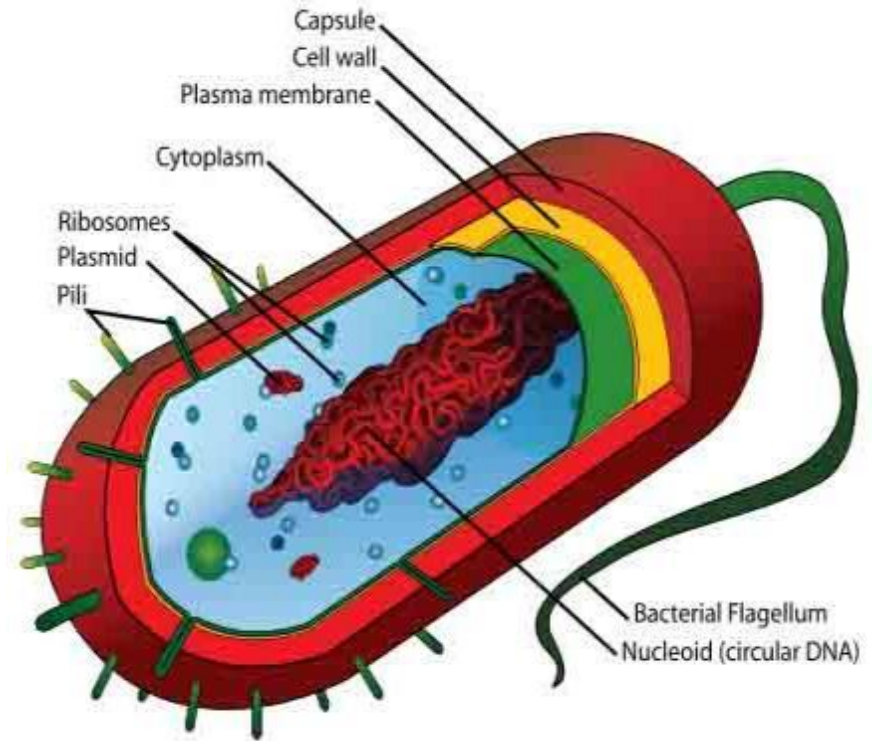


Dr. H. N. Sinha Arts And Commerce College, Patur



Prokaryotic Cell Structure & Function

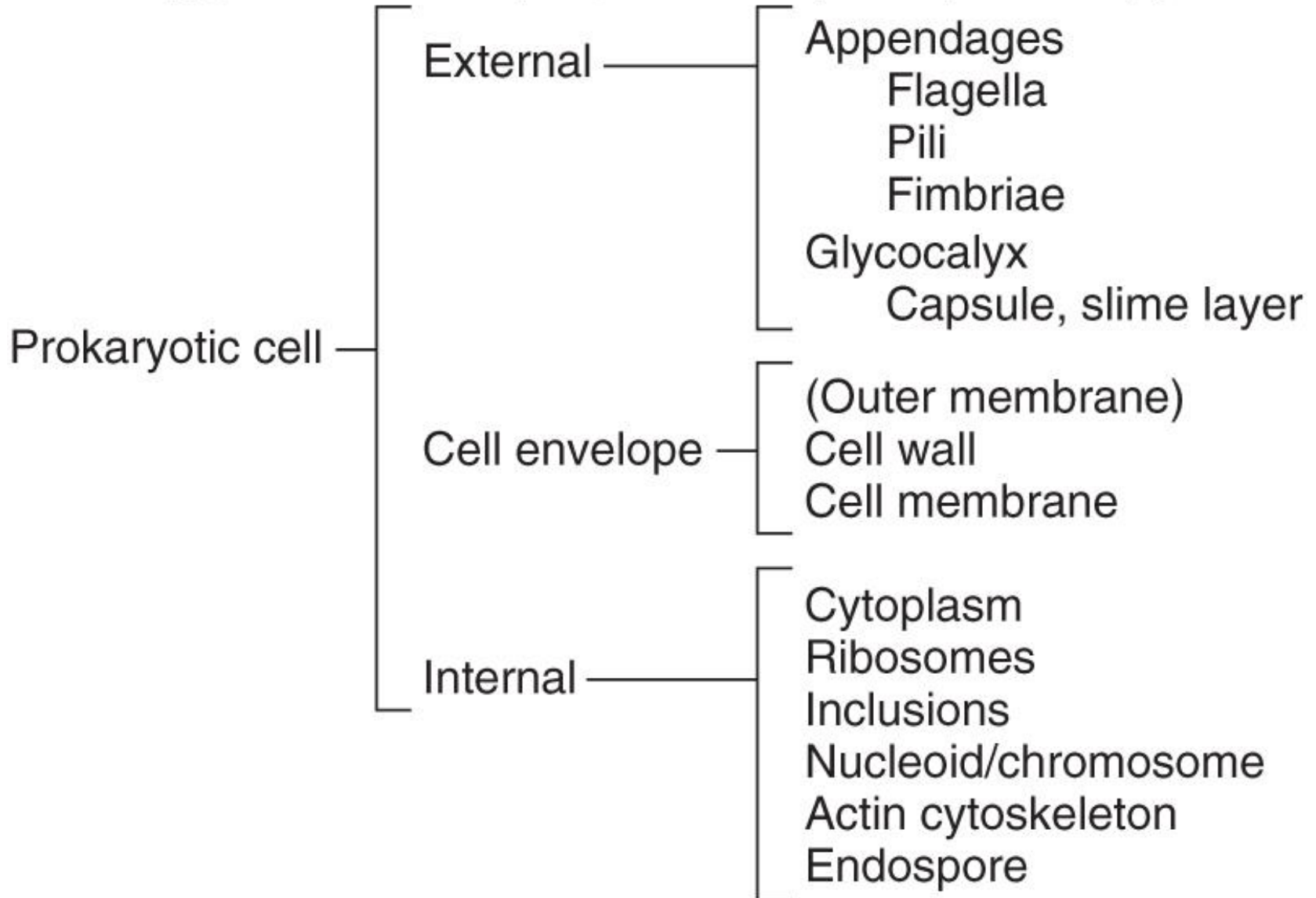
Presented by: Namrata A. Mohod

How are Prokaryotes Different from Eukaryotes?

- The way their DNA is packaged
 - No nucleus
 - Not wrapped around **histones**
- The makeup of their cell wall
 - Bacteria- peptidoglycan
 - Archae- tough and made of other chemicals, distinct to them
- Their internal structures
 - No complex, membrane-bound organelles

4.1 Prokaryotic Form and Function

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Structures in bacterial cells

Structures common to all bacterial cells

- Cell membrane
- Cytoplasm
- Ribosomes
- One (or a few) chromosomes

Structures found in most bacterial cells

- Cell wall
- Surface coating or glycocalyx

Structures found in some bacterial cells

- Flagella
- Pili
- Fimbriae
- Capsules
- Slime layers
- Inclusions
- Actin cytoskeleton
- Endospores

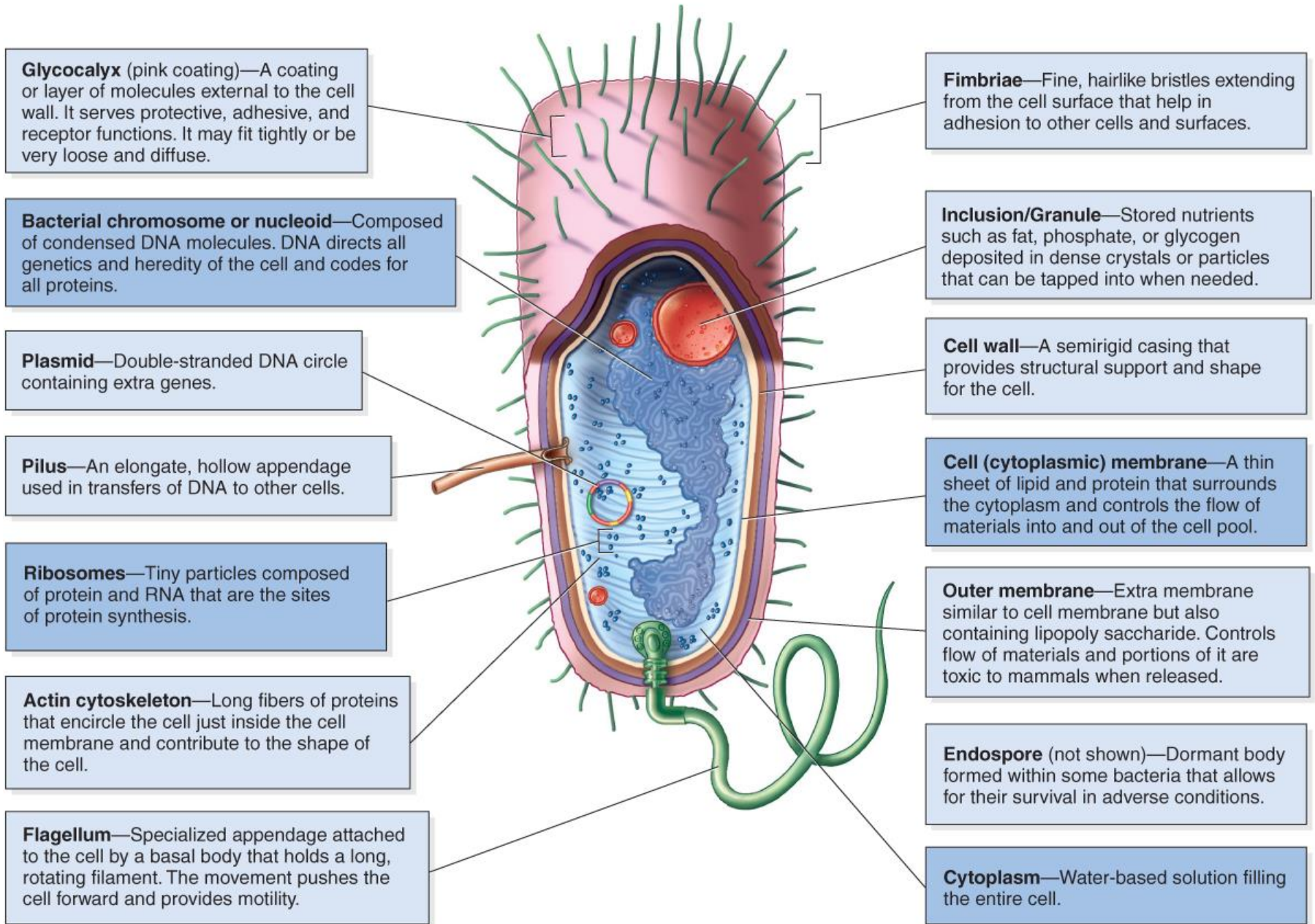


Figure 4.1

Bacterial Internal Structure

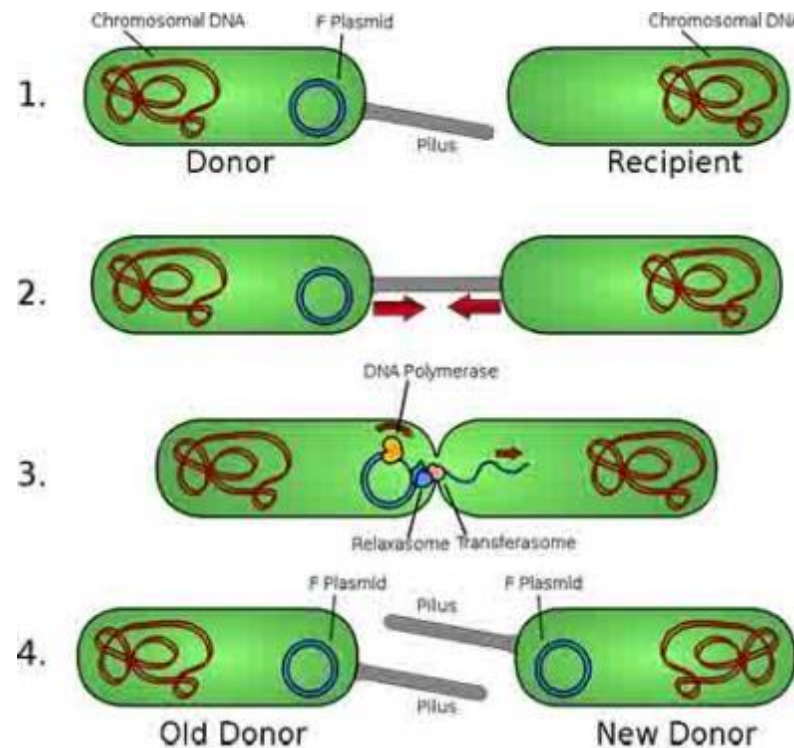
- Contents of the Cell **Cytoplasm**
 - Gelatinous solution
 - Site for many biochemical and synthetic activities
 - 70%-80% water
 - Also contains larger, discrete cell masses (chromatin body, ribosomes, granules, and actin strands)
 - Location of growth, metabolism, and replication

Bacterial Chromosome

- Single circular strand of DNA
- Aggregated in a dense area of the cell—the **nucleoid**

Plasmids

- Nonessential, circles of DNA (5-100 genes)
- Present in cytoplasm but may become incorporated into the chromosomal DNA
- Often confer protective traits such as drug resistance or the production of toxins and enzymes
- Pass on in conjugation

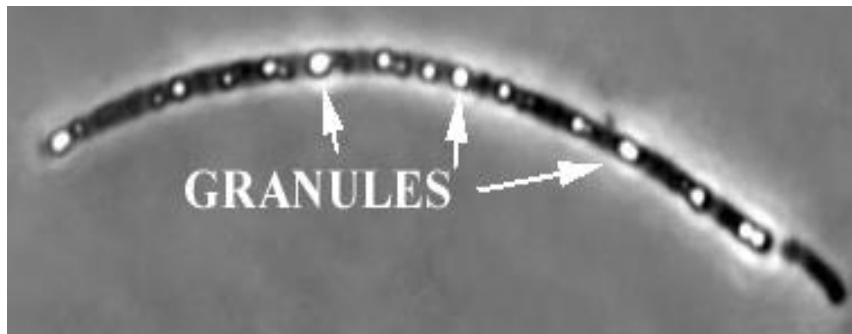


Inclusions

- Inclusions- also known as **inclusion bodies**
 - Some bacteria lay down nutrients in these inclusions during periods of nutrient abundance
 - Serve as a storehouse when nutrients become depleted
 - Some enclose condensed, energy-rich organic substances
 - Some aquatic bacterial inclusions include gas vesicles to provide buoyancy and flotation

Granules

- A type of inclusion body
- Contain crystals of inorganic compounds
- Are not enclosed by membranes
- Staining of some granules aids in identification.



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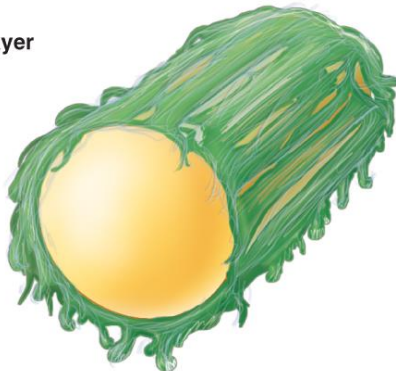
Figure 4.19

The Glycocalyx

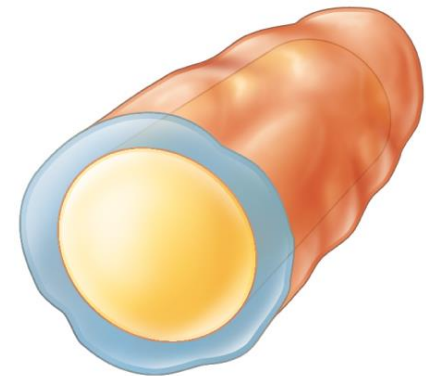
- a coating of repeating polysaccharide, protein, or both
- Protects the cell
- Can help the cell adhere to the environment
- **Slime layer**- a loose shield that protects some bacteria from loss of water and nutrients
- **Capsule**- when the glycocalyx is bound more tightly to the cell and is denser and thicker

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Slime Layer



Capsule



Functions of the Glycocalyx

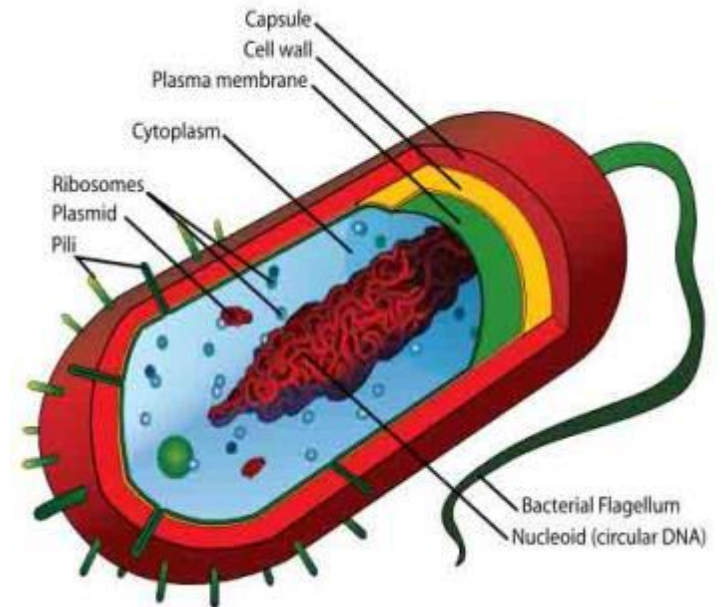
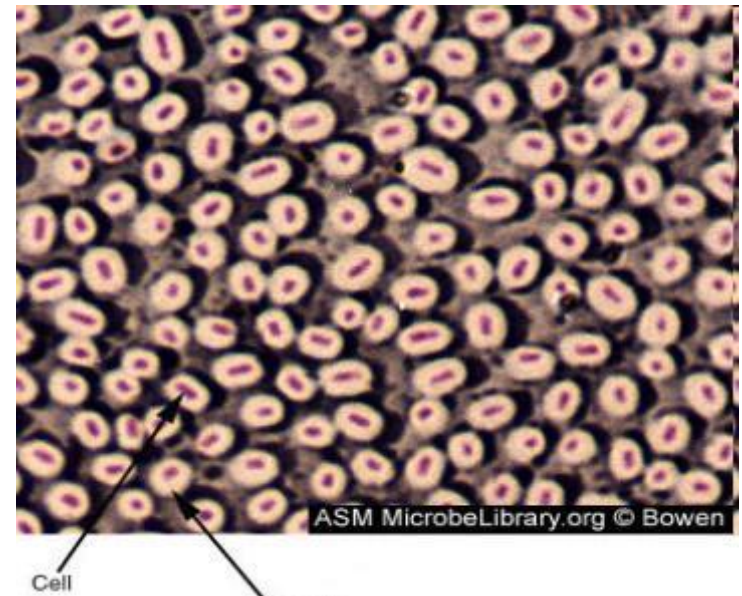
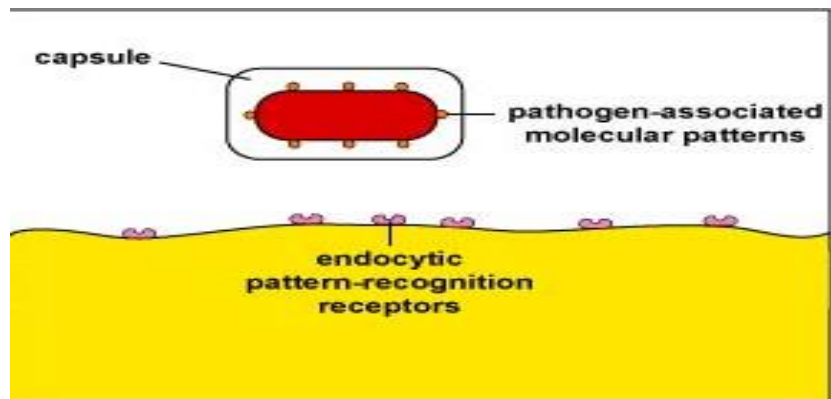
Many pathogenic bacteria have glycocalyxes

- Protect the bacteria against phagocytes
- Important in formation of biofilms
- *Streptococcus*
 - form a biofilm & eventually a buildup of plaque.
 - The slime layer of **Gram+** *Streptococcus mutans* allows it to accumulate on tooth enamel (yuck mouth and one of the causes of cavities).
 - Other bacteria in the mouth become trapped in the slime

Prokaryotes - Glycocalyx

2. Capsule

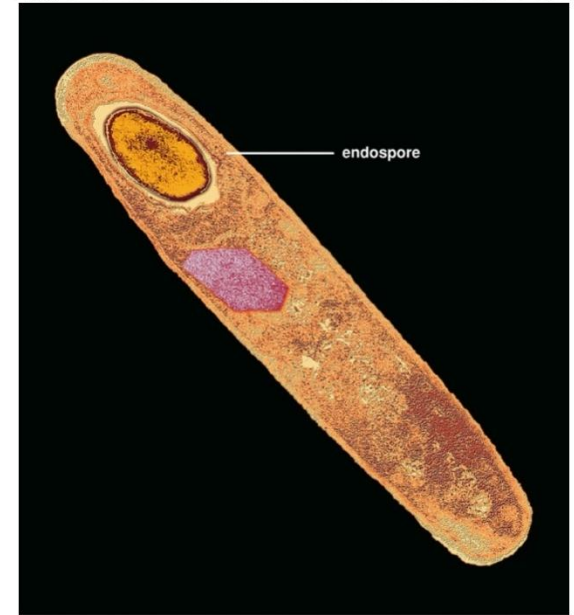
- Polysaccharides firmly attached to the cell wall.
- Capsules adhere to solid surfaces and to nutrients in the environment.
- Adhesive power of capsules is a major factor in the initiation of some bacterial diseases.
- Capsule also protect bacteria from being phagocytized by cells of the hosts immune system.



Bacterial Endospores: An Extremely Resistant Stage

- Dormant, tough, non-reproductive structure produced by small number of bacteria.
- Resistant to radiation, desiccation, lysozyme, temperature, starvation, and chemical disinfectants.
- Endospores are commonly found in soil and water, where they may survive for very long periods of time.

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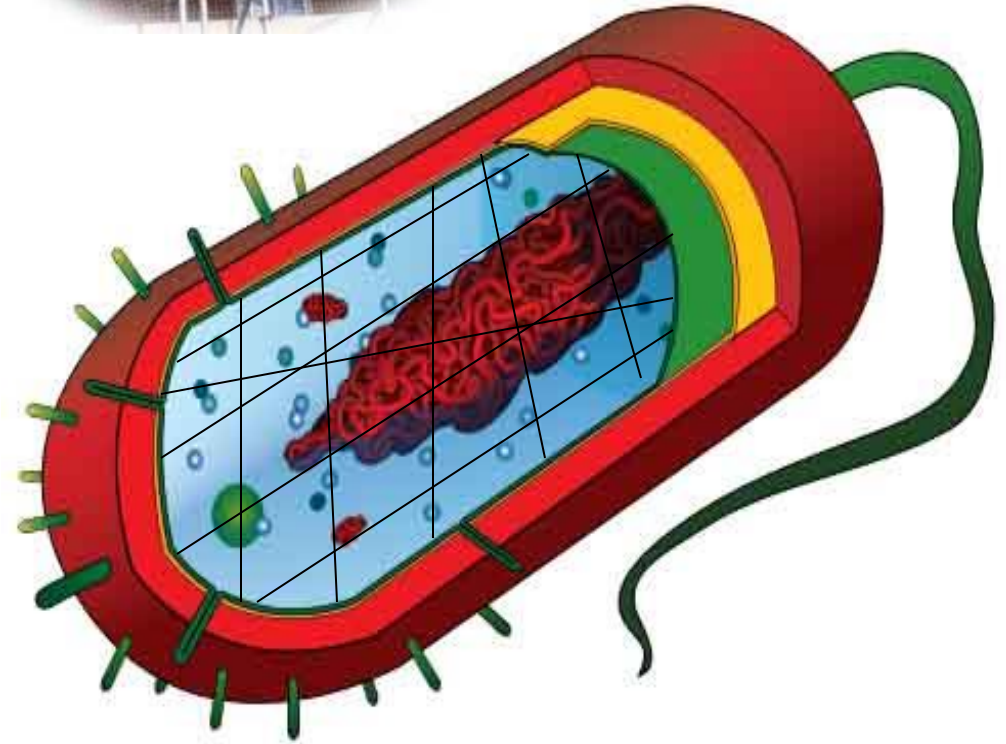


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Prokaryotes

Cytoskeleton

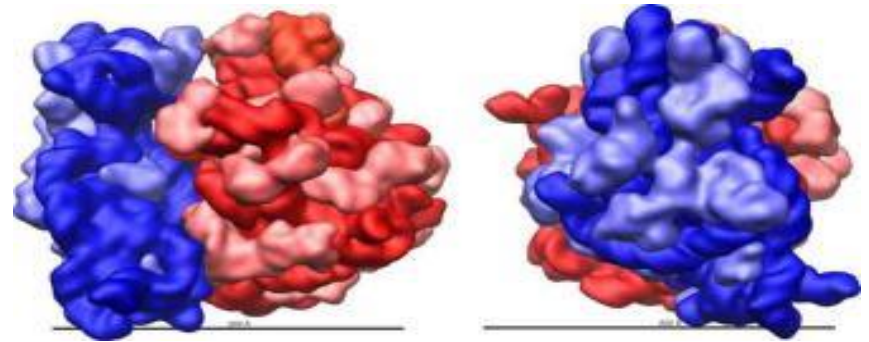
- Cellular "scaffolding" or "skeleton" within the cytoplasm.
- Major advance in prokaryotic cell biology in the last decade has been discovery of the prokaryotic cytoskeleton.
- Up until recently, thought to be a feature only of eukaryotic cells.



Prokaryotes

Ribosomes

- Found within cytoplasm or attached to plasma membrane.
- Made of protein & rRNA.
- Composed of two subunits.
- Cell may contain thousands
- Protein synthesis

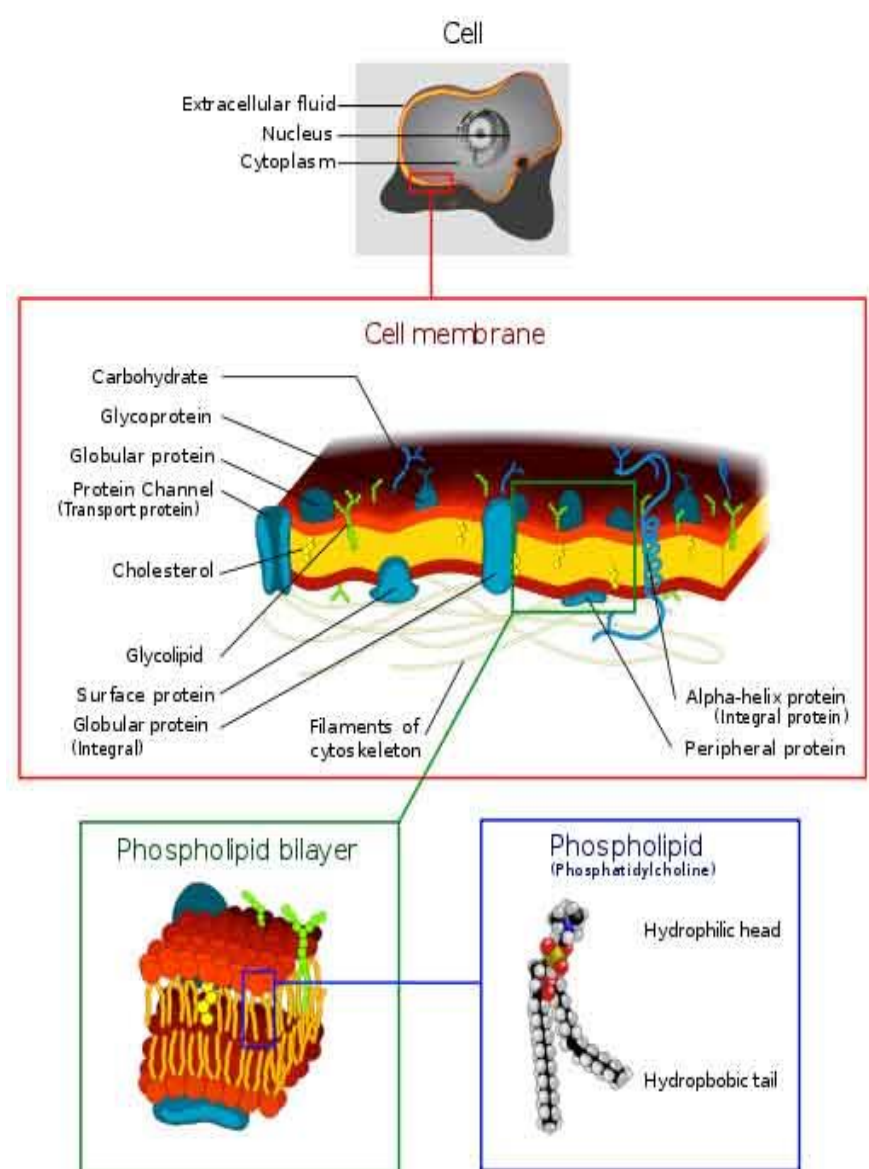


The Cell Envelope: The Boundary layer of Bacteria

- Majority of bacteria have a cell envelope
- Lies outside of the cytoplasm
- Composed of two or three basic layers
 - Cell membrane
 - Cell wall
 - In some bacteria, the outer membrane

Plasma Membrane

- Separates the cell from its environment
- Phospholipid bilayer with proteins embedded in two layers of lipids (lipid bilayer)
- Functions
 - Provides a site for functions such as energy reactions, nutrient processing, and synthesis
 - Regulates transport (selectively permeable membrane)
 - Secretion

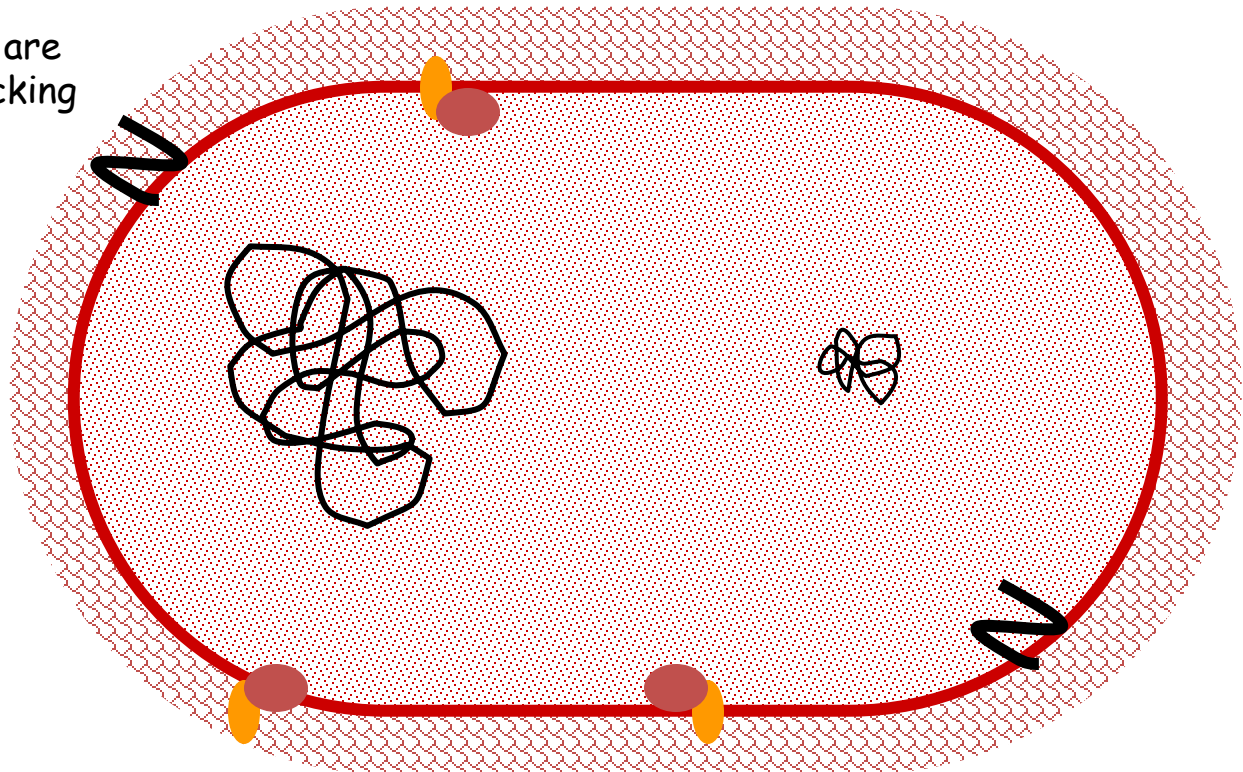
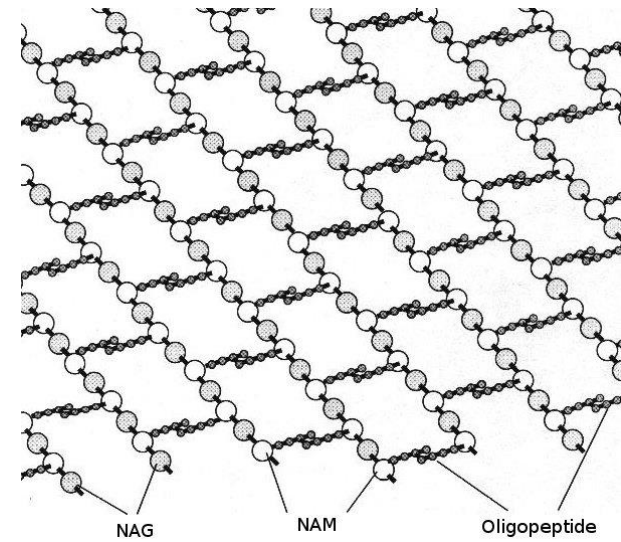


Differences in Cell Envelope Structure

- The differences between **gram-positive** and **gram-negative** bacteria lie in the cell envelope
- Gram-positive
 - Two layers
 - Cell wall and cytoplasmic membrane
- Gram-negative
 - Three layers
 - Outer membrane, cell wall, and cytoplasmic membrane

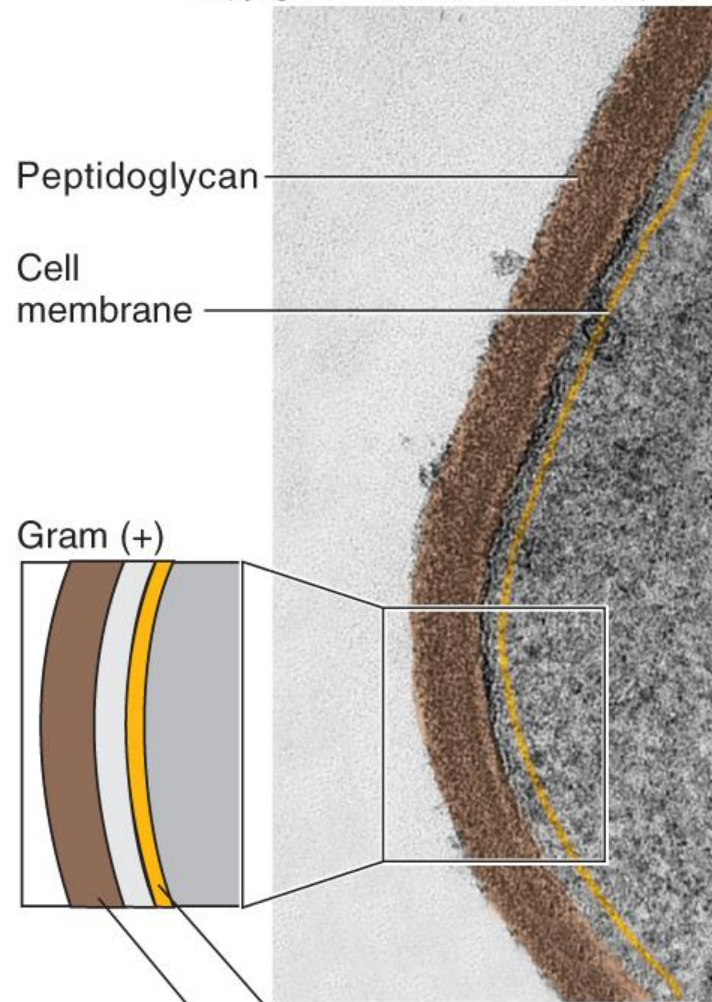
Bacterial Cell Wall

- **Peptidoglycan** is a huge polymer of interlocking chains of alternating monomers.
- Provides rigid support while freely permeable to solutes.
- Backbone of peptidoglycan molecule composed of two amino sugar derivatives of glucose. The "glycan" part of peptidoglycan:
 - N-acetylglucosamine (NAG)
 - N-acetylmuramic acid (NAM)
- NAG / NAM strands are connected by interlocking peptide bridges. The "peptid" part of peptidoglycan.



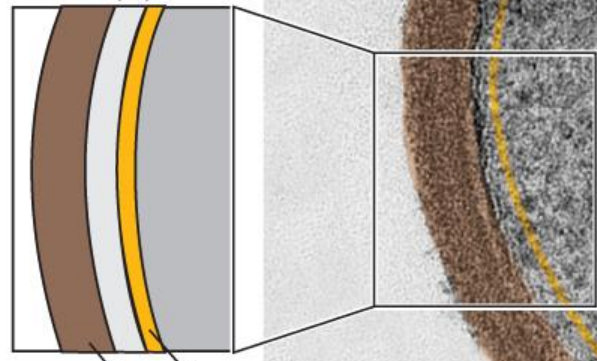
Structure of the Cell Wall

- Provides shape and strong structural support
- Most are rigid because of peptidoglycan content
- Target of many **antibiotics**- disrupt the cell wall, and cells have little protection from **lysis**
- Gram-positive cell (2 layers)
 - A thick (20 to 80 nm) peptidoglycan cell wall and membrane
- Gram-Negative Cell (3 layers)
 - Outer membrane
 - Single, thin (1 to 3 nm) sheet of peptidoglycan (Periplasmic space surrounds the peptidoglycan)
 - Cell membrane



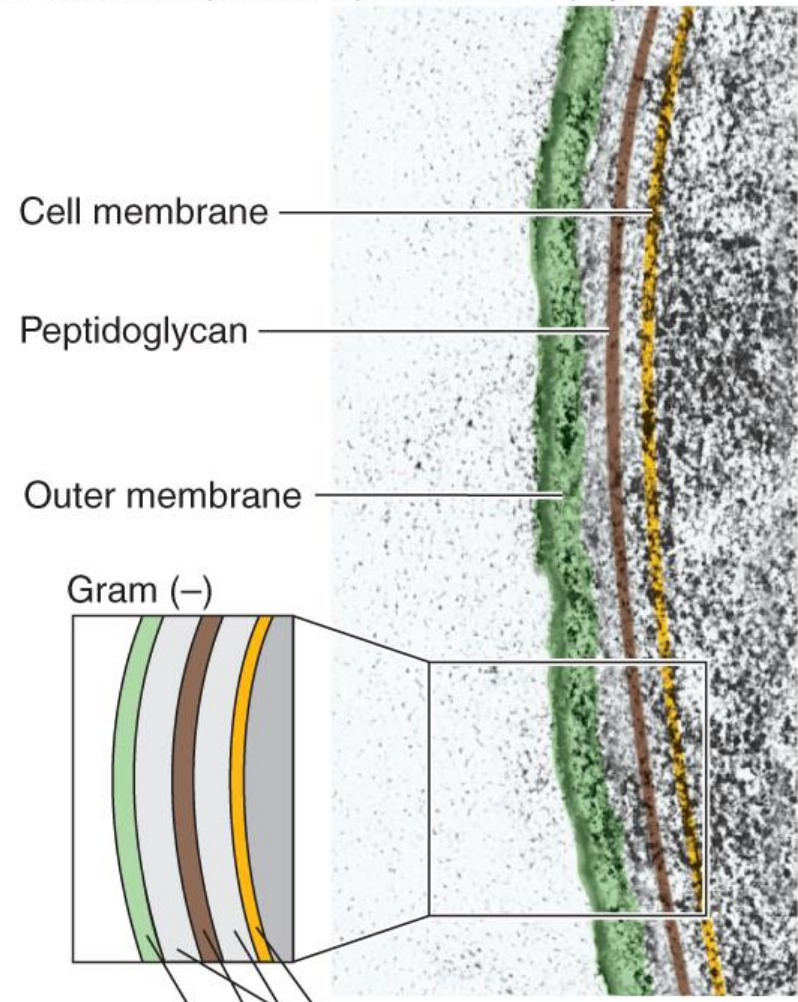
Peptidoglycan
Cell membrane

Gram (+)



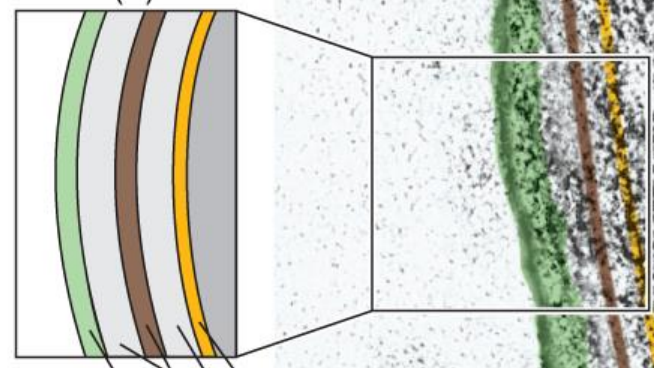
Cell membrane
Peptidoglycan

(a)



Cell membrane
Peptidoglycan
Outer membrane

Gram (-)



Cell membrane
Periplasmic space
Peptidoglycan
Outer membrane

(b)

Figure 4.12

Gram-Positive

Gram-Negative

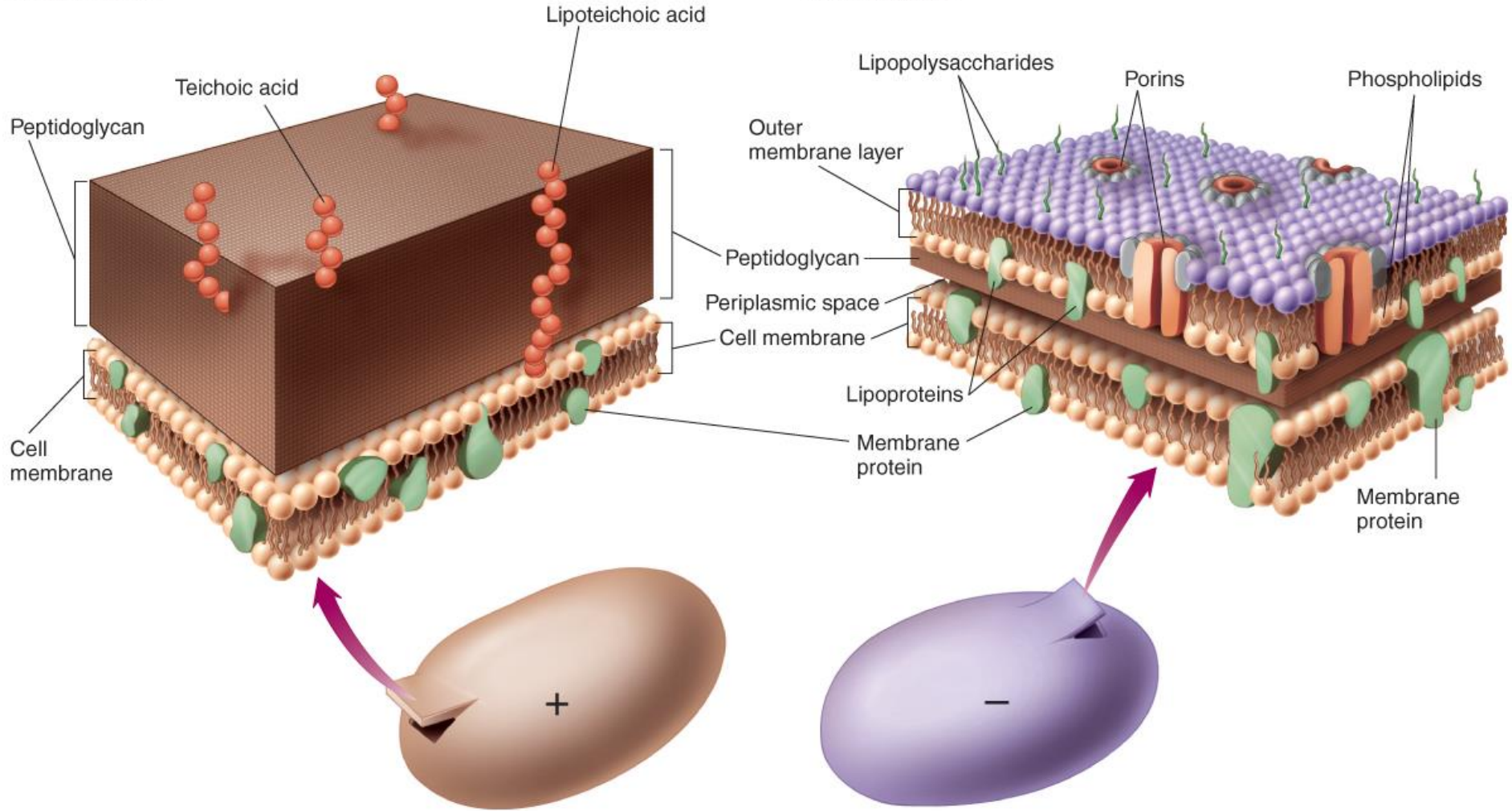


Figure 4.14

The Gram-Negative **Outer Membrane**

- Similar to the cell membrane, except it contains specialized polysaccharides and proteins
- Outermost layer- contains lipopolysaccharide (LPS)
- Innermost layer- phospholipid layer anchored by lipoproteins to the peptidoglycan layer below
- Outer membrane serves as a partial chemical sieve
 - Only relatively small molecules can penetrate
 - Access provided by special membrane channels formed by porin proteins

Practical Considerations of Differences in Cell Envelope Structure

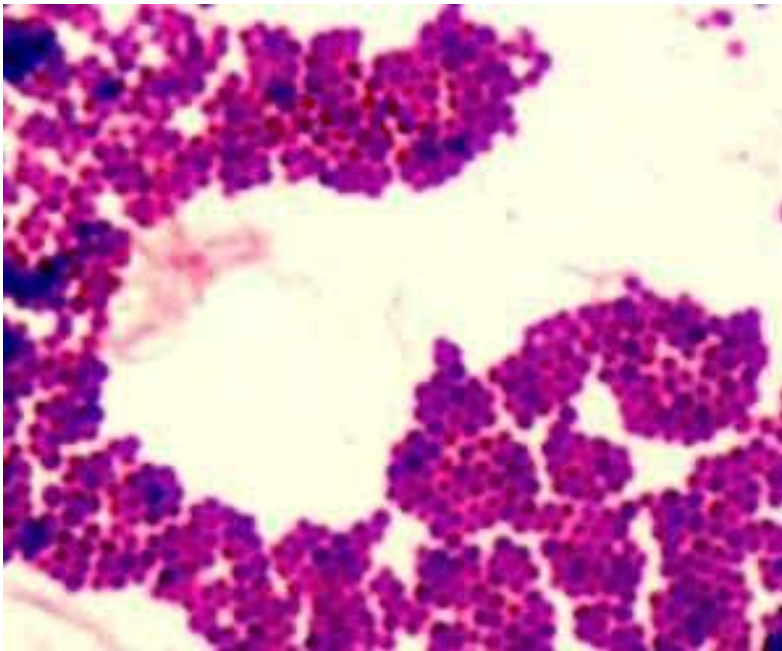
- Outer membrane- an extra barrier in gram-negative bacteria
 - Makes them impervious to some antimicrobial chemicals
 - Generally more difficult to inhibit or kill than gram-positive bacteria
- Cell envelope can interact with human tissues and cause disease
 - *Corynebacterium diphtheriae*
 - *Streptococcus pyogenes*

Prokaryotes - Cell Wall

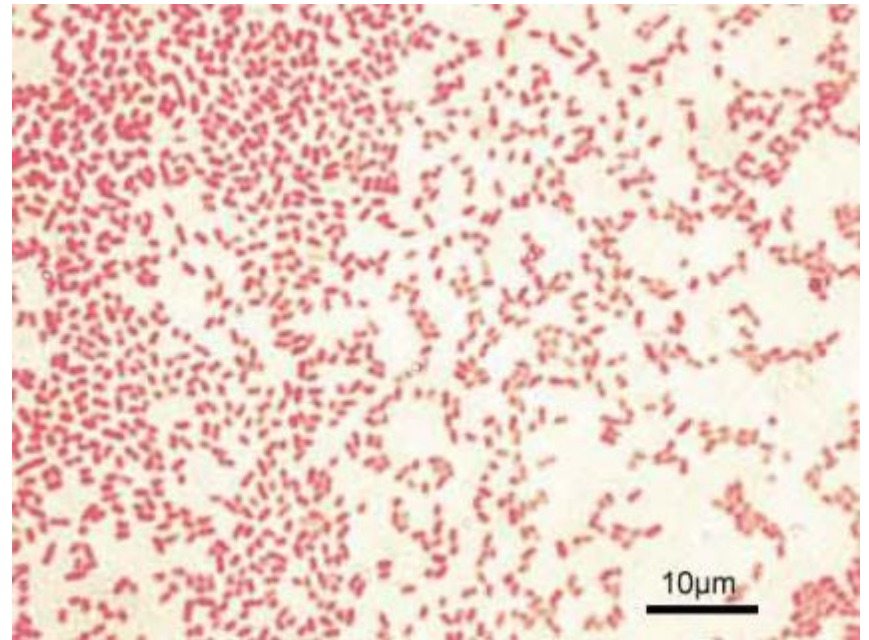
From the peptidoglycan inwards all bacteria are very similar. Going further out, the bacterial world divides into two major classes (plus a couple of odd types).

These are:

Gram-positive



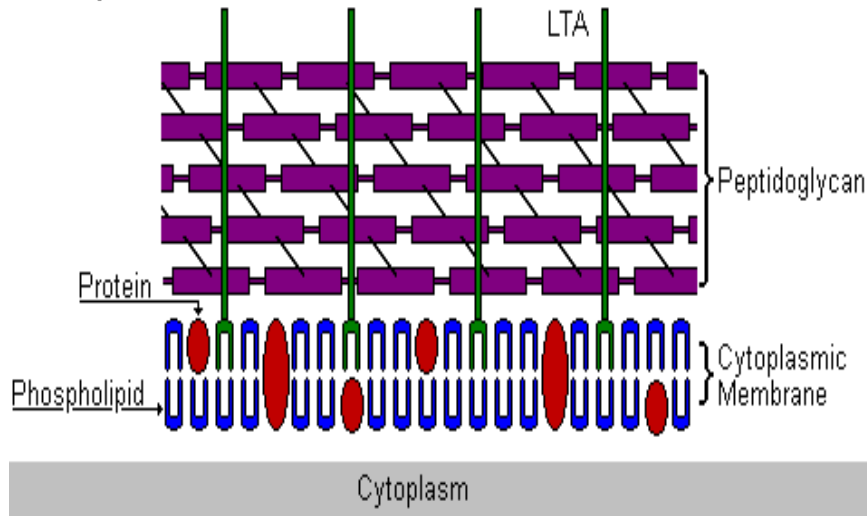
Gram-negative



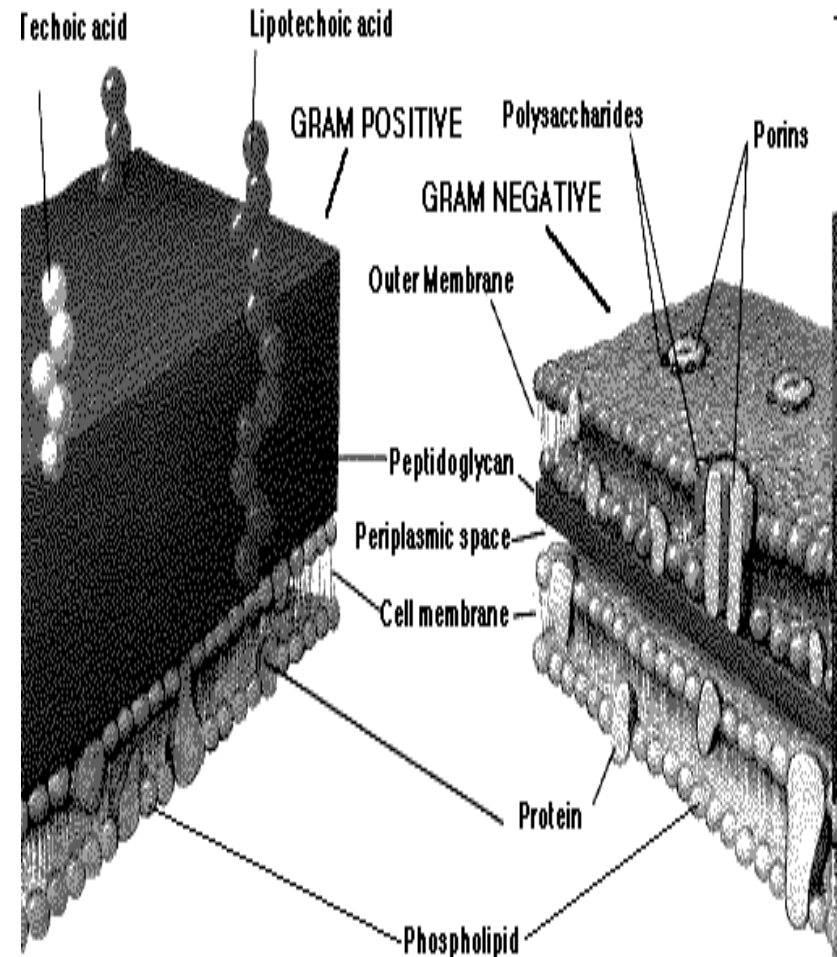
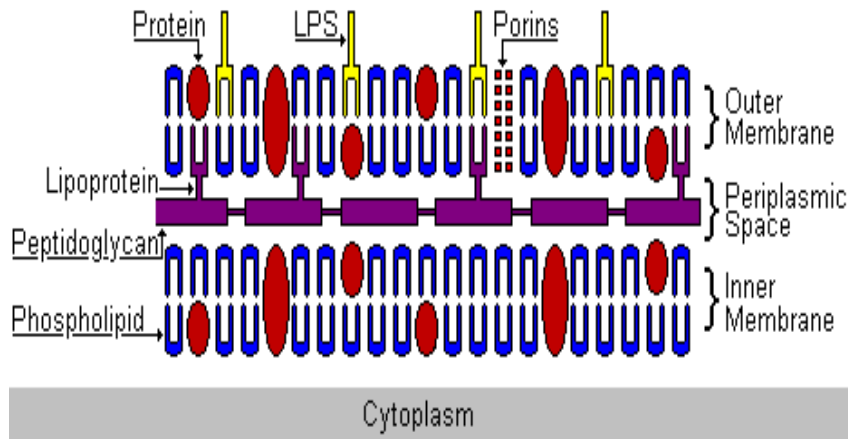
Prokaryotes - Cell Wall

Gram-Positive & Gram-Negative

Gram-positive Cell Wall

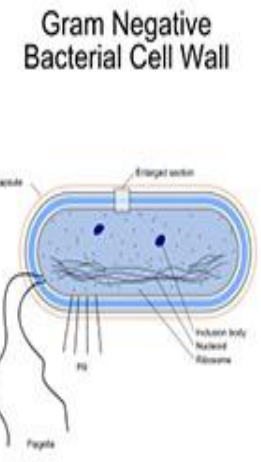
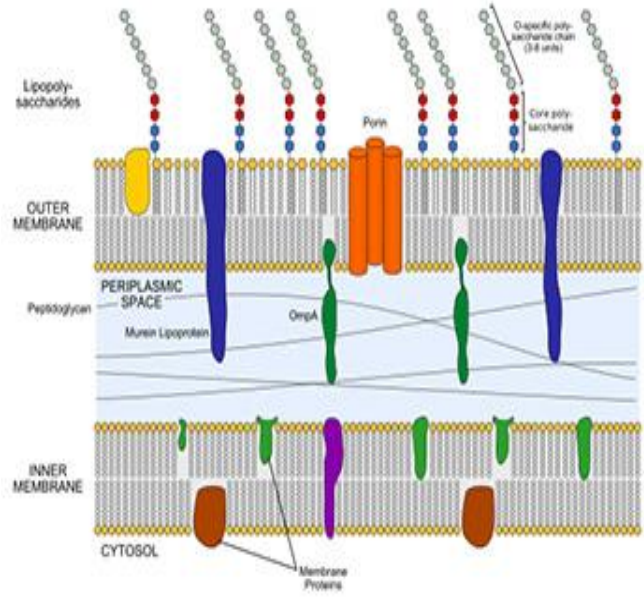
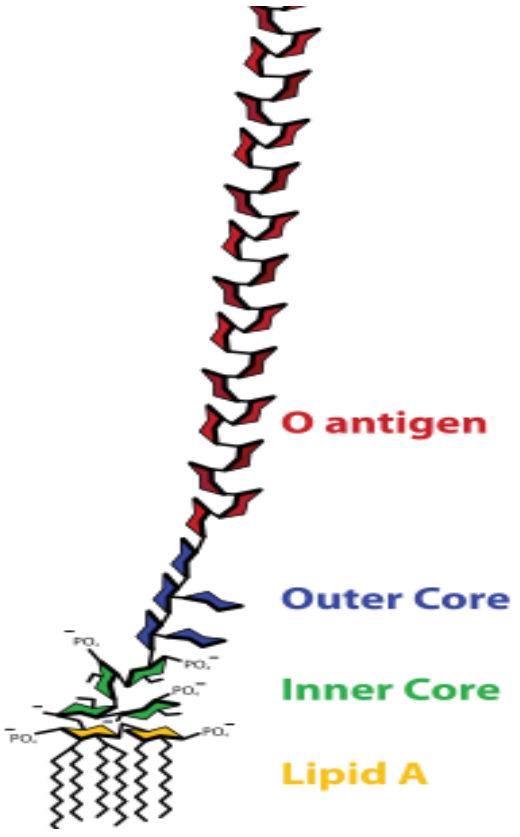
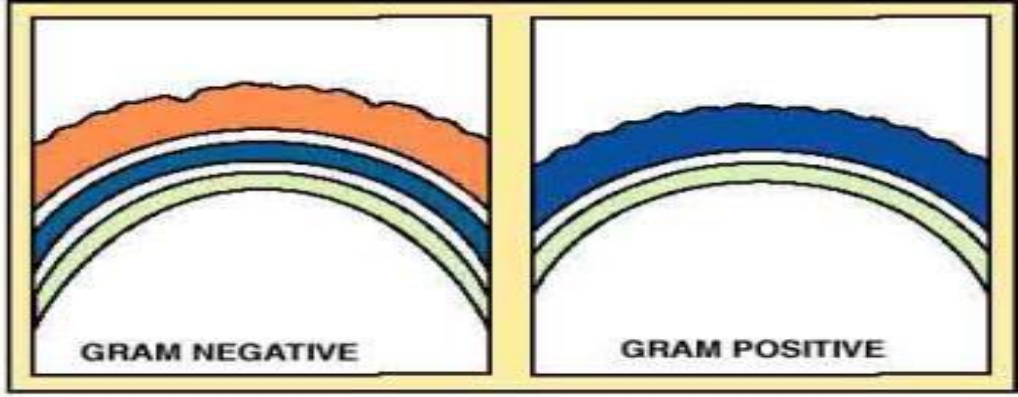


Gram-negative Cell Wall





Q: Why are these differences in bacterial cell wall structure so important?



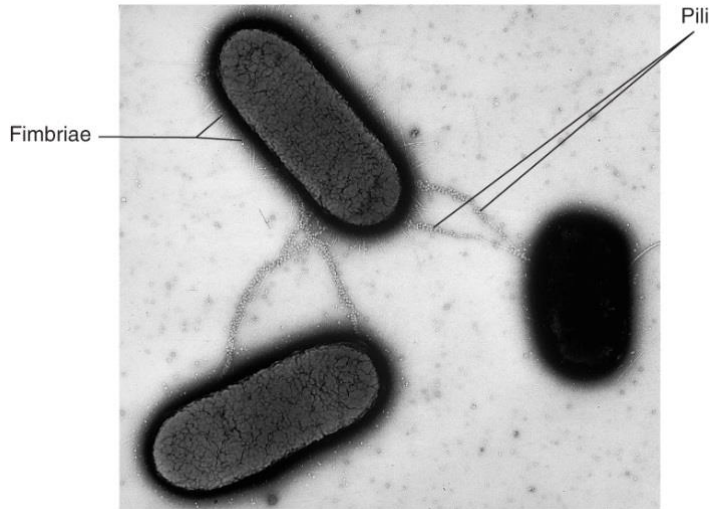
Nontypical Cell Walls

- Some aren't characterized as either gram-positive or gram-negative
- For example, *Mycobacterium* and *Nocardia*-unique types of lipids (acid-fast)
- Archaea – no peptidoglycan
- **Mycoplasmas**- lack cell wall entirely

External Structures

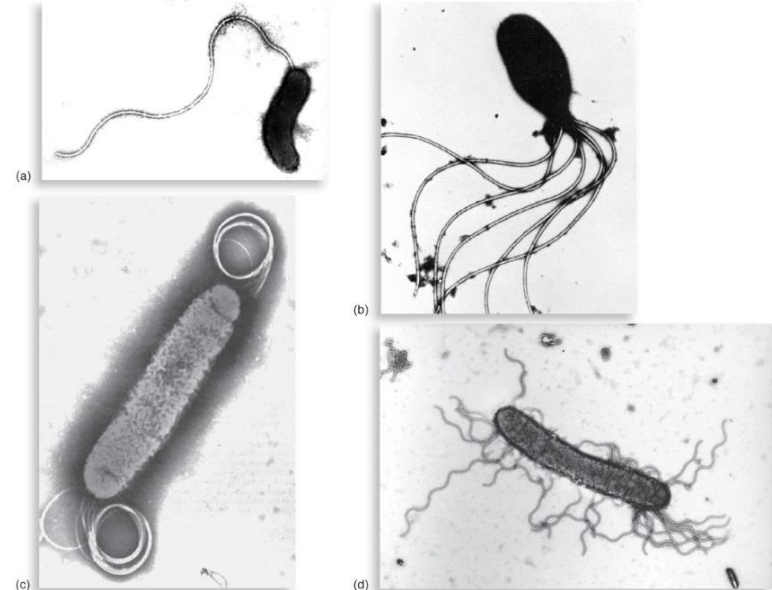
- **Appendages:** Cell extensions
 - Common but not present on all species
 - Can provide **motility** (**flagella** and axial filaments)
 - Can be used for attachment and mating (**pili** and **fimbriae**)

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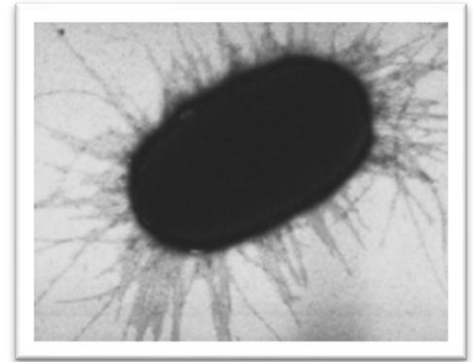
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Prokaryotes - Surface Appendages

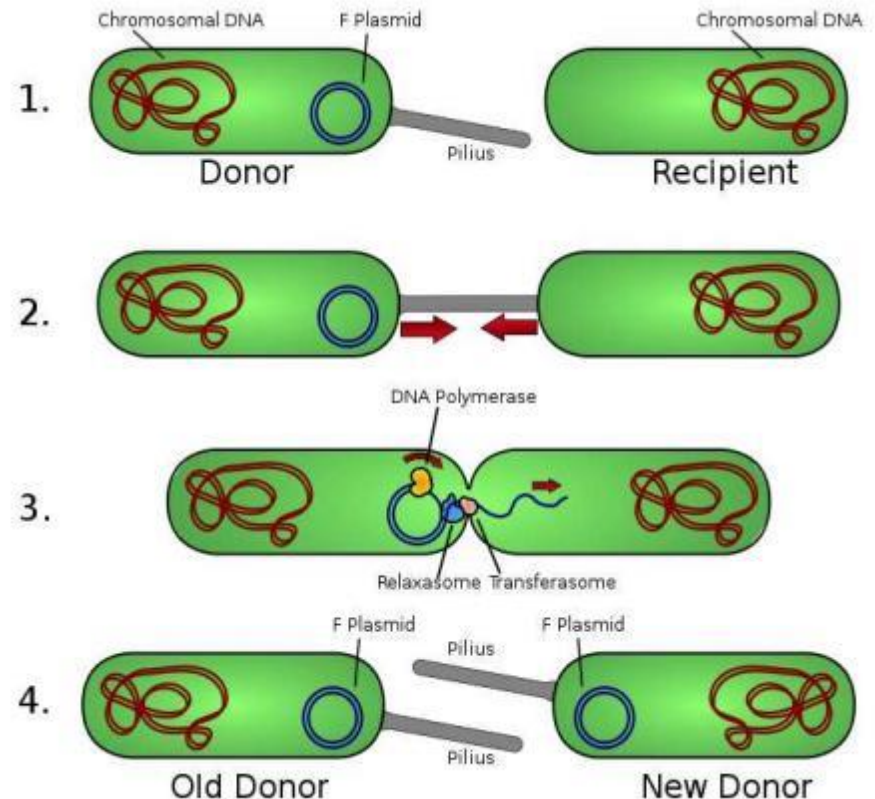


- **fimbriae:** Most Gram-negative bacteria have these short, fine appendages surrounding the cell. Gram+ bacteria don't have.

No role in motility. Help bacteria adhere to solid surfaces. Major factor in virulence.
(singular: fimbria)

- **pili:** Tubes that are longer than fimbriae, usually shorter than flagella.

Use for movement, like grappling hooks, and also use **conjugation** pili to transfer plasmids. (singular = pilus)



Prokaryotes - Cell Shapes

Most bacteria are classified according to shape:

1. **bacillus** (*pl. bacilli*) = rod-shaped
2. **COCCUS** (*pl. cocci ... sounds like cox-eye*) = spherical
3. spiral shaped
 - a. **spirillum** (*pl. spirilla*) = spiral with rigid cell wall, flagella
 - b. **spirochete** (*pl. spirochetes*) = spiral with flexible cell wall, axial filament

Pleomorphism- when cells of a single species vary to some extent in shape and size

There are many more shapes beyond these basic ones. A few examples:

- Coccobacilli = elongated coccal form
- Filamentous = bacilli that occur in long threads
- Vibrios = short, slightly curved rods
- Fusiform = bacilli with tapered ends

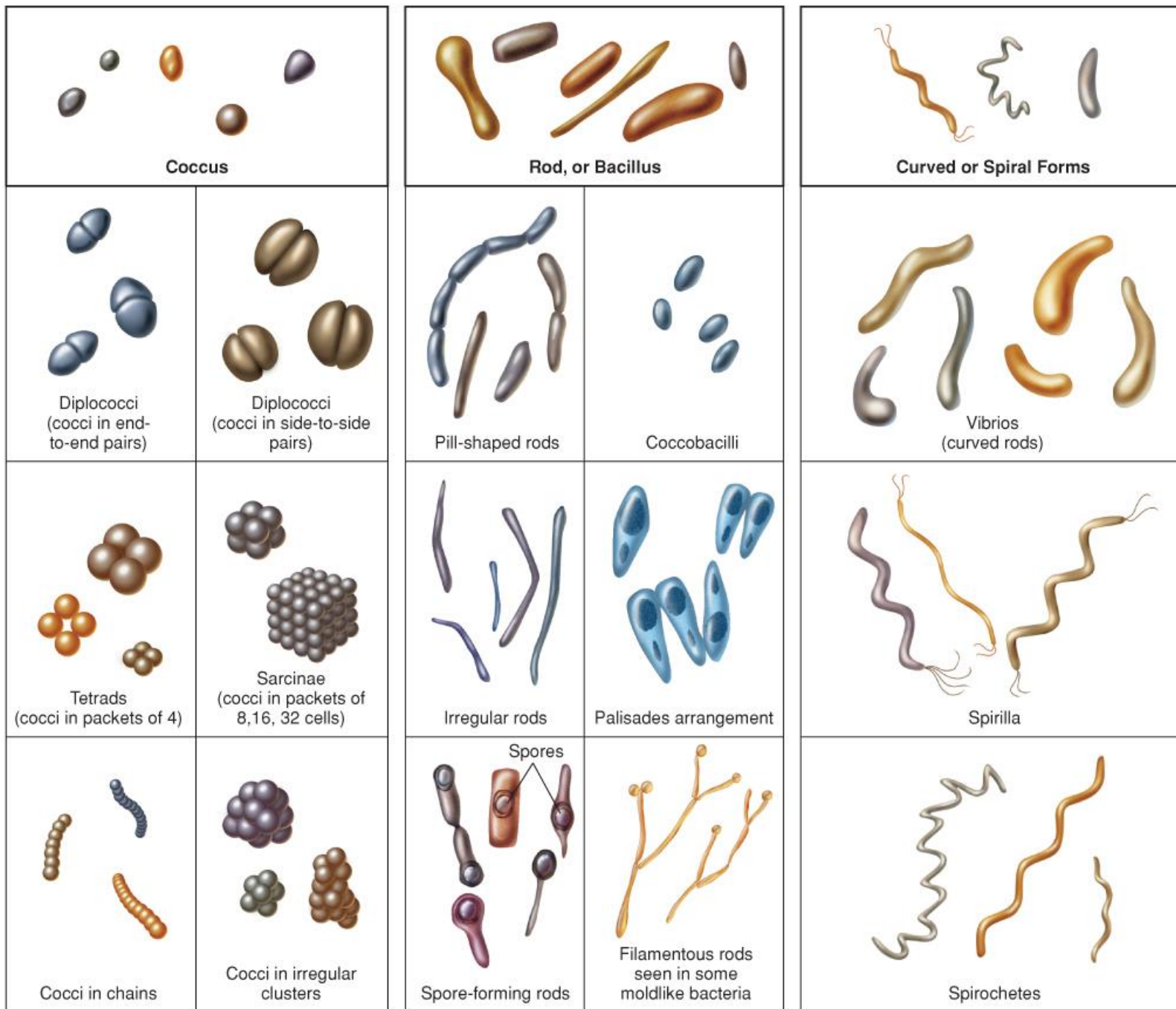


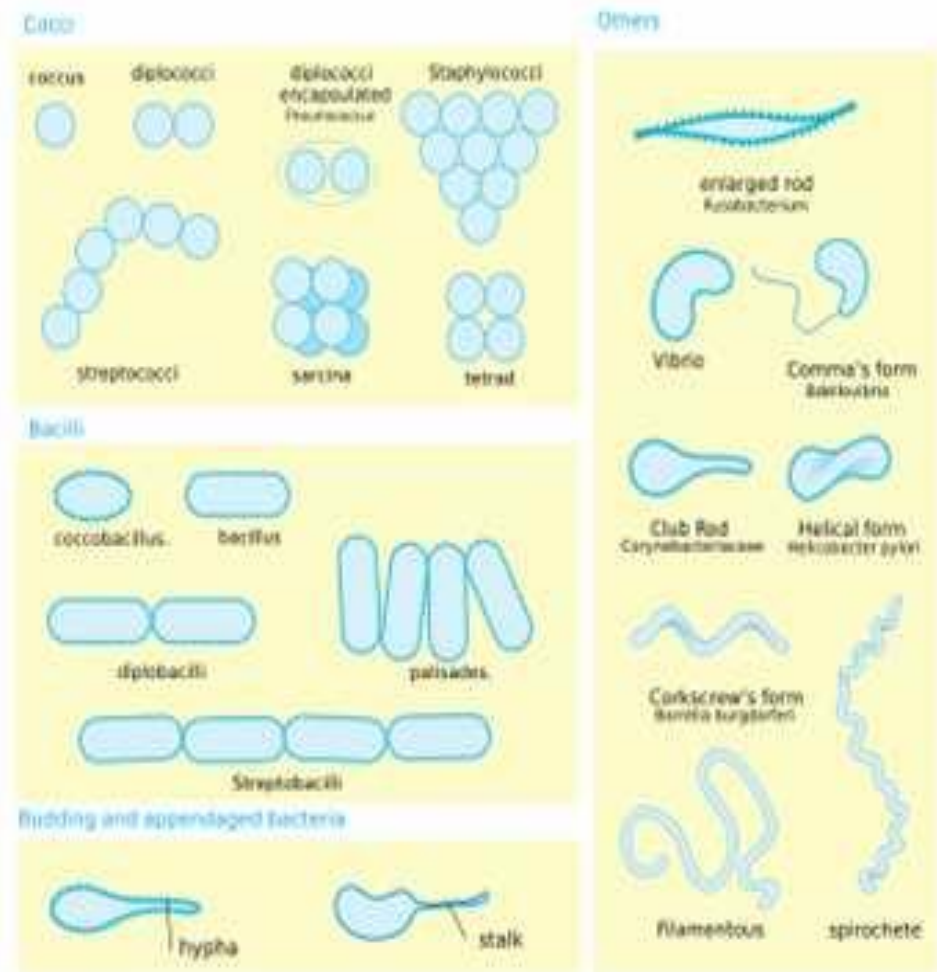
Figure 4.22

Arrangement, or Grouping

- Cocci- greatest variety in arrangement
 - Single
 - Pairs (diplococci)
 - Tetrads
 - Irregular clusters (staphylococci and micrococci)
 - Chains (streptococci)
 - Cubical packet (**sarcina**)
- Bacilli- less varied
 - Single
 - Pairs (diplobacilli)
 - Chain (streptobacilli)
 - Row of cells oriented side by side (**palisades**)
- Spirilla
 - Occasionally found in short chains

Prokaryotes - Arrangements of Cells

- Bacteria sometimes occur in groups, rather than singly.
- **bacilli** divide along a single axis, seen in pairs or chains.
- **cocci** divide on one or more planes, producing cells in:
 - pairs (diplococci)
 - chains (streptococci)
 - packets (sarcinae)
 - clusters (staphylococci).
- Size, shape and arrangement of cells often first clues in identification of a bacterium.
- Many "look-alikes", so shape and arrangement not enough for id of genus and species.



Prokaryotic reproduction

- **binary fission** - this process involves copying the chromosome and separating one cell into two
 - **asexual** form of reproduction
- **Transformation** - the prokaryote takes in DNA found in its environment that is shed by other prokaryotes.
- **transduction** - bacteriophages, the viruses that infect bacteria, sometimes also move short pieces of chromosomal DNA from one bacterium to another
- **Conjugation** - DNA is transferred from one prokaryote to another by means of a pilus

