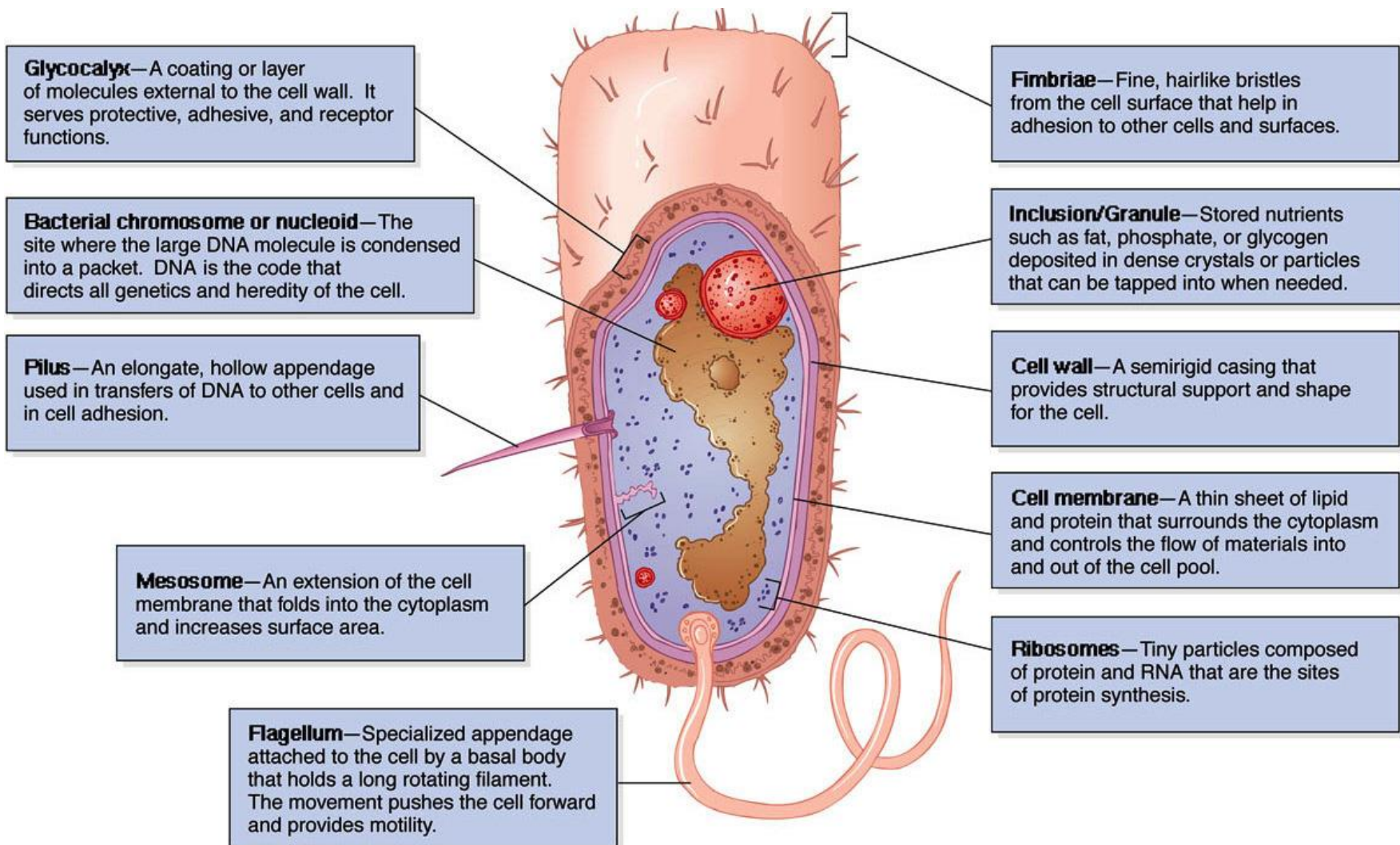


The Basic Structures of Bacteria

Anatomy and Physiology

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University of Basra, College of Nursing
2017-2018



Anatomy and Physiology of Bacteria

Bacterial Cell Wall

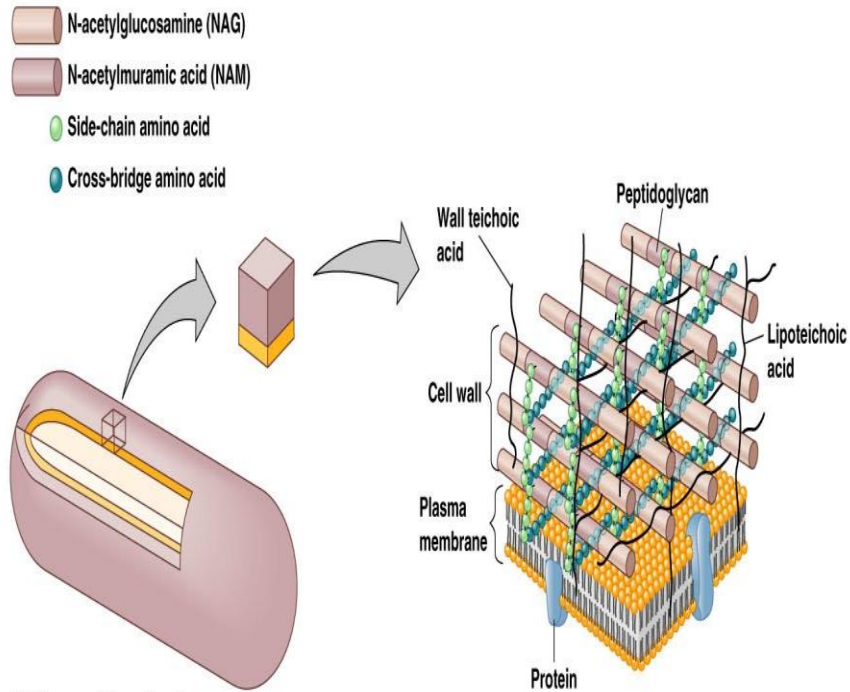
Four groups based on cell wall composition

1. Gram positive cells
2. Gram negative cells
3. Bacteria without cell walls
4. Bacteria with chemically unique cell walls

Peptidoglycan

- unique macromolecule composed of a repeating framework of long **glycan chains** cross-linked by short **peptide** fragments
- provides strong, flexible support to keep bacteria from bursting or collapsing because of changes in osmotic pressure

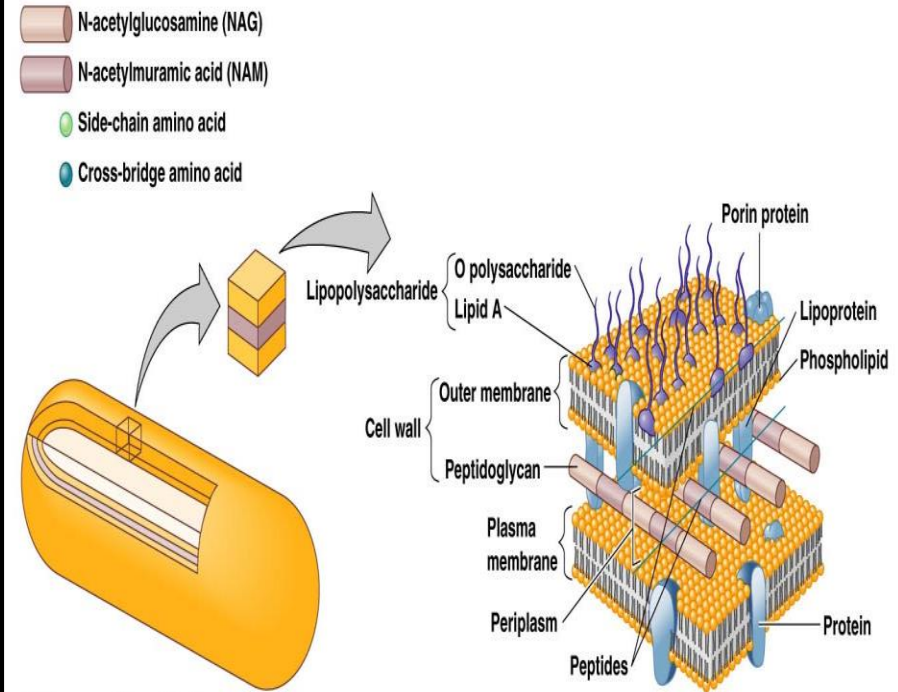
Gram positive



(b) Gram-positive cell wall

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Gram negative



(c) Gram-negative cell wall

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Gram-Positive & Gram-Negative cell wall

Gram _____+_____

Peptidoglycan is the thick, outermost layer of the cell wall.

About 90% of the Gram-positive cell wall is made of peptidoglycan.

Consists of

a thick, homogenous sheath of peptidoglycan 20-80 nm thick
tightly bound acidic polysaccharides, including teichoic acid and lipoteichoic acid

cell membrane

Retain crystal violet and stain purple

Gram _____-_____

The cell walls of gram-negative bacteria are more chemically complex, thinner and less compact.

Peptidoglycan only 5 – 20% of the cell wall.

Peptidoglycan is **not the outermost layer**, but between the plasma membrane and the outer membrane.

Not accessible to the action of antibiotics.

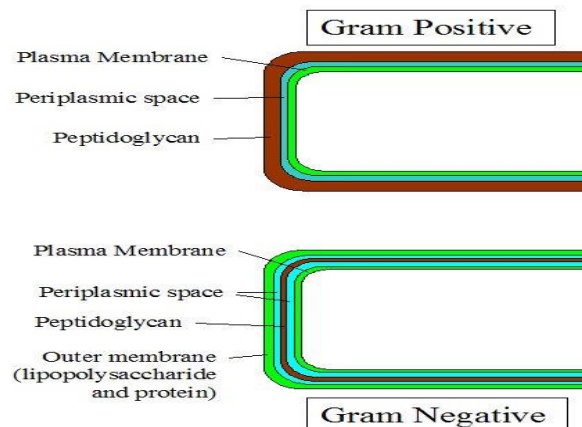
Outer membrane is similar to the plasma membrane, but is less permeable and contains lipopolysaccharides (LPS).

LPS is a harmful substance classified as an endotoxin.

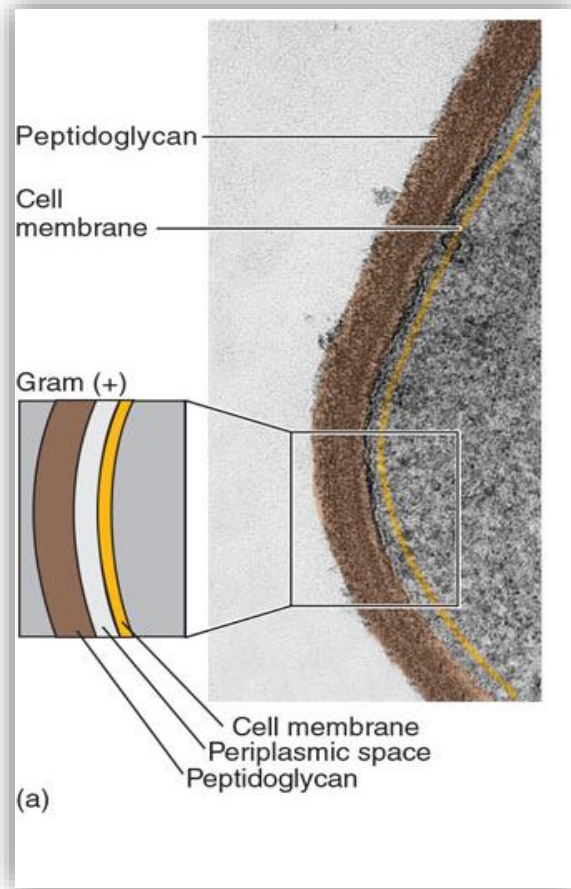
Consists of

an outer membrane containing lipopolysaccharide (LPS)
thin shell of peptidoglycan
periplasmic space
inner membrane

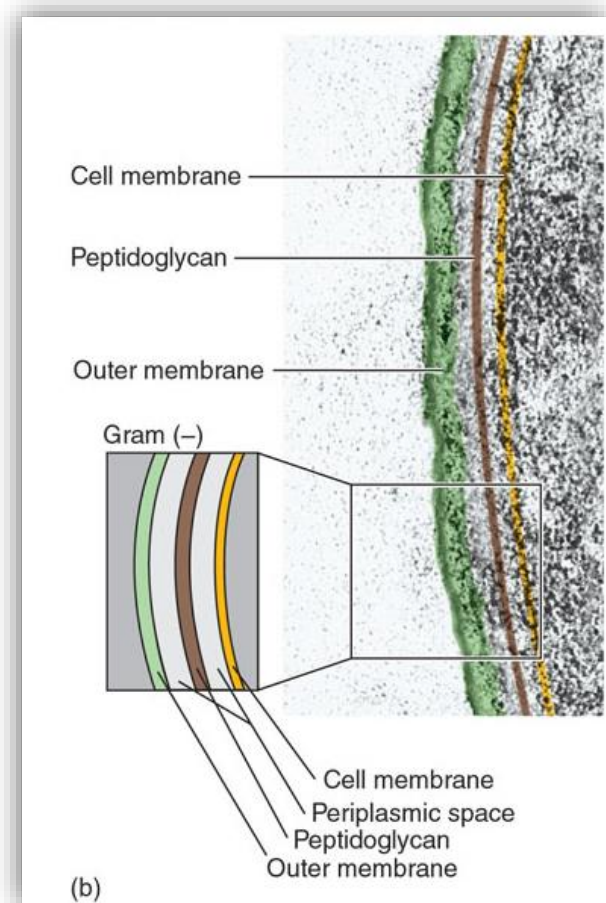
Lose crystal violet and stain red from safranin counterstain



















Gram positive wall



Gram negative cell wall



Step	Microscopic Appearance of Cell		Chemical Reaction in Cell Wall (very magnified view)	
	Gram (+)	Gram (-)	Gram (+)	Gram (-)
1. Crystal violet				
2. Gram's iodine				
3. Alcohol				
4. Safranin (red dye)				

Both cell walls affix the dye

Dye crystals trapped in wall

No effect of iodine

Crystals remain in cell wall

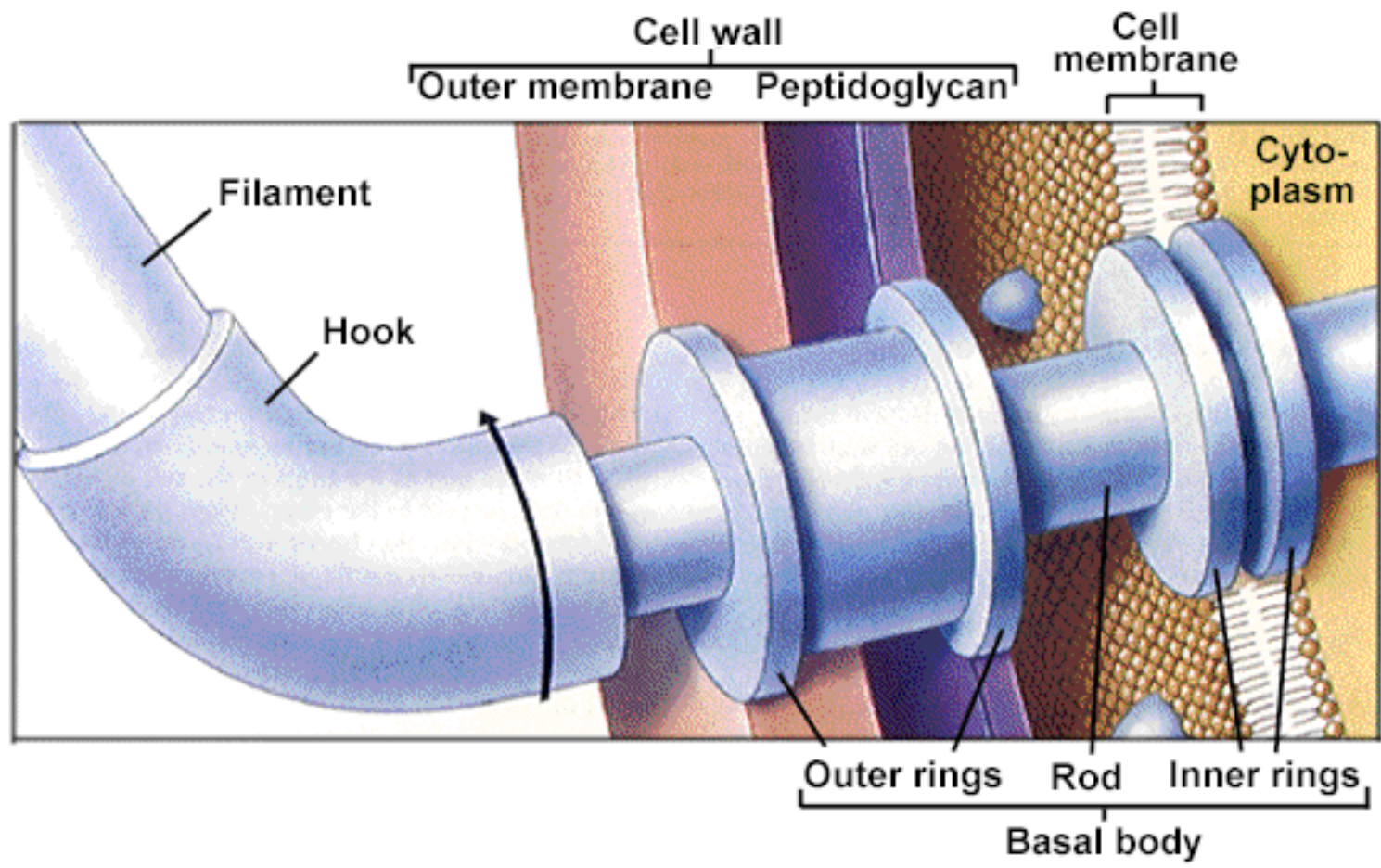
Cell wall partially dissolved, loses dye

Red dye has no effect

Red dye stains the colorless cell

Flagellum

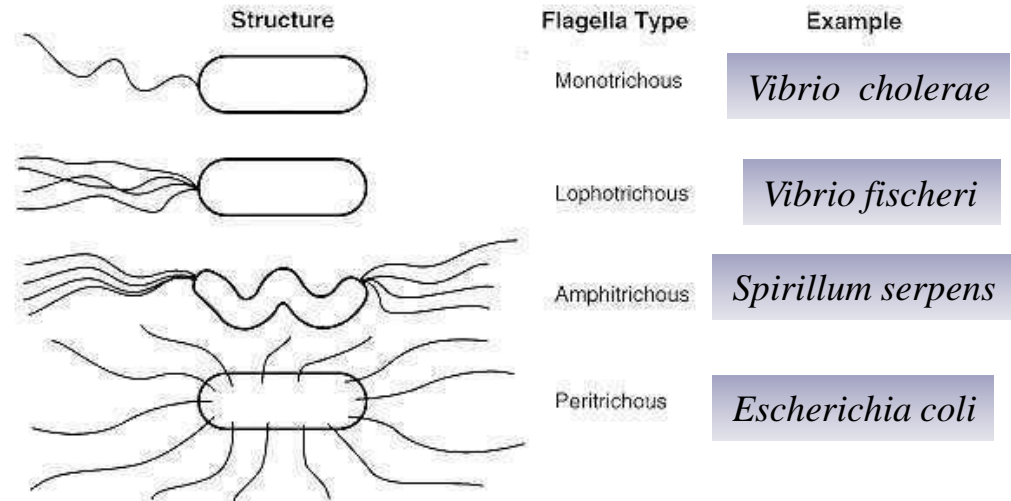
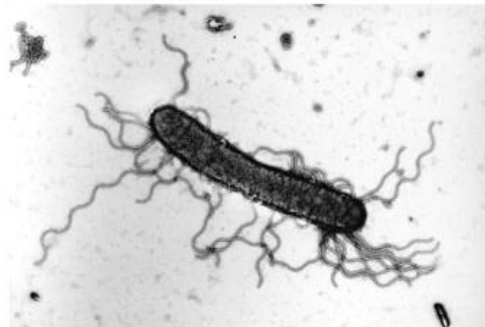
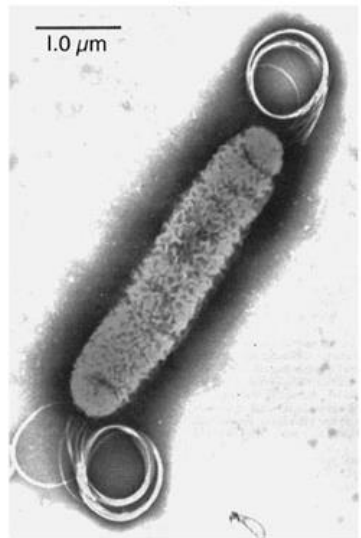
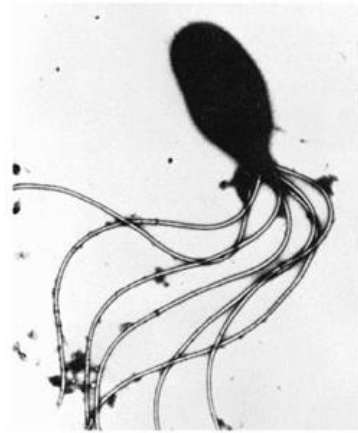
- **Flagellum** : Specialized appendage attached to the cell by a basal body that holds a long rotating filament. The movement pushes the cell forward and provides motility . (20 nm in diameter and 15-20 μm long)
- Consist of **Tree** Parts :
 - filament : long, thin, helical structure composed of proteins
 - Hook : curved sheath
 - basal body : stack of rings firmly anchored in cell wall, In gram negative bacteria, there are two pair of rings, In gram positive bacteria, only the inner pair is present.
- rotates 360°
- One to two or many distributed over entire cell



Flagellar arrangements

1. **monotrichous** : single flagellum at one end
2. **lophotrichous** : small bunches arising from one end of cell
3. **amphitrichous** : flagella at both ends of cell
4. **peritrichous** : flagella dispersed over surface of cell, slowest

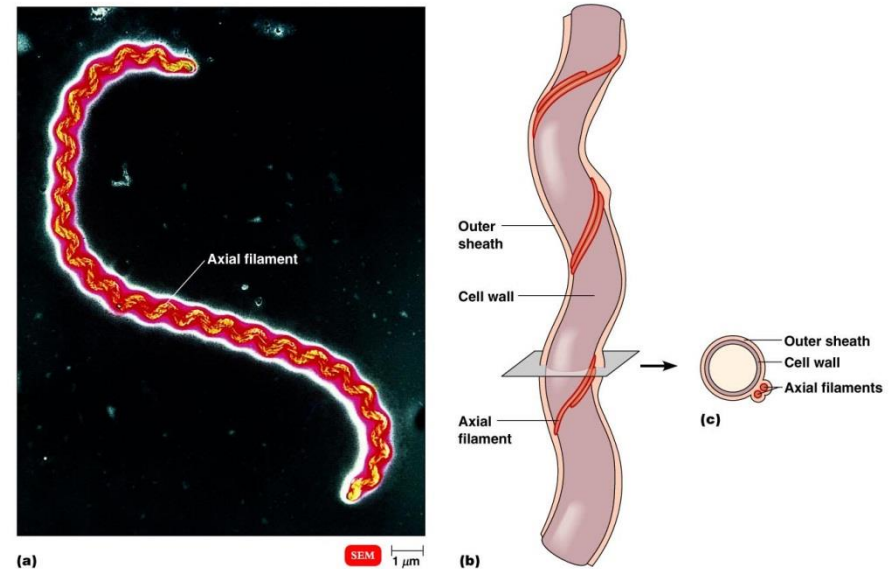
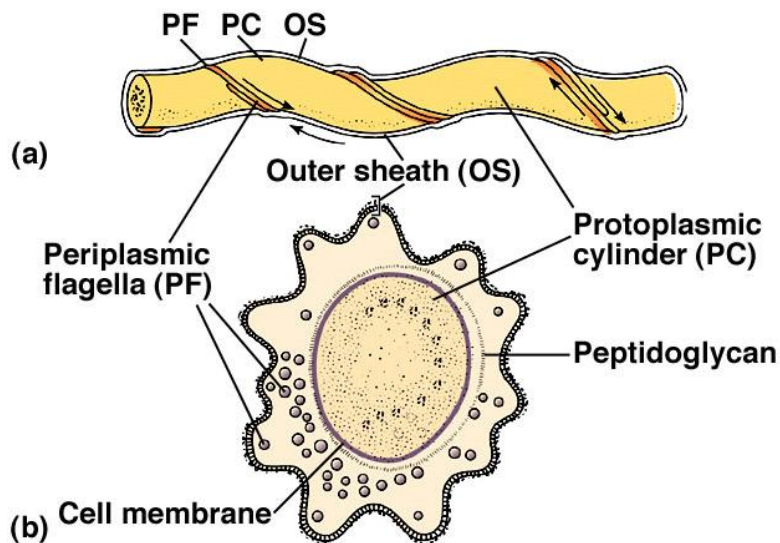
Flagellar arrangements



Axial filaments

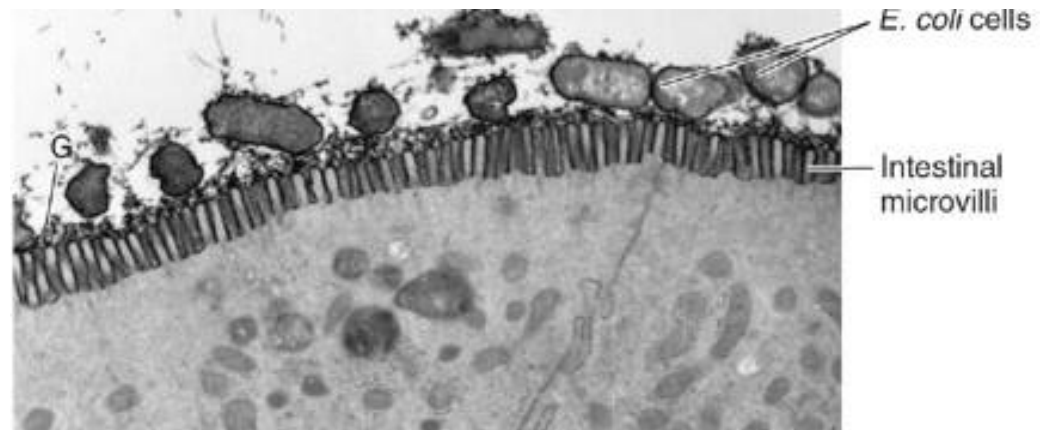
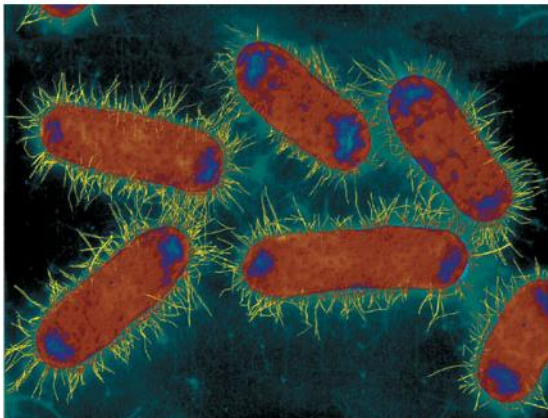
- periplasmic, internal flagella, enclosed between cell wall and cell membrane of spirochetes
- Motility
- *Treponema pallidum* causes syphilis

Q: What is the difference between flagella and axial filaments?



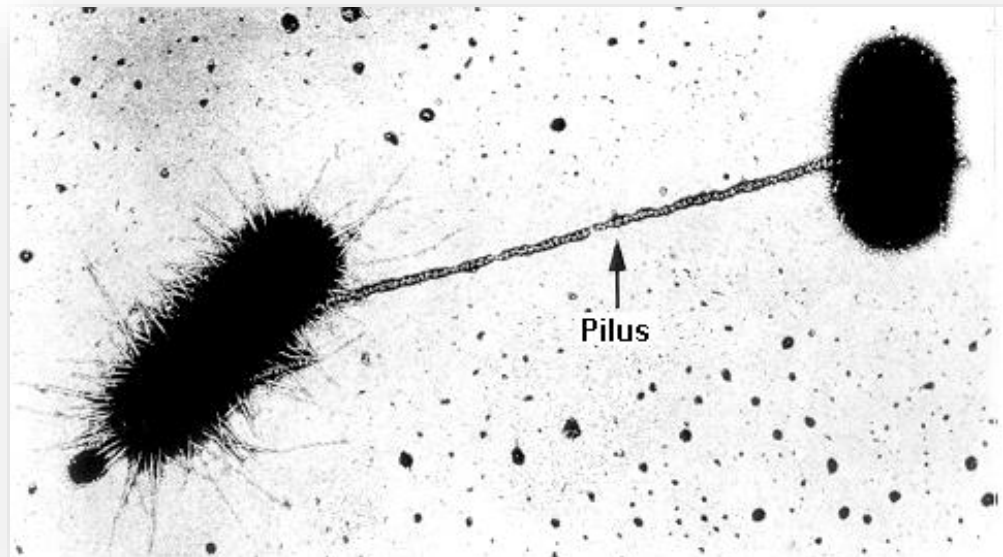
Fimbriae

- fine hairlike bristles from the cell surface
- found on many **Gram-negative** and some **Gram-positive** bacteria
- thinner and shorter than a flagellum
- function in adhesion to other cells and surfaces
- Fimbriae are one of the primary mechanisms of **virulence** for *E. coli*, *Bordetella pertussis*, *Staphylococcus* and *Streptococcus* bacteria. Their presence greatly enhances the bacteria's ability to attach to the host and cause disease.



pili

- rigid tubular structure found on the surface of bacteria
- All pili are primarily composed of **oligomeric pilin proteins**
- found only in Gram negative cells
- Functions
 - joins bacterial cells for DNA transfer (conjugation)
 - adhesion

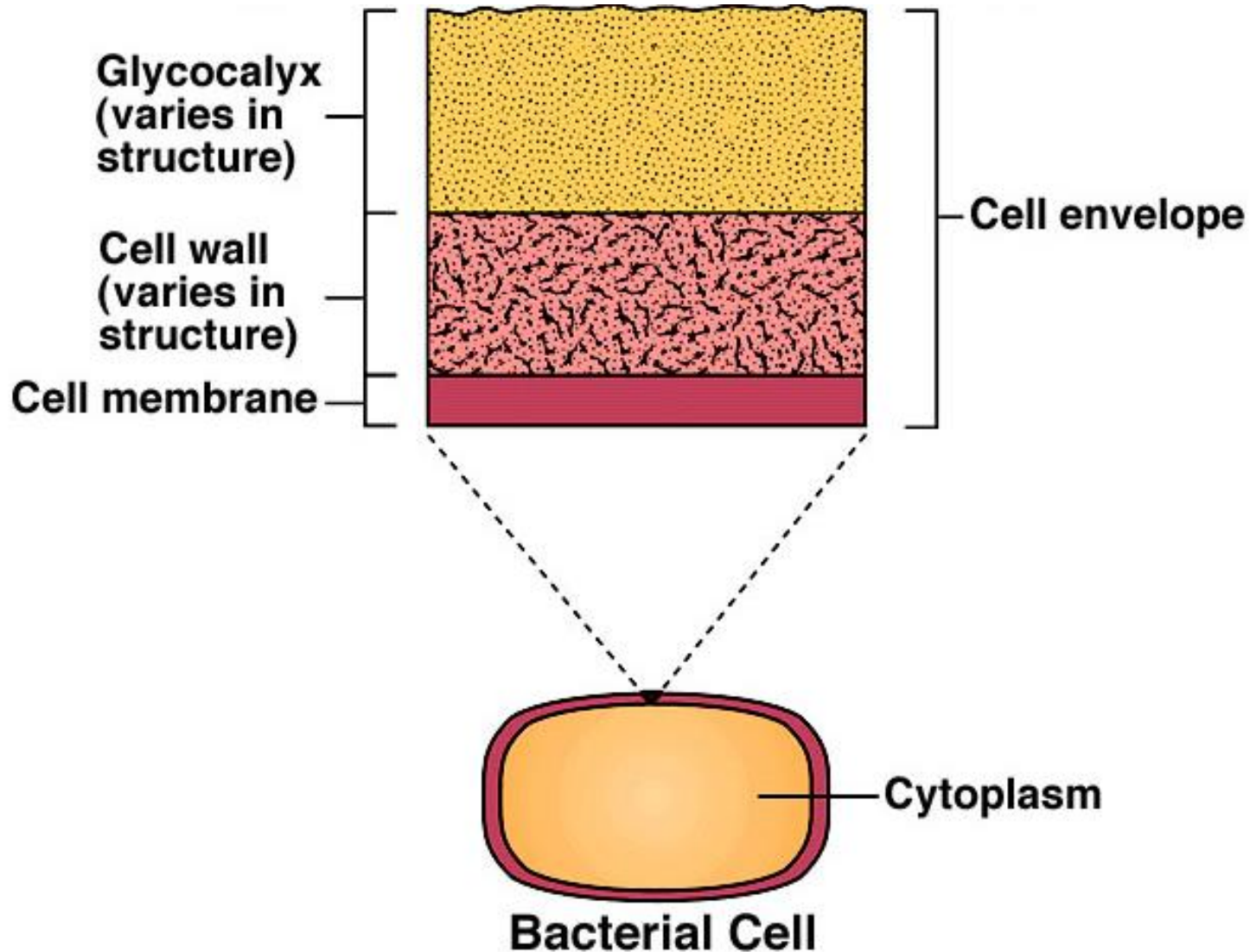


Conjugation

Glycocalyx

- Glycocalyx means sugar coat, and is a sticky, gelatinous polymer that is outside the cell wall made of sugars **and/or** proteins (**glycoprotein**)
- 2 types
 1. capsule - highly organized, tightly attached
 2. slime layer - loosely organized and attached
- functions
 - attachment
 - inhibits killing by white blood cells
 - Receptor
- *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Bacillus anthracis* have them
- *Streptococcus pneumoniae* attaches itself to lung cell by **Glycocalyx**

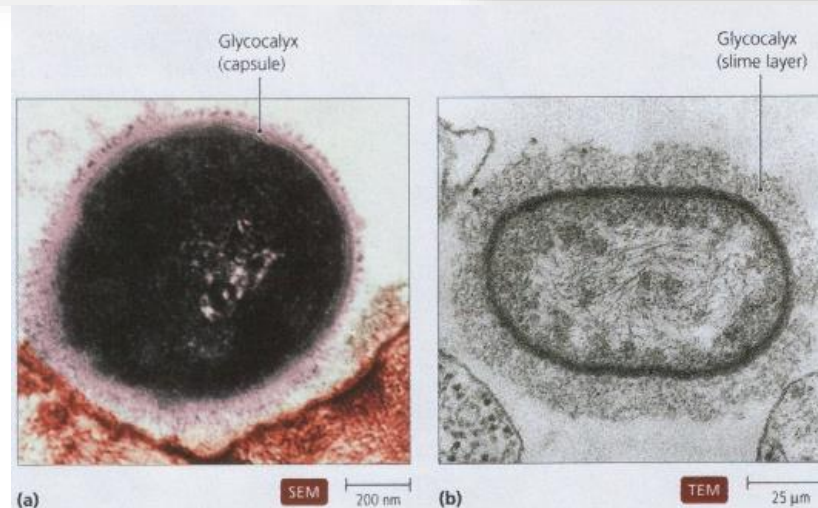
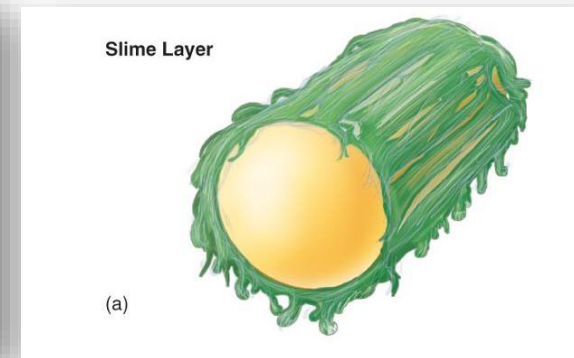
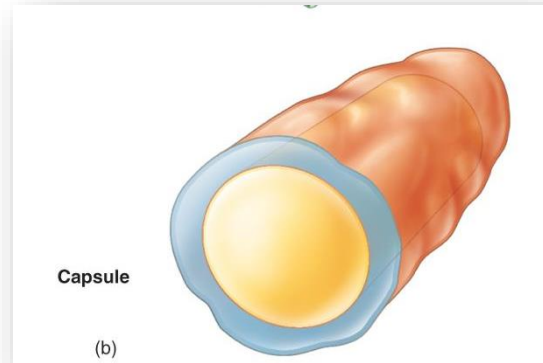
Structure of Glycocalyx



Two Types of Glycocalyx:

A. Slime Layer

B. Capsule



▲ **Figure 3.4**

Glycocalyxes. (a) Micrograph of *Streptococcus pneumoniae*, the common cause of pneumonia, showing a prominent capsule. (b) *Bacteroides*, a common fecal bacterium, has a slime layer surrounding the cell.

Cytoplasm

- dense gelatinous solution of sugars, amino acids, & salts
- 70-80% water
- serves as solvent for materials used in all cell functions

Chromosome

- single, circular, double-stranded DNA molecule that contains all the genetic information required by a cell
- DNA is tightly coiled around a protein, aggregated in a dense area called the **nucleoid**

plasmids

- small circular, double-stranded DNA
- free or integrated into the chromosome
- duplicated and passed on to offspring
- not essential to bacterial growth & metabolism
- may encode antibiotic resistance, tolerance to toxic metals, enzymes & toxins
- used in genetic engineering- readily manipulated & transferred from cell to cell

Ribosomes

- made of 60% ribosomal RNA & 40% protein
- consist of 2 subunits: large & small
- procaryotic differ from eucaryotic ribosomes in size & number of proteins
- site of protein synthesis
- All cells have ribosomes
- The differences in structure allow some [antibiotics](#) to kill bacteria by inhibiting their ribosomes, while leaving human ribosomes unaffected.

Ribosomes

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Ribosome (70S)



Large
subunit
(50S)



Small
subunit
(30S)

Inclusions, granules

- intracellular storage bodies
- vary in size, number & content
- bacterial cell can use them when environmental sources are depleted
- Examples: glycogen, poly- β -hydroxybutyrate, gas vesicles for floating, sulfur and polyphosphate granules

Inclusions

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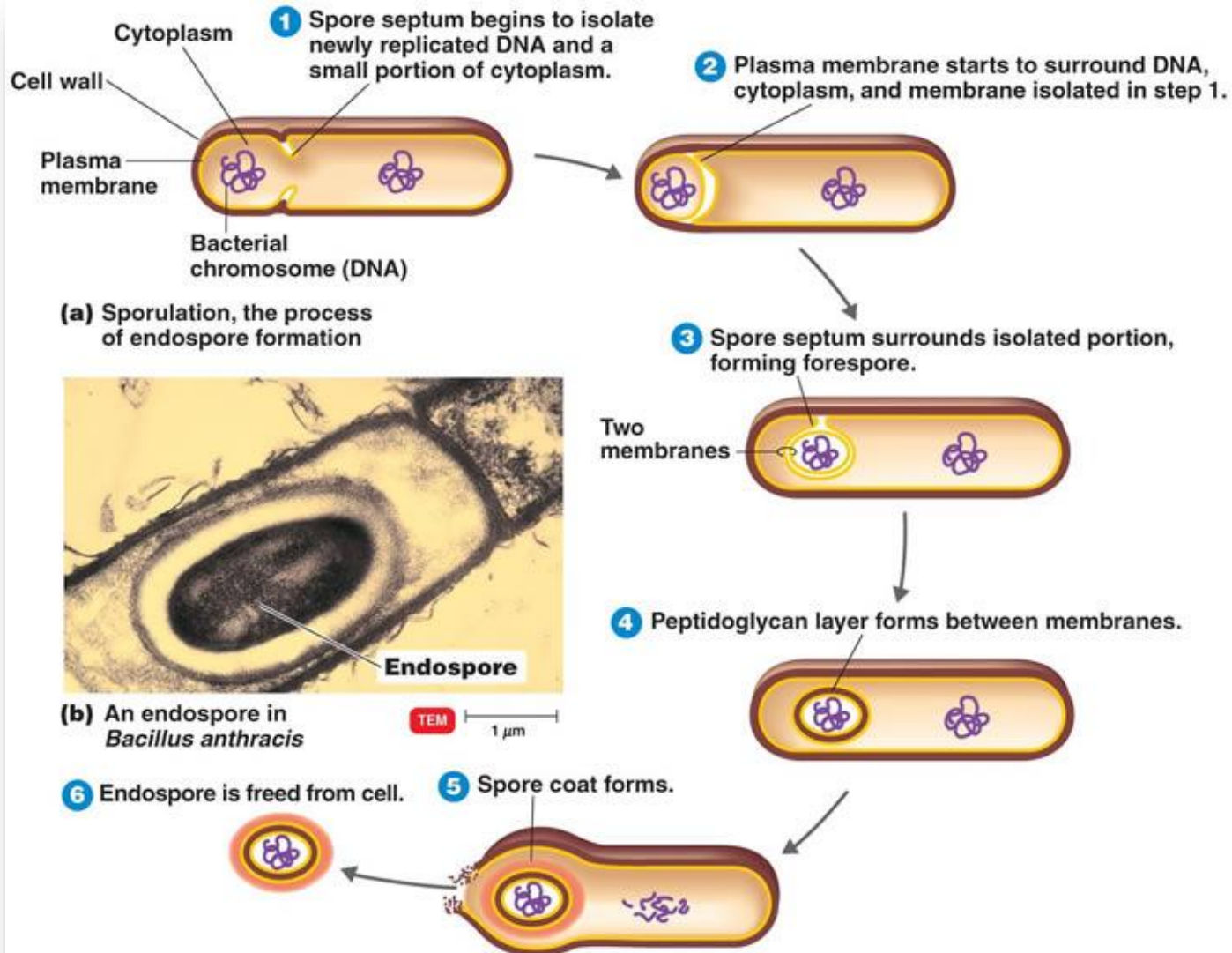
0.5 μm

Storage granules

Endospores

- Resting, dormant cells
- produced by some **G+ genera**: *Clostridium*, *Bacillus* & *Sporosarcina*
- Have a 2-phase life cycle – vegetative cell & an endospore
- **sporulation** -formation of endospores
- **germination**- return to vegetative growth
- hardiest of all life forms
- withstand extremes in heat, drying, freezing, radiation & chemicals not a means of reproduction

Endospores



Shapes of bacteria

- cocci - spherical
- bacilli - rod
- spiral - helical, comma, twisted rod, spirochete`

Shapes of Bacteria

- Coccus (cocci = spherical)
 - Chain = Streptococcus
 - Cluster = Staphylococcus
- Bacillus(bacilli = rod)
 - Chain = Streptobacillus
- Coccobacillus
- Spiral :
- Vibrio = curved
- Spirillum
- Spirochete
- Square
- Star



Coccus



Coccobacillus



Vibrio












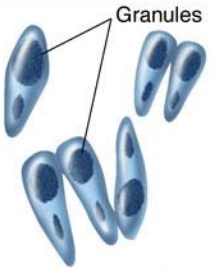






Bacillus



Spirillum



Spirochete

 <p>Coccus</p>		 <p>Rod, or bacillus</p>		 <p>Curved forms: Spirillum/Spirochete</p>	
 <p>Diplococci (cocci in pairs)</p>	 <p>Neisseriae (coffee-bean shape in pairs)</p>	 <p>Coccobacilli</p>		 <p>Vibrios (curved rods)</p>	
 <p>Tetrads (cocci in packets of 4)</p>	 <p>Sarcinae (cocci in packets of 8, 16, 32 cells)</p>	 <p>Mycobacteria</p>	 <p>Granules Corynebacteria (palisades arrangement)</p>	 <p>Spirilla</p>	
 <p>Streptococci (cocci in chains)</p>	 <p>Micrococci and staphylo- cocci (large cocci in irregular clusters)</p>	 <p>Spores Spore-forming rods</p>	 <p>Streptomycetes (moldlike, filamentous bacteria)</p>	 <p>Spirochetes</p>	

Methods in bacterial identification

1. Microscopic morphology
2. Macroscopic morphology – colony appearance
3. Physiological / biochemical characteristics
4. Chemical analysis
5. Serological analysis
6. Genetic & molecular analysis
 - G + C base composition
 - DNA analysis using genetic probes
 - Nucleic acid sequencing & rRNA analysis

Major Taxonomic Groups of Bacteria per *Bergey's manual*

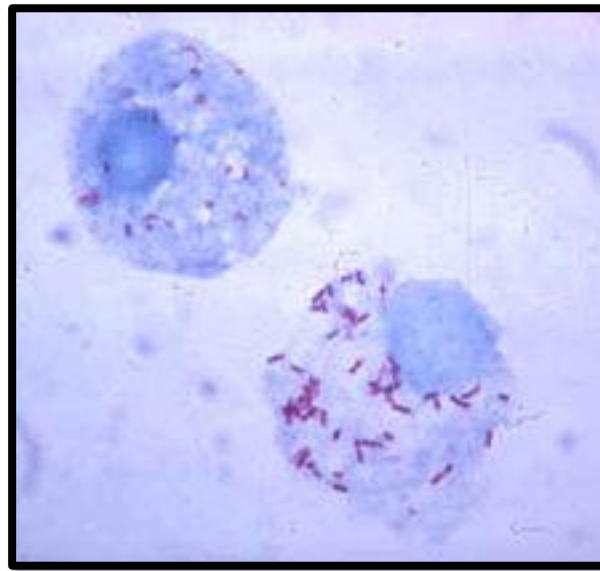
- **Gracilicutes** – gram-negative cell walls, thin-skinned
- **Firmicutes** – gram-positive cell walls, thick skinned
- **Tenericutes** – lack a cell wall & are soft
- **Mendosicutes** – archaea, primitive procaryotes with unusual cell walls & nutritional habits



Prokaryotes with unusual characteristics

Rickettsia

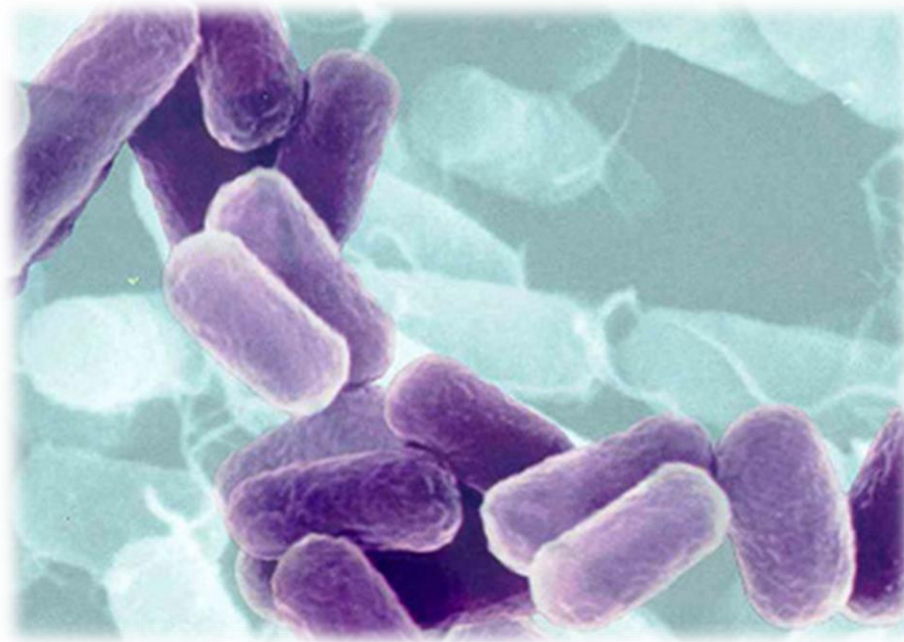
Rickettsia : is a genus of non-motile, very tiny, Gram-negative, non-sporeforming, highly pleomorphic bacteria . Being obligate intracellular parasites, the *Rickettsia* survival depends on entry, growth, and replication within the cytoplasm of eukaryotic host cells . Because of this, *Rickettsia* cannot live in artificial nutrient environments and are grown either in tissue or embryo cultures (typically, chicken embryos are used). In the past they were positioned somewhere between viruses and true bacteria. The majority of *Rickettsia* bacteria are susceptible to antibiotics of the tetracycline group.



Rickettsias

- most are pathogens that alternate between mammals and fleas, lice or ticks
- cannot carry out metabolism on their own
- *Rickettsia rickettsii* – Rocky Mountain spotted fever
- *Rickettsia prowazekii* – epidemic typhus
- *Coxiella burnetti* – Q fever

Chlamydia : A genus of pathogenic bacteria . It is tiny, obligate intracellular parasites , not transmitted by arthropods, caused many diseases to human and animal .

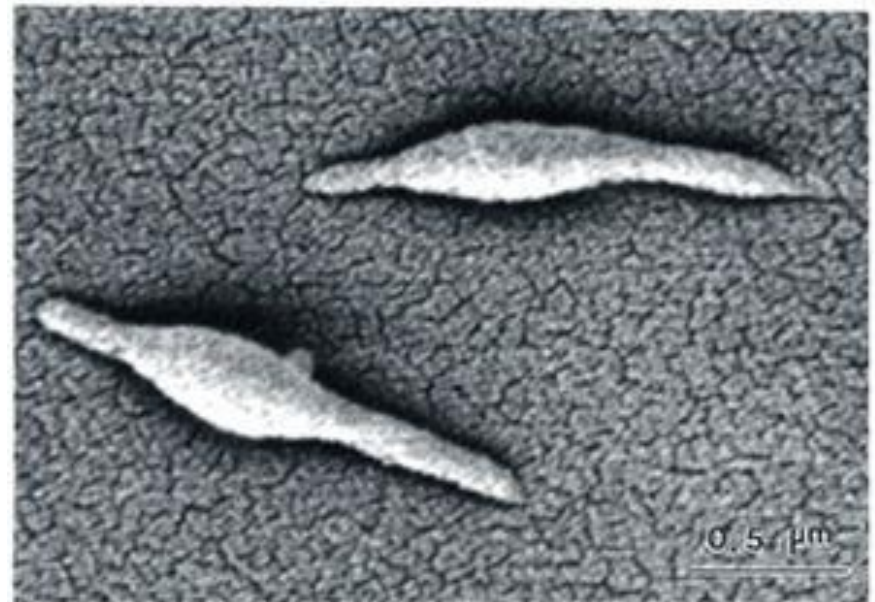
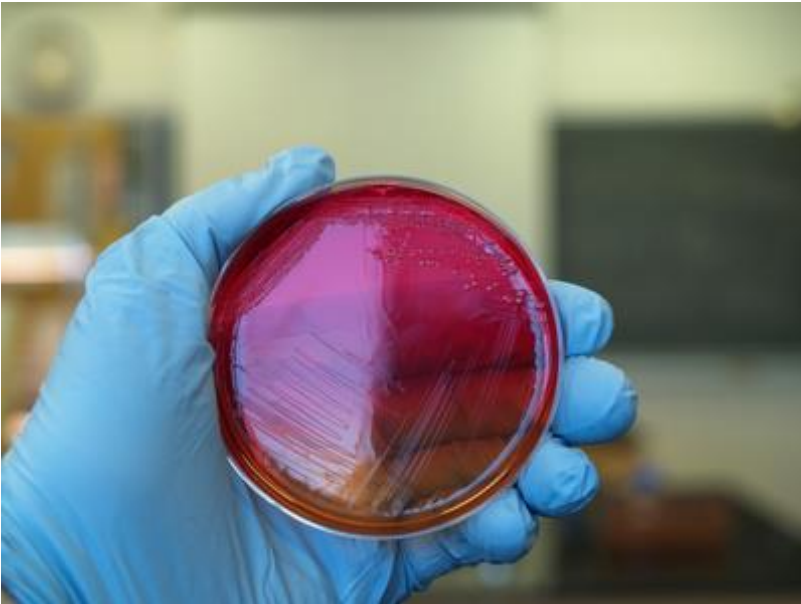


Chlamydias

- *Chlamydia trachomatis* : causing human sexually transmitted disease and severe eye infection .
- *Chlamydia psittaci* : A highly virulent chlamydial species prevalent in birds (ornithosis) parrot fever.
- *Chlamydia pneumoniae* : An airborne chlamydial species responsible for human respiratory infection and numerous animal infections (lung infections).

Mycoplasmas

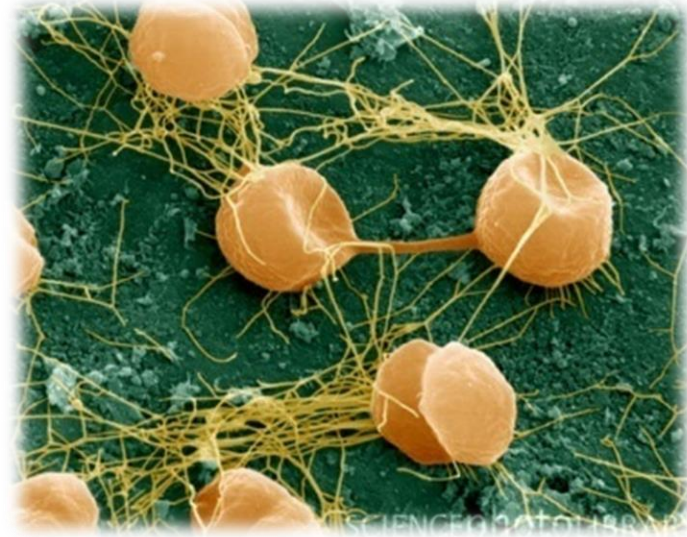
Tenericutes - lack a cell wall & are soft



- ***Mycoplasma*** : refers to a genus of bacteria that lack a cell wall (Without a cell wall), they are unaffected by many common antibiotics such as penicillin or other beta-lactam antibiotics that target cell wall synthesis. They can be parasitic or saprotrophic. Several species are pathogenic in humans, including *M. pneumoniae*, which is an important cause of atypical pneumonia and other respiratory disorders, and *M. genitalium*, which is believed to be involved in pelvic inflammatory diseases.
- stabilized by sterols, resistant to lysis
- extremely small
- range in shape from filamentous to coccus or doughnut shaped

Archaea

Are a group of single-celled microorganisms . A single individual or species from this domain is called an *archaeon* . They have no cell nucleus or any other membrane-bound organelles within their cells.



Archaea: the other procaryotes

Mendosicutes - archaea, primitive procaryotes with unusual cell walls & nutritional habits

- constitute third Domain Archaea
- seem more closely related to Domain Eukarya than to bacteria
- contain unique genetic sequences in their rRNA
- have unique membrane lipids & cell wall construction
- live in the most extreme habitats in nature, extremophiles
- adapted to heat salt acid pH, pressure & atmosphere
- includes: methane producers, hyperthermophiles, extreme halophiles, and sulfur reducers

Types of Culture Media For Bacterial Growth



Culture medium

- **Culture medium**: is a method of multiplying microbial organisms by letting them reproduce in predetermined culture media under controlled laboratory conditions.
- **Liquid (broth) vs. semisolid media**
 - Liquid medium
 - Components are dissolved in water and sterilized
 - Semisolid medium
 - A medium to which has been added a gelling agent
 - Agar (most commonly used)
 - Gelatin
 - Silica gel (used when a non-organic gelling agent is required)

- Most commonly used:
 - **nutrient broth** – liquid medium containing beef extract & peptone
 - **nutrient agar** – solid media containing beef extract, peptone & agar
- **agar** is a complex polysaccharide isolated from red algae
 - solid at room temp, liquefies at boiling (100°C), does not resolidify until it cools to 42°C
 - provides framework to hold moisture & nutrients
 - not digestible for most microbes

Types of Culture Media

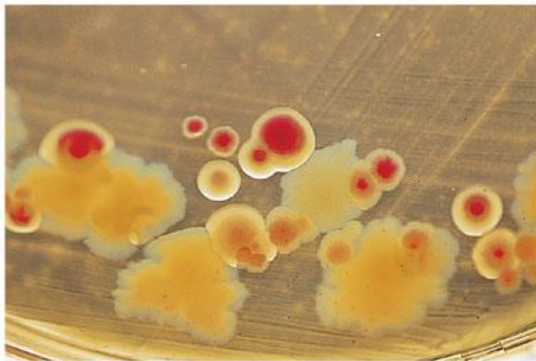
- **general purpose media-** grows a broad range of microbes, usually nonsynthetic
- **Selective medium:** encourages growth of some organisms but suppresses growth of others (Inhibits the growth of some bacteria while selecting for the growth of others)
Example: (e.g. antibiotics)
- **Differential medium:** Differentiates between different organisms growing on the same plate (e.g. MacConkey agar).
Blood Agar Plates used to differentiate different types of *Streptococci*.
- **Enrichment medium:** contains special nutrients that allow growth of a particular organism that might not otherwise be present in sufficient numbers to allow it to be isolated and identified. (contains complex organic substances such as blood, serum, hemoglobin or special growth factors required by fastidious microbes)

selective & differential media

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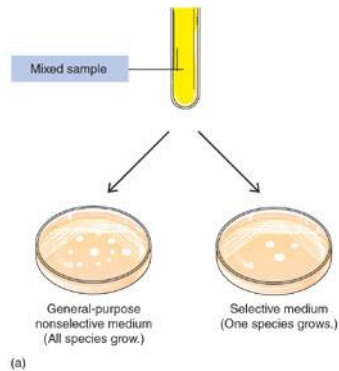


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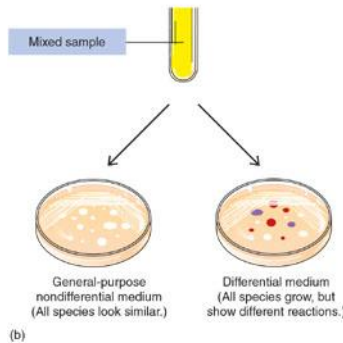


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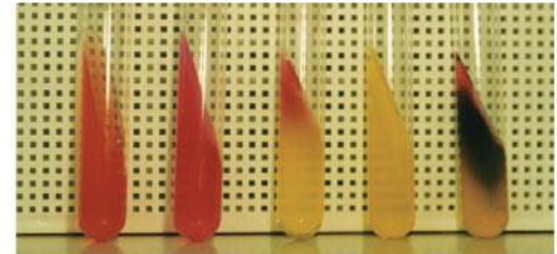


(a)



(b)

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(a)



(b)

Q:

- the flagella is a project as strand while the axial filaments are spirochetes.

* flagella : move cell by propeller like action ,
axial filaments : snake-like movement.

flagella : present in gram (+)and gram (-) , while
the filaments only in gram (-) .

both of them have the same function