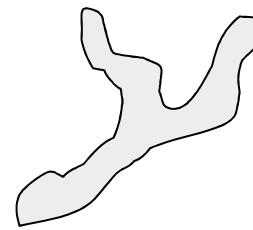
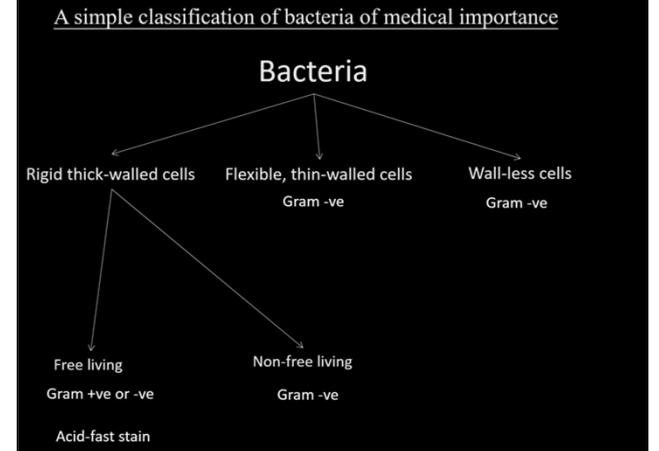
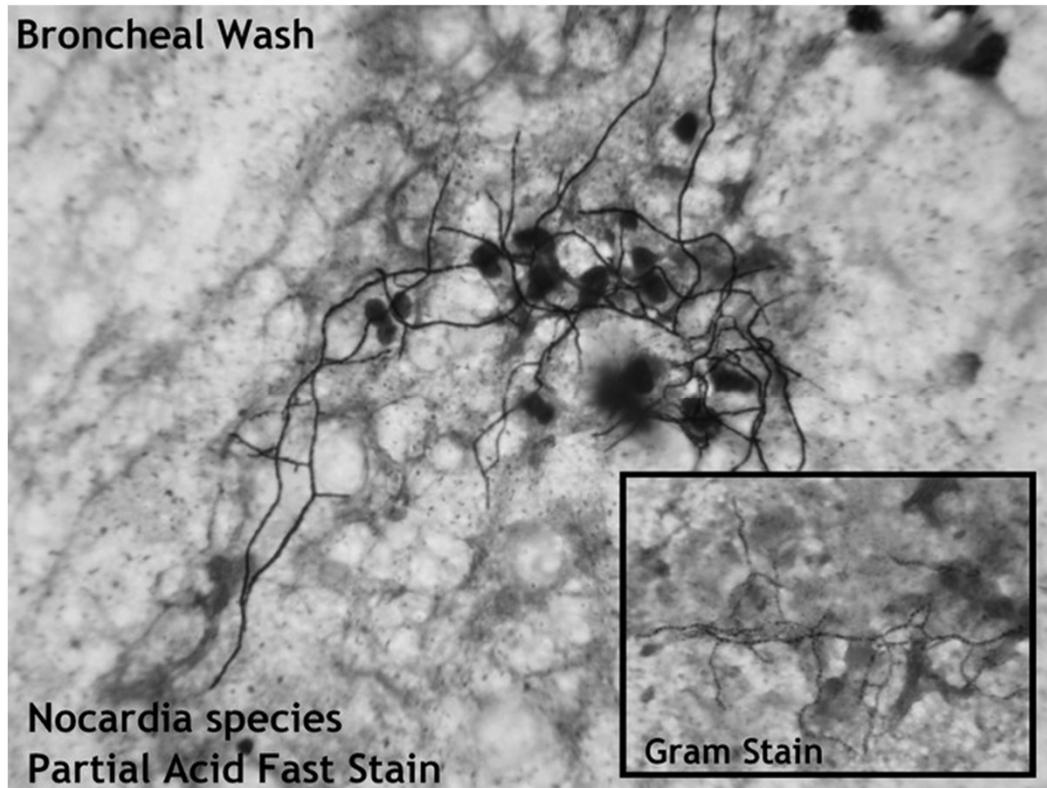
#### Symptoms after eating

- Double vision
- Droopy eyelids
- Trouble speaking, swallowing or breathing
- Untreated botulism can be fatal

# Free living bacteria (II)

## Filamentous bacteria

- Gram positive
- cells show true branching
- e.g. *Nocardia, Mycobacterium*



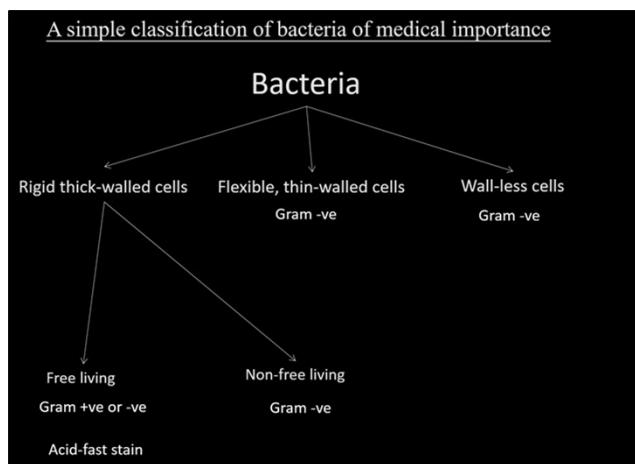
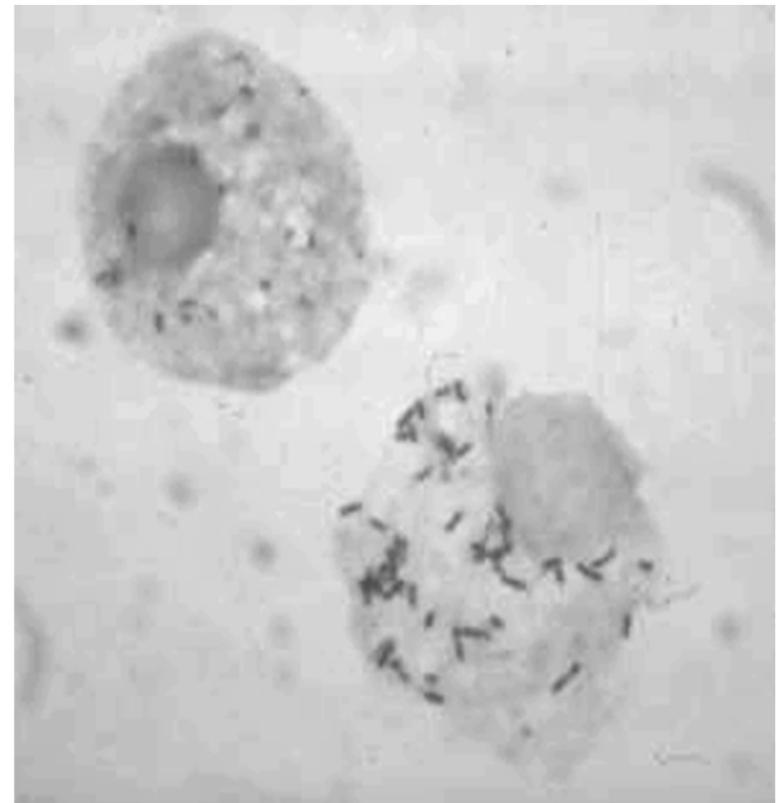
## Acid-fast stain

- cell membrane made of wax and glycolipids
- difficult to be stained by gram staining

# Non-free living, rigid thick-walled cells

Rickettsiase and chlamydiae

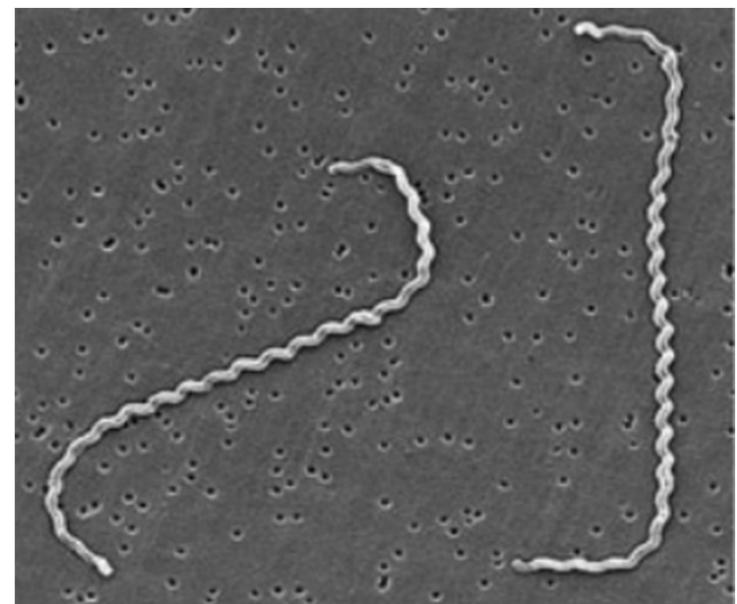
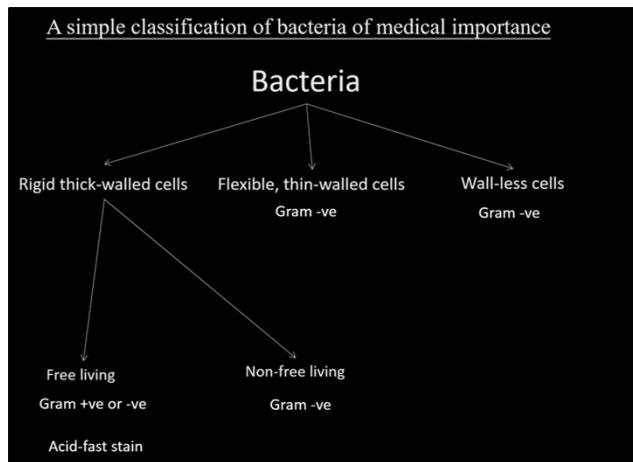
- obligate intercellular pathogens
- Gram negative
- e.g. *Rickettsia*, *Chlamydia*



# Flexible, thin-walled bacteria cells

## Spirochaetes

- Gram negative
- with slender flexuous spiral filaments
- without possession of flagella
- e.g. *Treponema*, *Borrelia*, *Leptospira*



# Wall-less bacteria cells

## Mycoplasma

- Gram negative
- lack rigid cell wall & pleomorphic
- e.g. *Mycoplasma*

