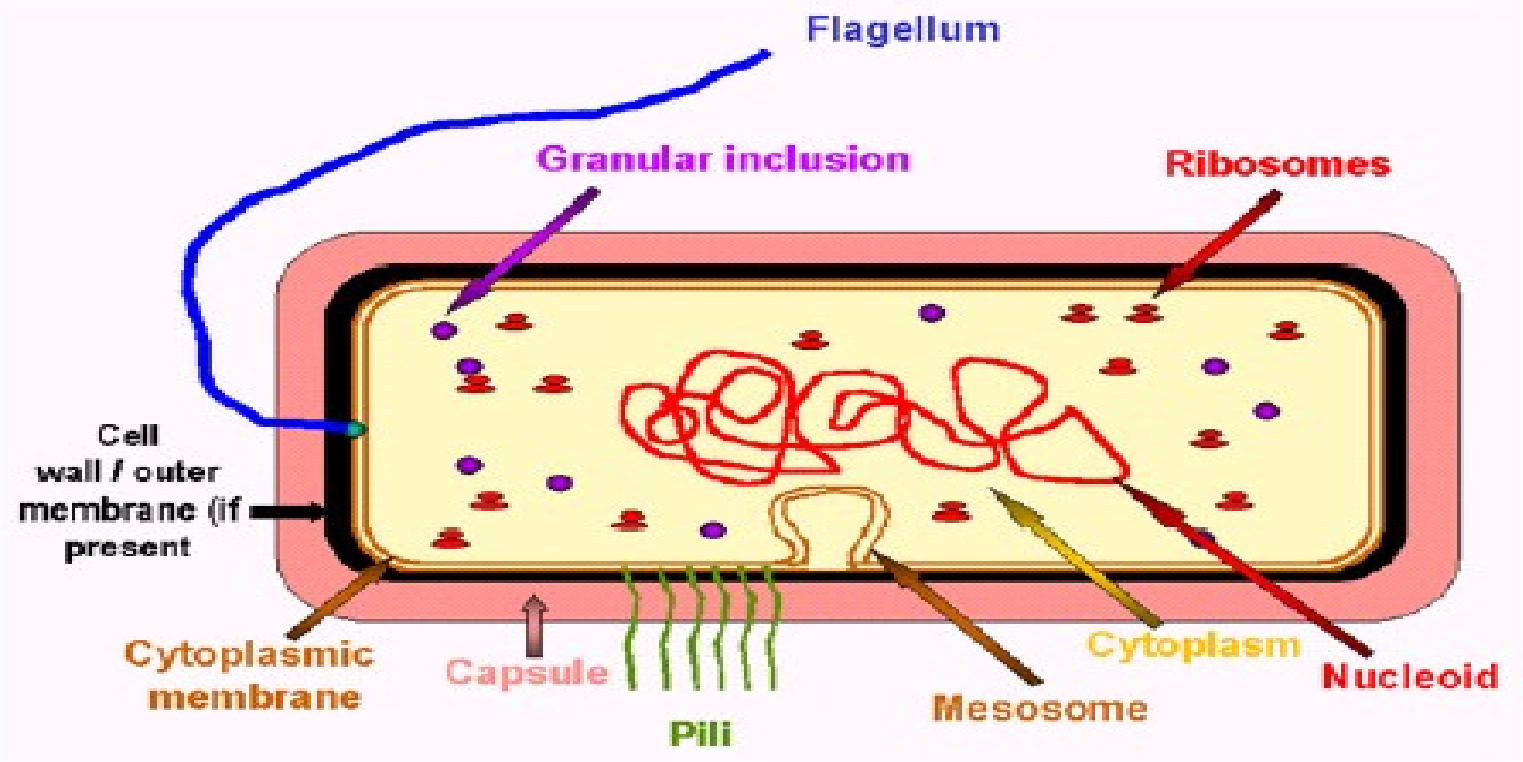
BACTERIAL STRUCTURE



Basic features of Bacterial Cell

- **General property**
  - Typical prokaryotic cell
  - Contain both DNA and RNA
  - Most grow in artificial media
  - Replication is by **binary fission**
  - Contain rigid cell wall

Size of Bacteria

- Average bacteria 0.5 - 2.0 μm in diameter
- Surface Area ~12 μm^2
- Volume is ~4 um
- Surface Area to Volume is 3:1
- Typical Eukaryote Cell SA/Vol is 0.3:1
- Food enters through SA, quickly reaches all parts of bacteria
- Eukaryotes need structures & organelles

Structure of Bacteria

Bacterial structure is considered at three levels.

1. Cell envelope proper:

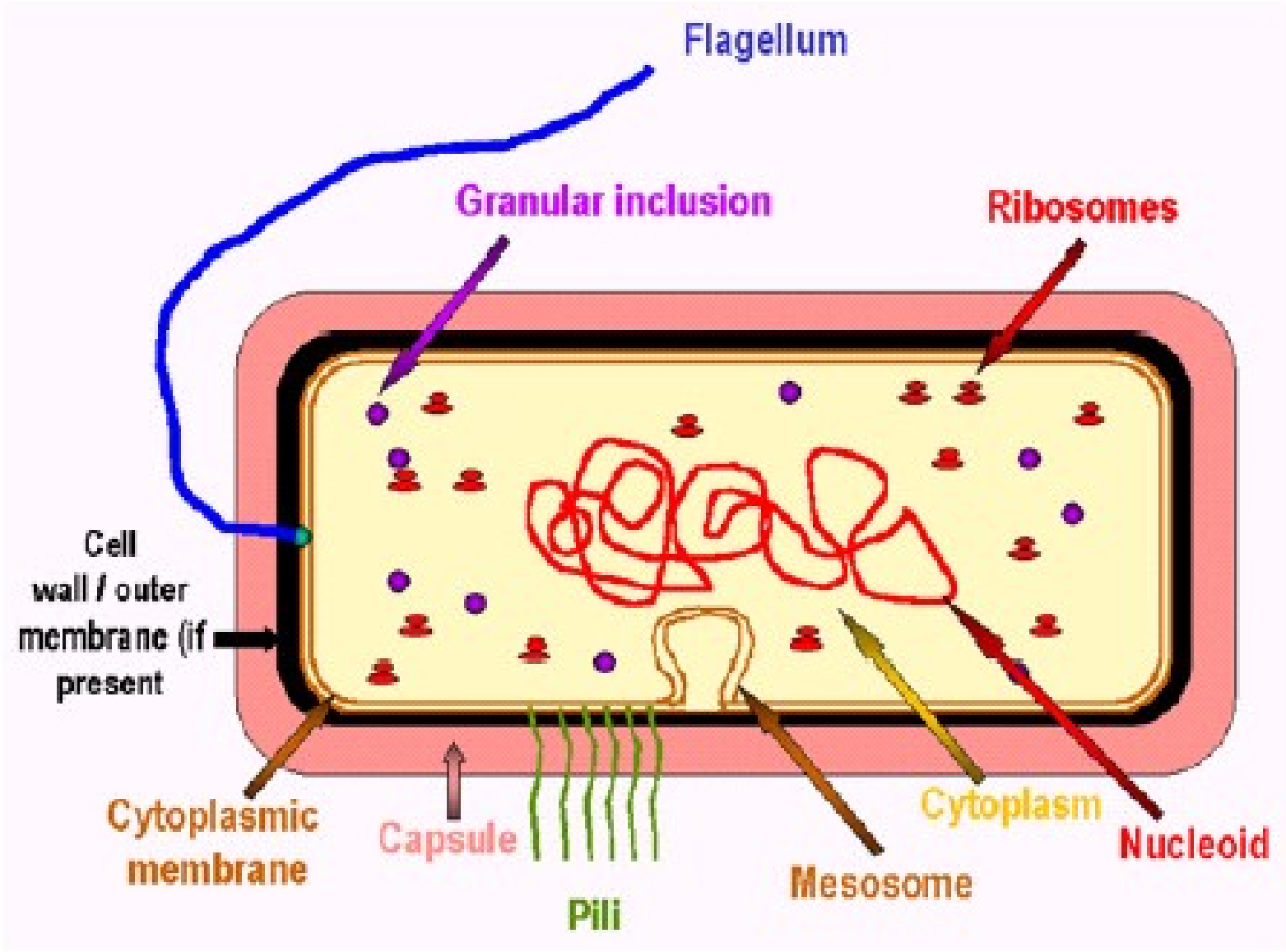
cell wall and cell membrane

2. Cellular element enclosed with in the cell envelope:

ribosome, nuclear material, mesosome

3. Cellular element external to the cell envelope (appendages) : Capsule, *Flagellum, Pilus*

Bacterial structure



1. Cell Envelop proper

- a **cell envelope** consists of **cell wall** and **plasma membrane**
- **Cell wall:**
  - Rigid peptidoglycan /murien/layer surrounds the cytoplasmic membrane
  - Multi layered structure and constitutes about 20% of the bacterial dry weight
  - Average thickness is 0.15-0.5 μm
    - Determine shape of bacteria
    - Strength, prevents osmotic rupture
    - Some antibiotics effect directly

Chemical Composition of cell wall

- The major component of cell wall is **peptidoglycan (PG)**
- Some times called back bone of bacteria
- The rigidity of the cell wall is due to the presence of this substance
- It consists of a polymer of disaccharides cross-linked by short chains of amino acids (peptides).
  - peptidoglycan layer (murein) is a complex, interwoven network that surrounds the entire cells and is composed of a single covalently linked macromolecules.
- Found only in bacterial cell walls

Prokaryotic cell structure.

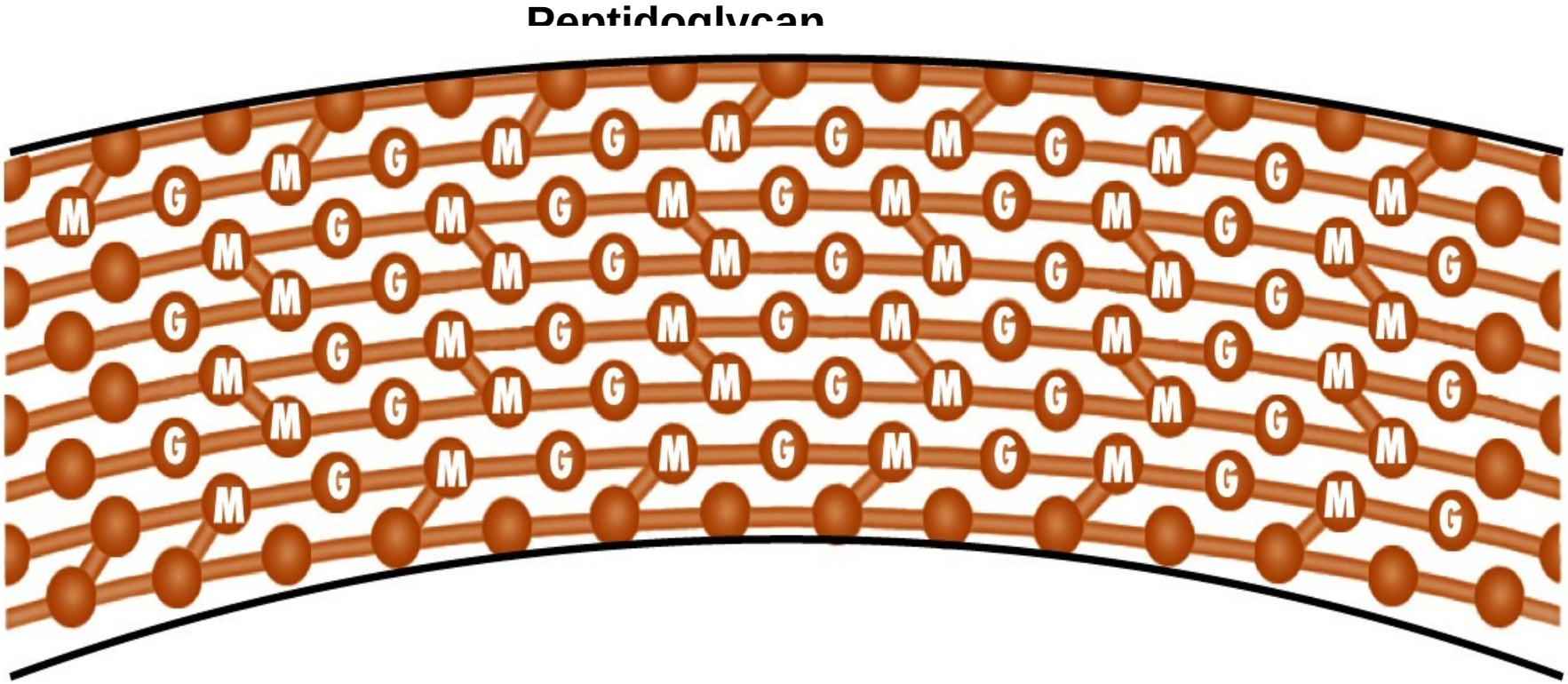


Figure 4-30c Brock Biology of Microorganisms 11/e
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Peptidoglycan is composed of repeating units of two sugar derivatives, N-acetylglucosamine and N-acetylmuramic acid and a small number of special amino acids Peptidoglycan is only found in the cell walls of species of bacteria it has never been found in cell walls of Archaea or Eukarya.

Gram positive cell wall

- Consists of
  - a thick, homogenous sheath of peptidoglycan
  - tightly bound acidic polysaccharides
    - teichoic acid and lipoteichoic acid
  - cell membrane
- The large amount of peptideglycan make gram- positive bacteria susceptible to
  - the enzyme lysozyme and penicillin.
- Teichoic acids and cell well- associated protein are the major surface antigens of the gram- positive cell well.

Gram positive cell wall.

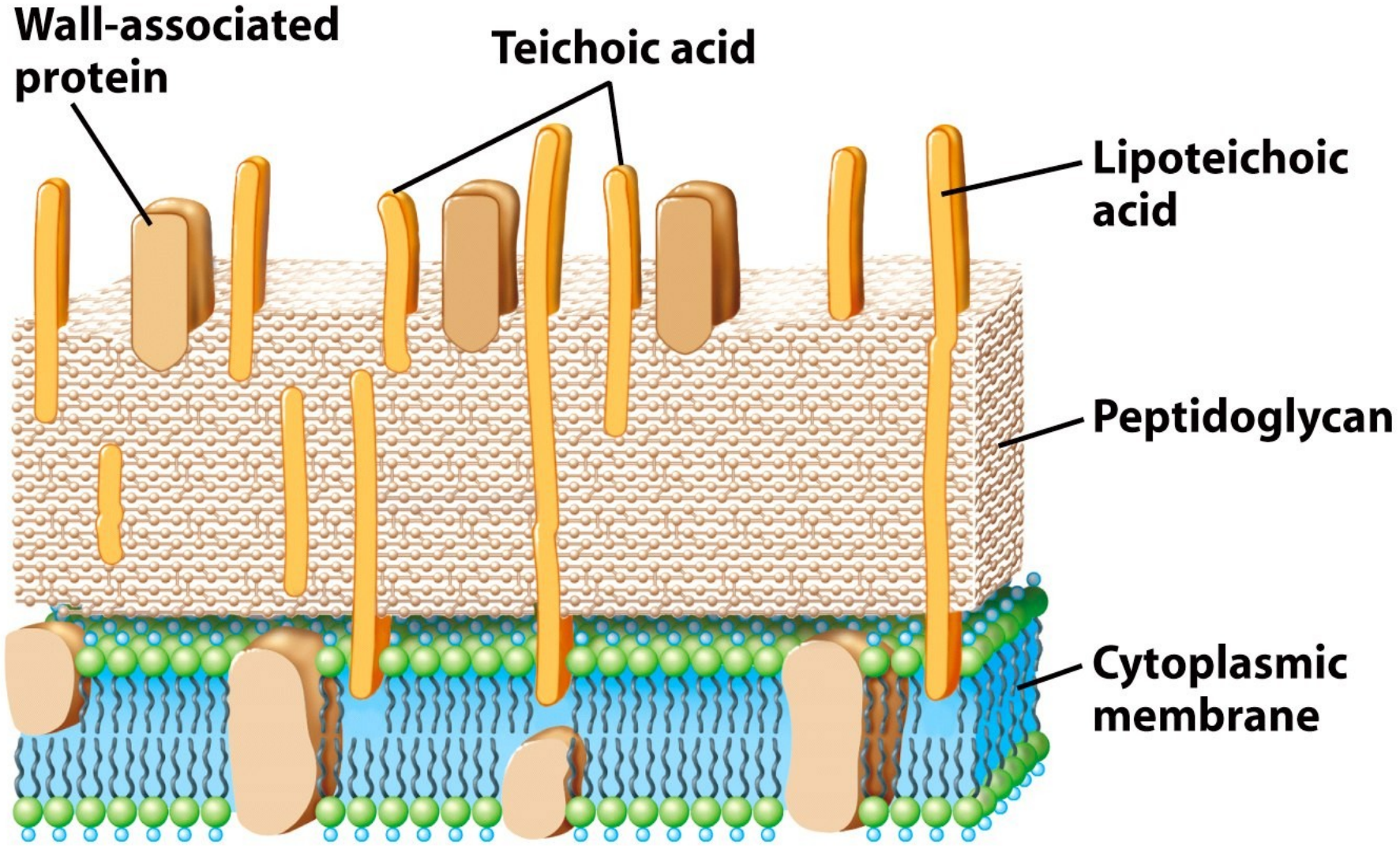


Figure 4-31b Brock Biology of Microorganisms 11/e
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Gram negative bacteria cell wall

- More complex than gram positive structurally and chemically
- contain two layers external to cytoplasmic memberane
- Immediately to cytoplasmic memberane thin layer of peptodoglycan layer
- External to peptidoglycan –outer membrane uniqe for gram negative only
- No teichoic and lipoteichoic acid

Gram negative bacteria cell wall

- The area b/n external surface of cytoplasmic meb-mbrane and internal surface outer membrane called periplasmic space

– contain hydrolytic enzymes like lipase,protease nuclease ,phosphate

Periplasmic space

– Found between outer membrane and the cell membrane

– Mostly contain enzymes and endotoxins

Gram negative cell wall.

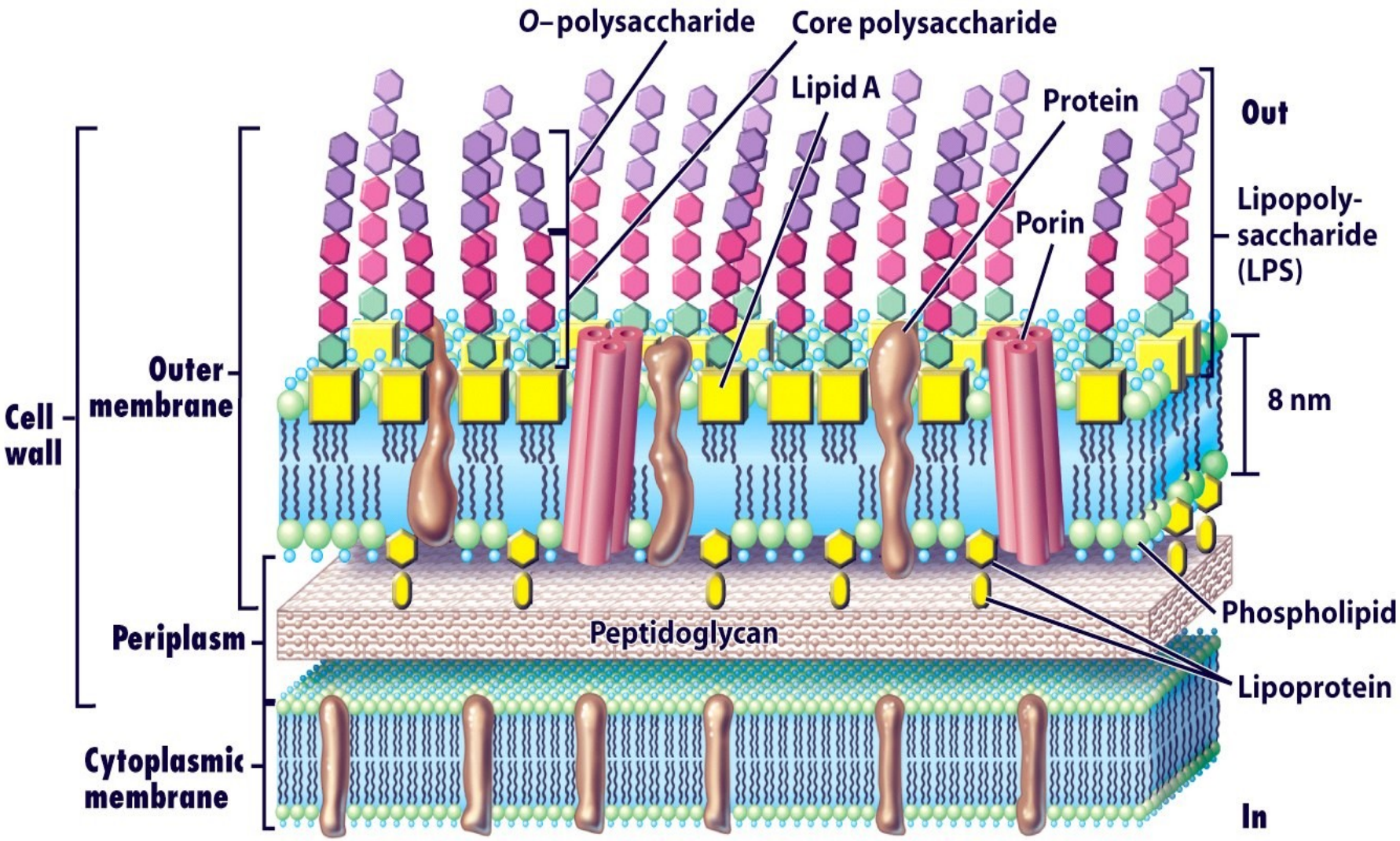


Figure 4-35a Brock Biology of Microorganisms 11/e

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Outer-membrane

- Maintain structure
- Permeability barriers to large molecules and hydrophobic enzyemes
- Protect from adverse environmental condition
- Contain lipopolysaccharide (LPS)-endotoxin

- LPS
  - endotoxin that may become toxic when released during infections
  - may function as receptors and blocking immune response
  - contains **porin** proteins in upper layer
    - Regulates molecules entering and leaving cell

Bacterial cell wall

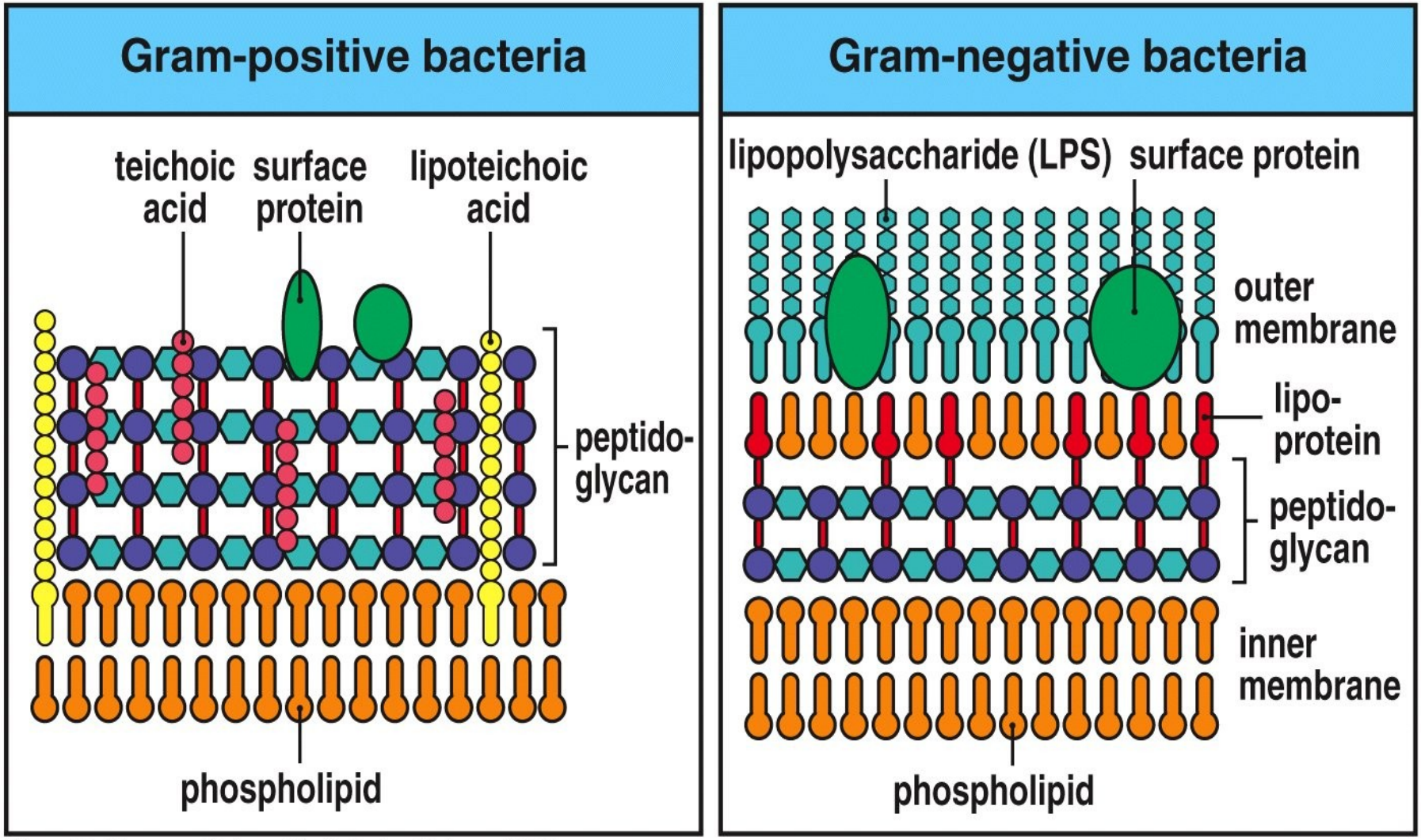


Figure 15-3 Immunobiology, 6/e. (© Garland Science 2005)

Non-typical Cell Walls

- Some bacterial groups lack typical cell wall structure, i.e., ***Mycobacterium* and *Nocardia***
  - Gram-positive cell wall structure with lipid **mycolic acid** (cord factor)
    - Pathogenicity and high degree of resistance to certain chemicals and dyes
    - Basis for **acid-fast stain** used for diagnosis of infections caused by these microorganisms
- Some have no cell wall, i.e., ***Mycoplasma***
  - Cell membrane is stabilized by sterols
  - Pleomorphic



Functions of Cell Wall

- Maintaining the cell's characteristic shape- the rigid wall compensates for the flexibility of the phospholipid membrane
- Countering the effects of **osmotic pressure**
- Providing **attachment sites** for bacteriophages
- Providing a rigid platform for surface appendages- **flagella**, **fimbriae**, and **pili** all emanate from the wall and extend beyond it
- Play an essential role in cell division
- Be the sites of major **antigenic determinants** of the cell surface ◦

Cytoplasmic membrane (Plasma membrane)

- It is the actual barrier between the interior and exterior of the bacteria cell.
- It accounts for 30% of the dry weight of bacterial cell
- Chemically, consists of proteins and phospholipids.
- It is 60% protein, 20 – 30% lipid and 10-20% carbohydrate
- The cytoplasmic membrane exhibits
  - a well- defined selective permeability,
  - excretion of enzyme, and
  - biosynthesis of cell well and other proteins

Cytoplasmic membrane … Cont'd

Function of Cell Membrane

- Regulates the transport of nutrients and waste products into and out of the cell. (It is selectively permeable)
- Assists DNA replication
- Captures energy in ATP (i.e it is site of oxidative phosphorylation)
- Although procaryotes lack any intracellular organelles for respiration or photosynthesis, many species possess the physiologic ability to conduct these processes, usually as a function of their **plasma membrane**.

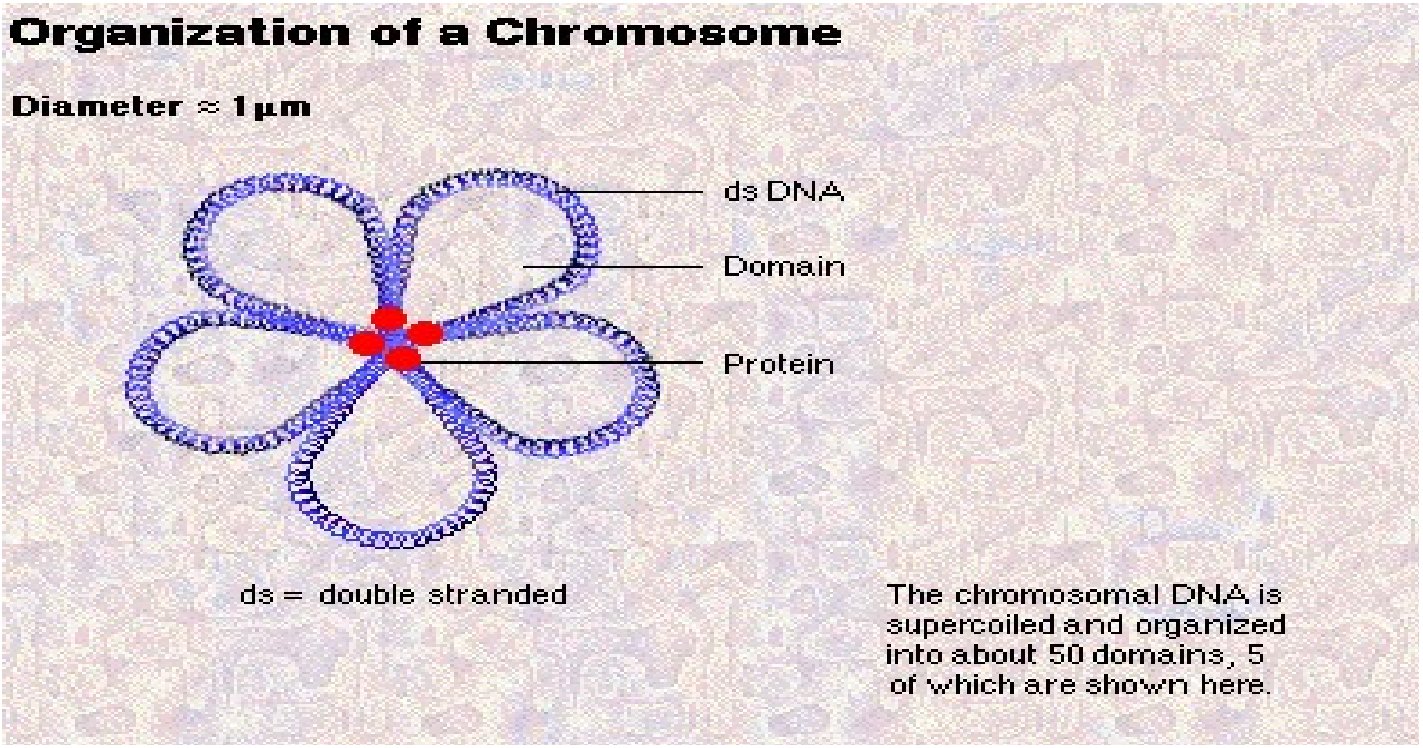
Bacterial structure

1.CYTOPLASMIC STRUCTURES

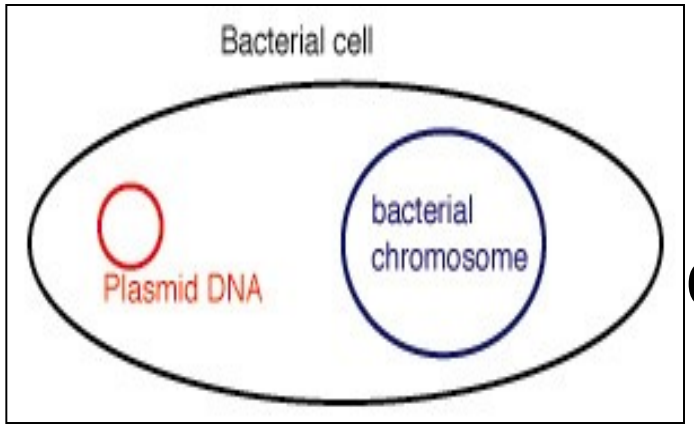
- Both gram positive/negative bacteria contain similar internal structure
- Contain :-
  - Bacterial Chromosomes DNA, mRNA,
  - Mesosomes
  - Ribosomes ,proteins and metabolites
  - Plasmids

Bacterial chromosome

- a single double strand circular contained in nucleoid
- Lacking nuclear membrane, absence of nucleoli, hence known as nucleic material or nucleoid,
- Not associated with histone protein which keep conformation of DNA in eukaryotic

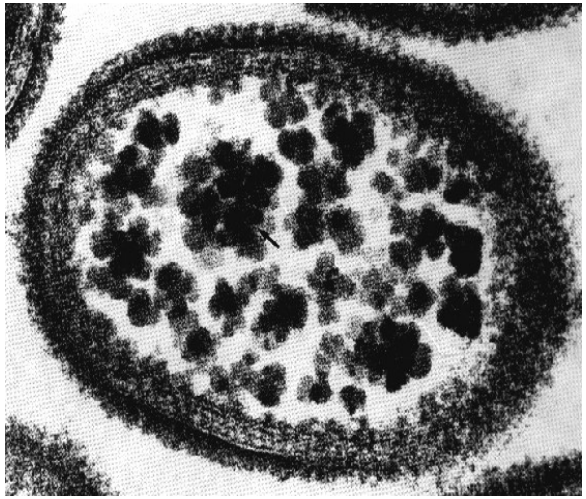


Plasmid



- Plasmids are small , circular , extrachromosomal , double-stranded DNA molecules ◦
- They are capable of self-replication and contain genes that confer some properties such as antibiotic resistance and virulence factors ◦
- Plasmids are not essential for cellular survival.

Inclusions of Bacteria



- Inclusions are aggregates of various compounds that are normally involved in storing energy reserves or building blocks for the cell.
- Inclusions accumilate when a cell is grown

Ribosomes

– Cytoplamic particles, which are the sites of protein synthesis

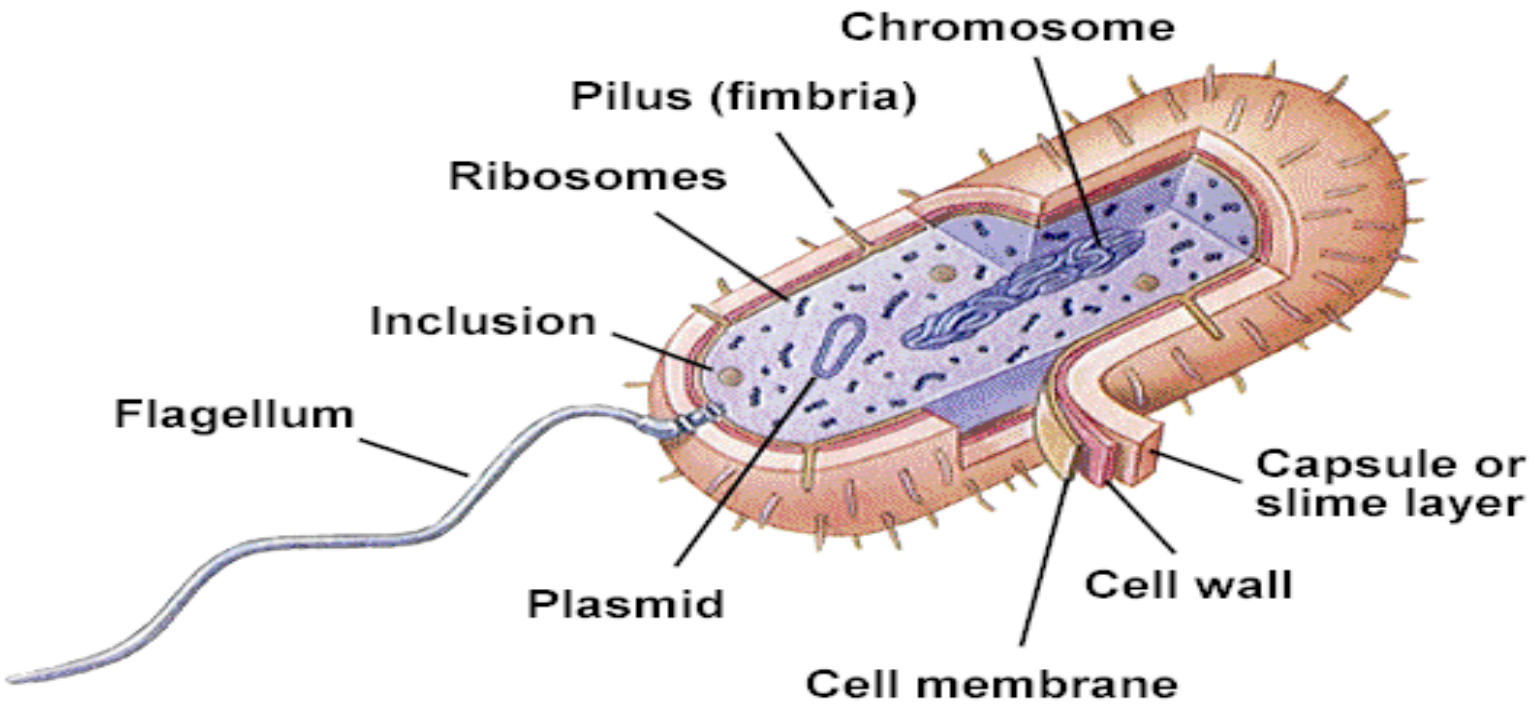
– It is composed of ribosomal RNA (rRNA) (70%) and proteins (30%)

– The ribosomes of procaryotes are smaller than cytoplasmic ribosomes of eucaryotes.

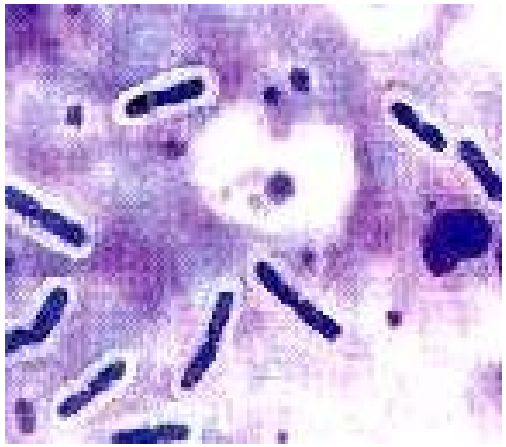
– Procaryotic ribosomes are 70S in size, being composed of 30S and 50S subunits.

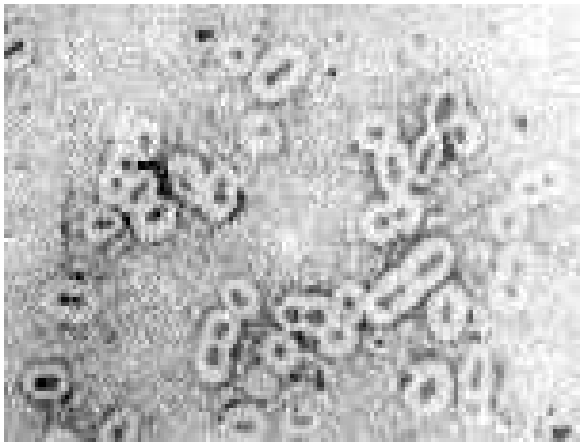
3. External structures

- **Capsule and slime layer**– mostly carbohydrate
  - Protective – phagocytosis, desiccation, immune respon
- **Flagella (sing. Flagellum)** Motility; act as propellers
- **Fimbriae (pili)** Adherence and attachment to cells



Capsules and slime layers





- **Attachment**
- **Protection from phagocytic engulfment.**
- **Resistance to drying.**
- **Depot for waste products.**
- **Reservoir for certain nutrients.**
- **protection**

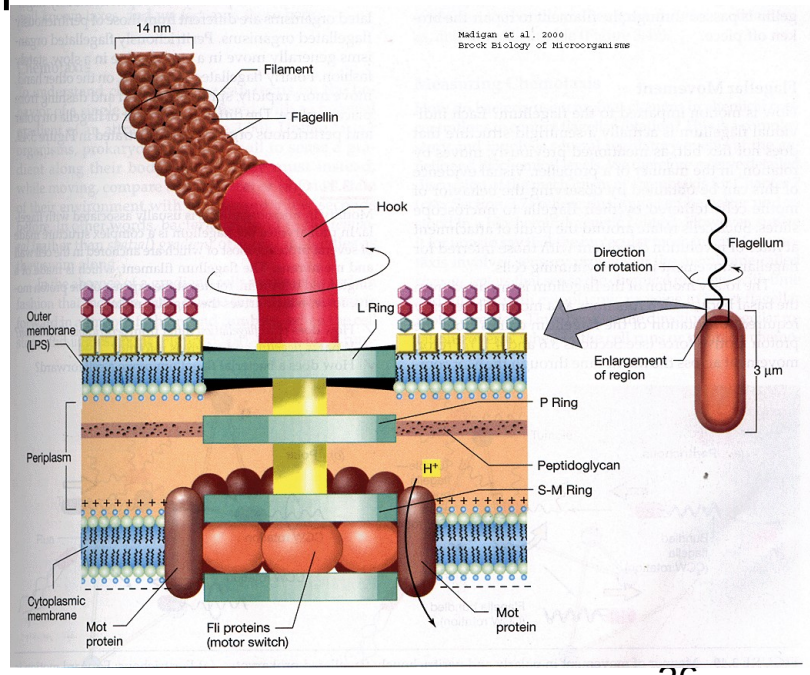
- These are structures surrounding the outside of the **cell envelope.**
- They usually consist of polysaccharide; however, in certain **bacilli** they are composed of **a polypeptide (polyglutamic acid**).
- They are not essential to cell viability and some strains within a species will produce a capsule, whilst others do not.
- Capsules are often lost during *in vitro* culture**.**

1. Slime layer - loosely organized and attached
2. Capsule - highly organized, tightly attached

Flagella

- Some bacterial species are mobile and possess locomotory organelles - flagella.
- Rope like structure and helically coiled composed of flagellin protein
- Anchored to the bacterial memberane
- Used for motility towards food and away from poison
- Different types of flagella

- **Identification of Bacteria**
- **Pathogenesis**
- **Motility of bacteria**



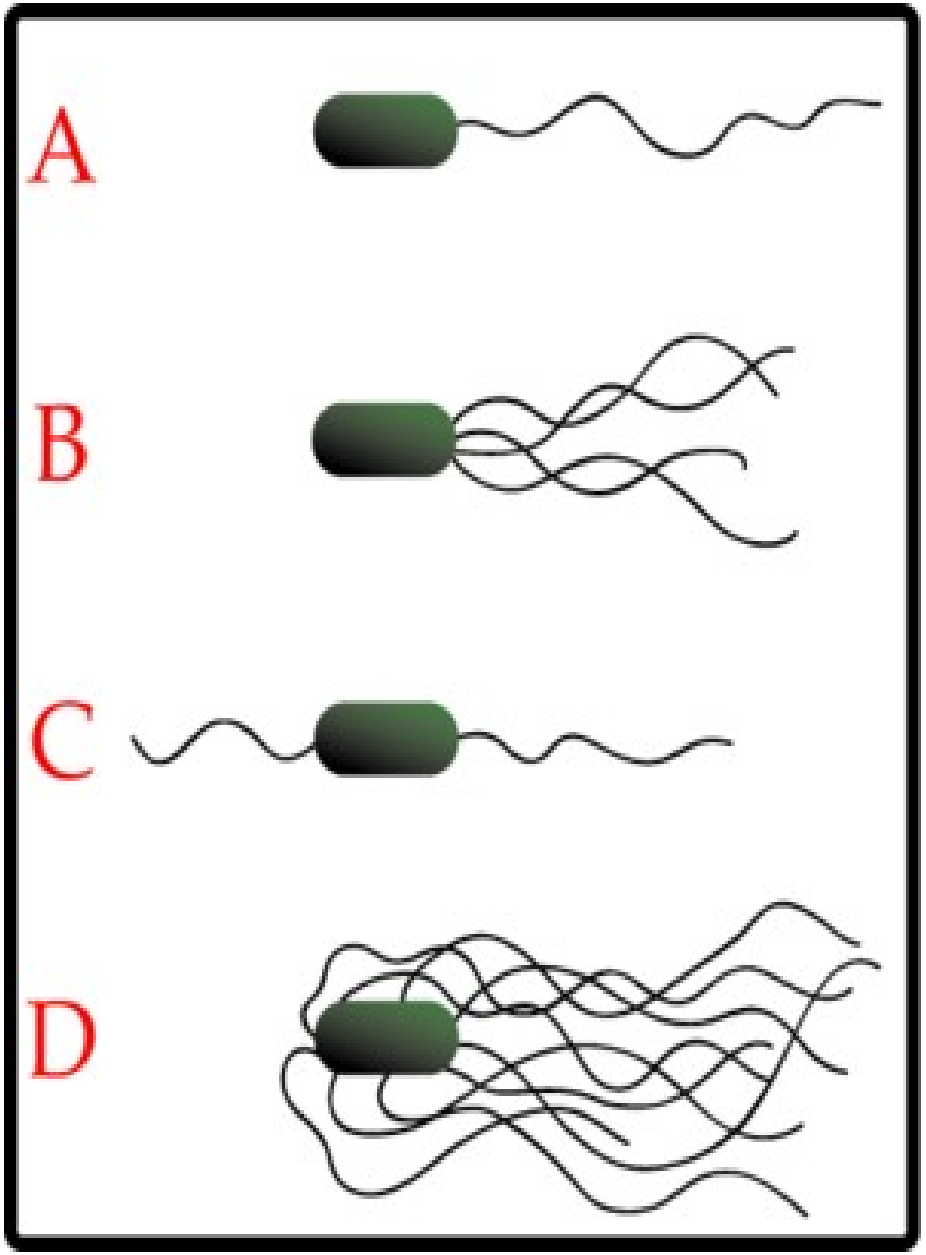
Types of flagella

A-Monotrichous: single flagella at one end

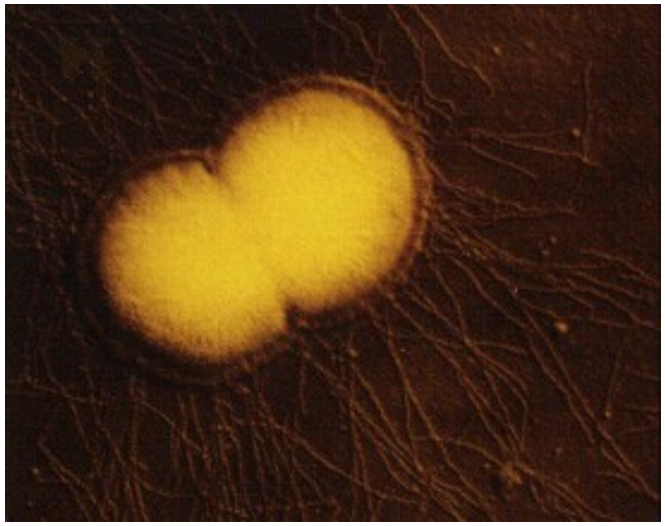
B-Lophotrichous:a tuft of flagella found at one pole of the bacteria

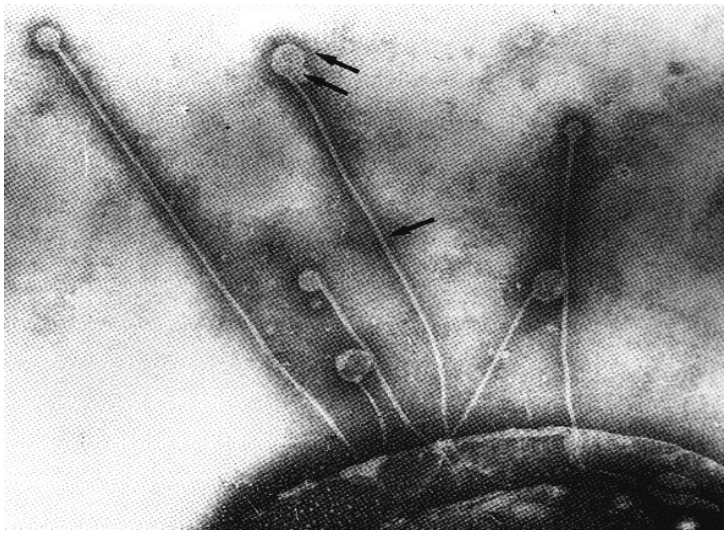
C-Amphitrichous: flagella at both poles

D-Peritrichous:Multiple flagella found at several locations about the cell



Pili





- Pili are hair-like projections of the cell ,
- They are known to be receptors for certain bacterial viruses.
- Chemical nature is pilin

Classification and Function

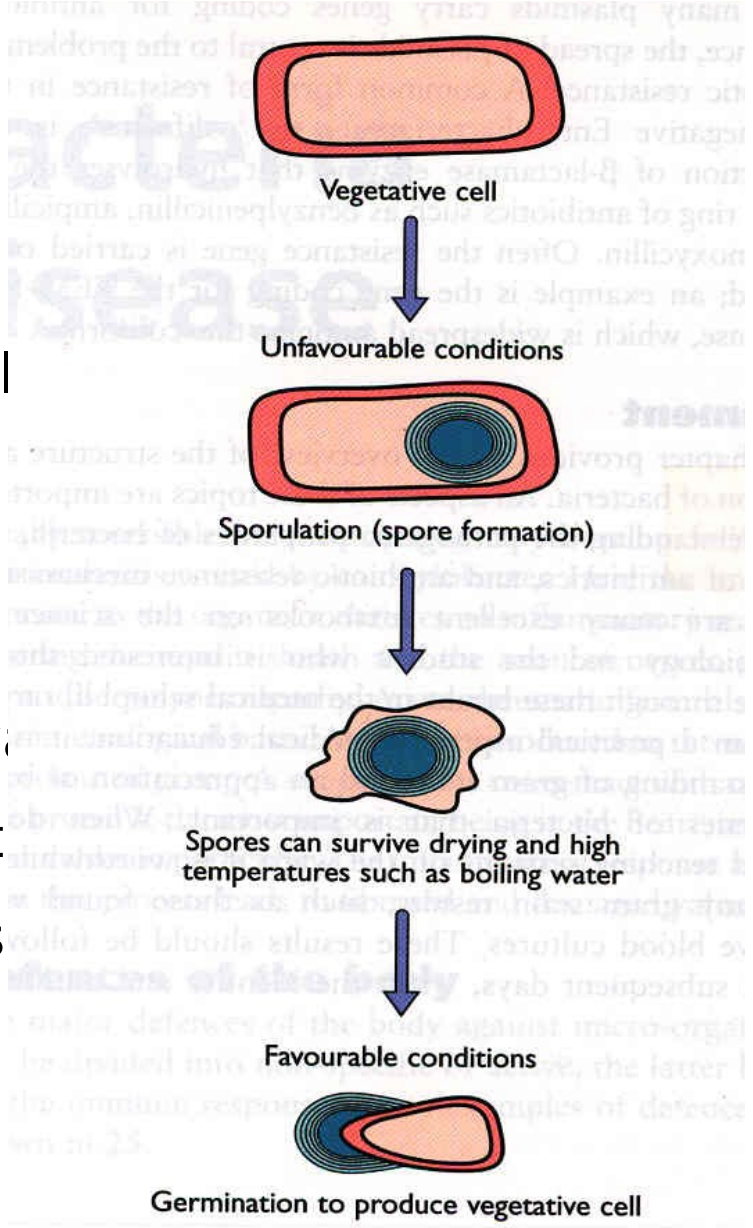
a. Common pili or fimbriae: fine , rigid numerous, related to bacterial adhesion

b. Sex pili: longer and coarser, only 1-4, related to bacterial conjugation --genetic transfer

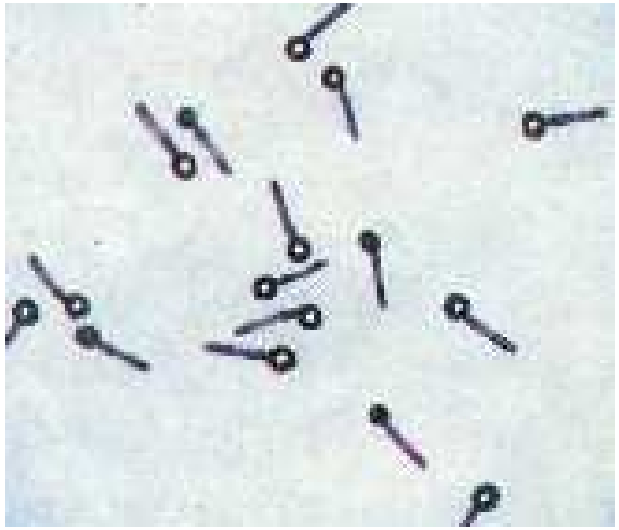
Bacterial spores

- Under conditions of limited supply of nutrition, vegetative forms of certain bacteria especially gram-positive bacill form highly resistant and dehydrated forms, which are called **endospores.**

- These endospors are capable of surviv under adverse conditions such as heat drying, freezing, radiation, and actions of toxic chemicals.

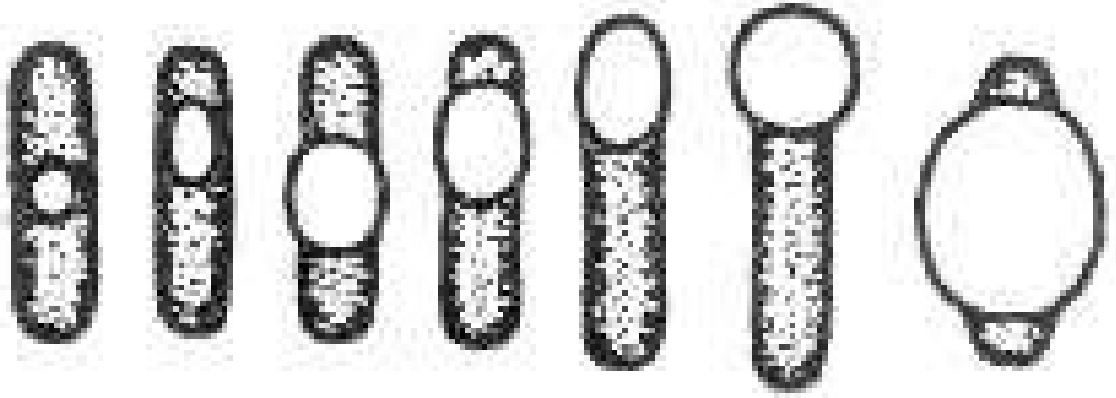


Endospores (spores)



- Identification of Bacteria
- Pathogenesis
- Resistance





- **Dormant cell**
- **Resistant to adverse conditions**

  - high temperatures

  - organic solvents

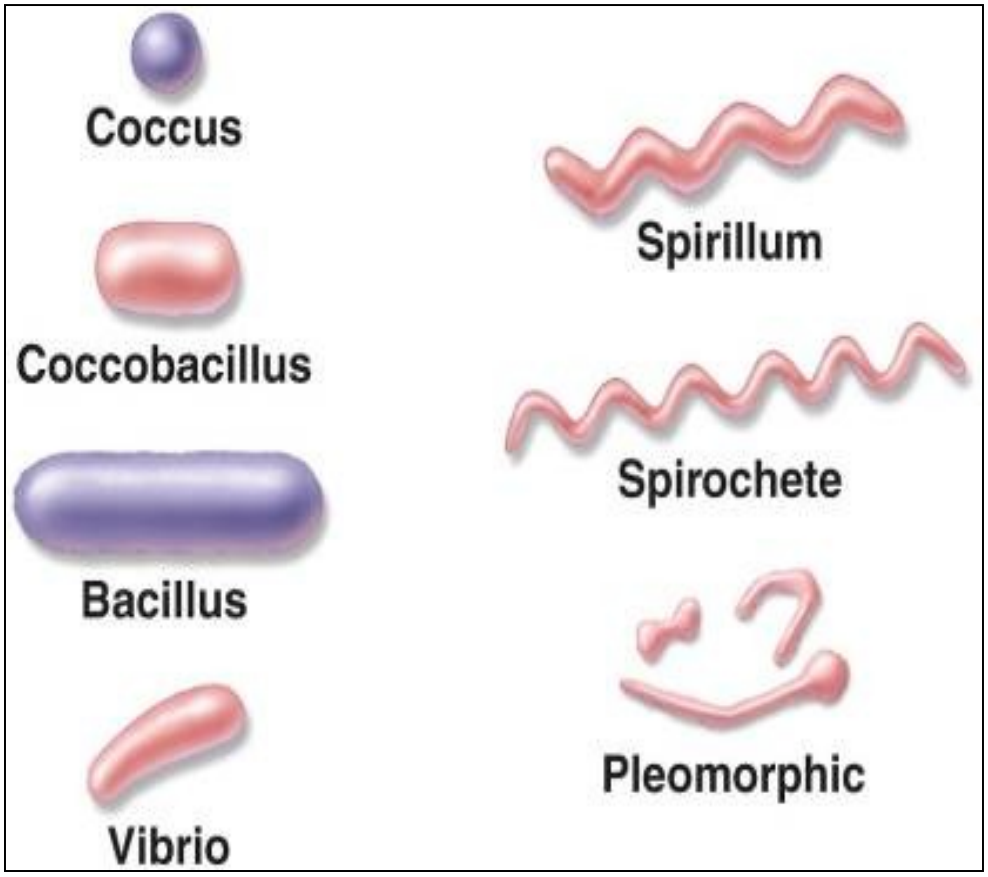
- **Produced when starved**
- **Contain calcium dipicolinate**

  DPA, Dipicolinic acid

- ***Bacillus* and *Clostridium***

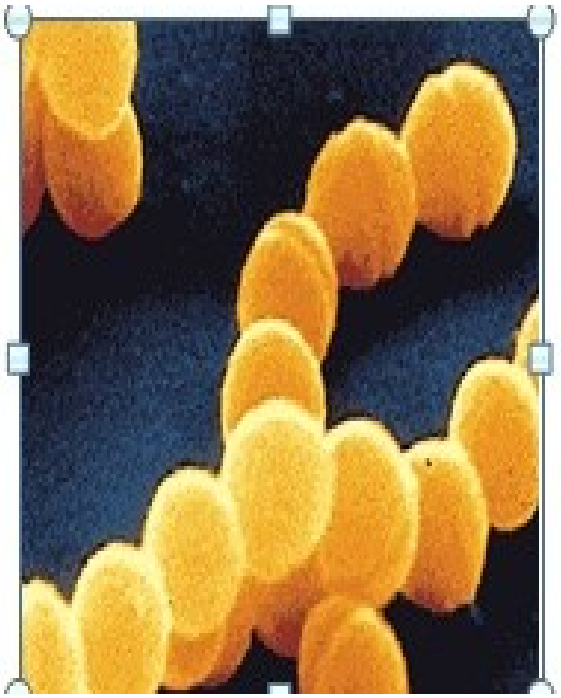
Bacterial Shapes, Arrangements, and Sizes

- Typically described by one of three basic shapes:
  - **coccus**
    - Spherical
  - **bacillus**
    - Rod
      - coccobacillus
      - vibrio
  - **spirillum**
    - Helical, twisted rod,
      - Spirochete

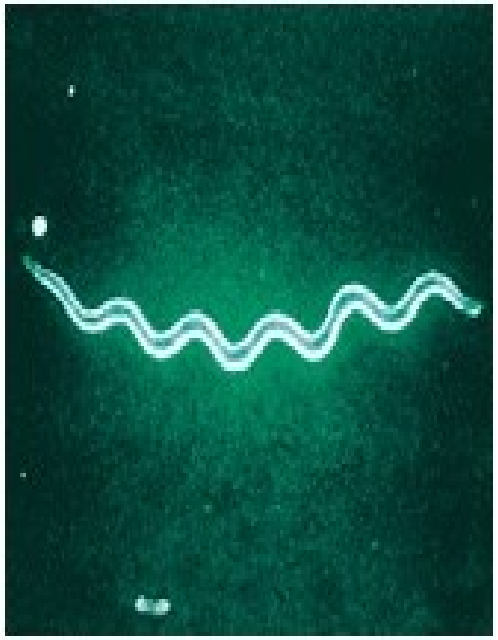


Morphology

- **Coccus** (plural = cocci) spherical cells
- **Bacillus** (plural = bacilli,); rod-shaped cells.
- **Coccobacillus**: cells that are not perfectly round, as are true cocci, but appear to have blunted ends

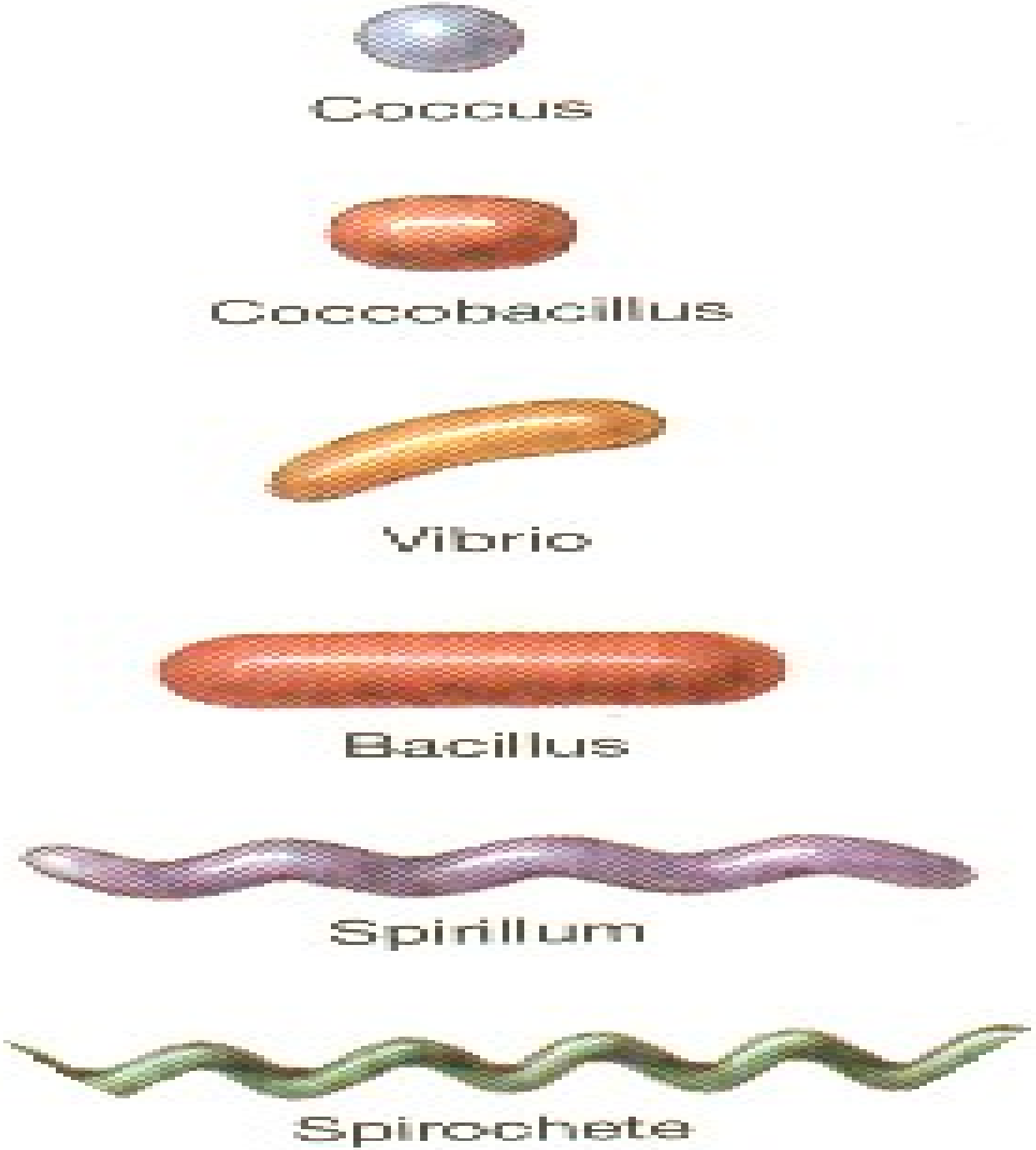






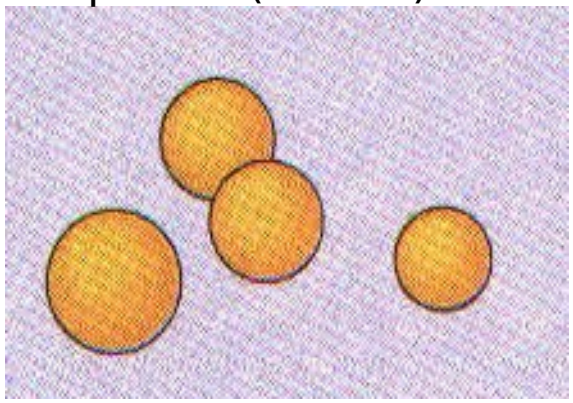
Morphology

- **Spirillum** (plural spirilla): cells with spiral or curved bodies with one or more twists. Spirilla are often motile by means of flagella.
- **Spirochetes** are also spiral shaped but are more flexible than spirilla and move by an internal flagellum known as an axial filament.
- **Vibrio**: comma shaped cells, typically motile by flagella.

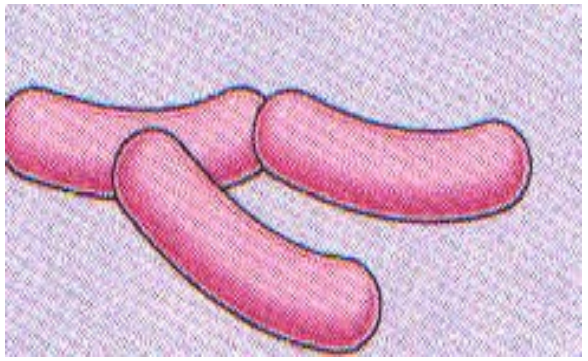

Coccus
Coccobacillus
Vibrio
Bacillus
Spirillum
Spirochete

Bacterial shape

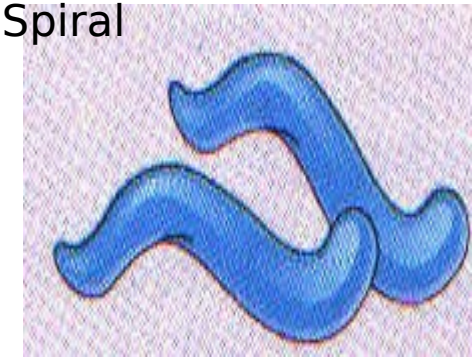
Sperical (coccus)



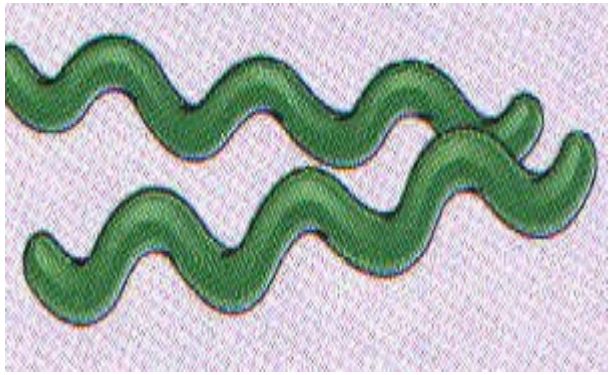
Rod-shaped



Spiral



Spiral or spirillum



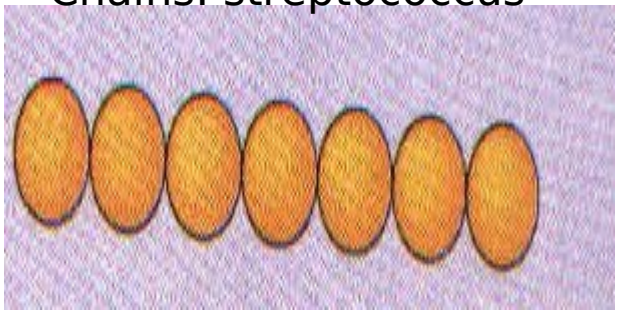
Helix or spirochete

Arrangement of bacterial cells

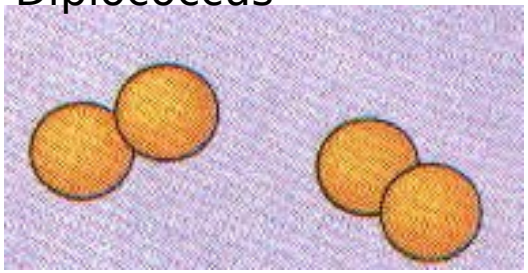
- Arrangement of cells dependent on pattern of division and how cells remain attached after division
- **Groupings of cocci include:**
- Diplococci: pairs of cocci
- Streptococci: chains of cocci.
- Staphylococci: clusters of geometrically arranged cocci.
- Tetrads: packets of 4 cells
- Sarcinus: packet of 8 cocci

Bacterial arrangement

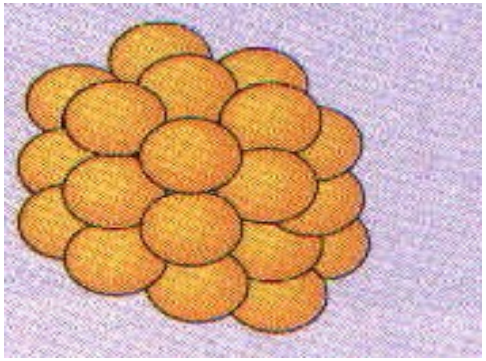
Chains: streptococcus



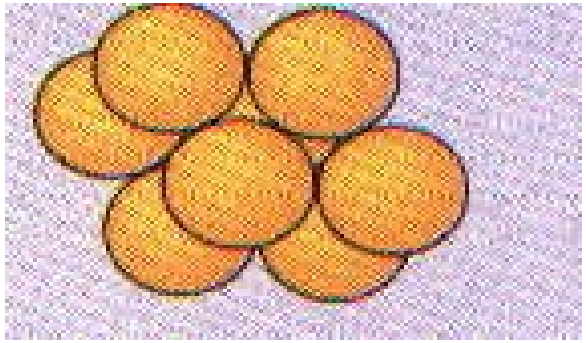
Diplococcus



Clusters: staphylococcus



Packets of eight:sarcina



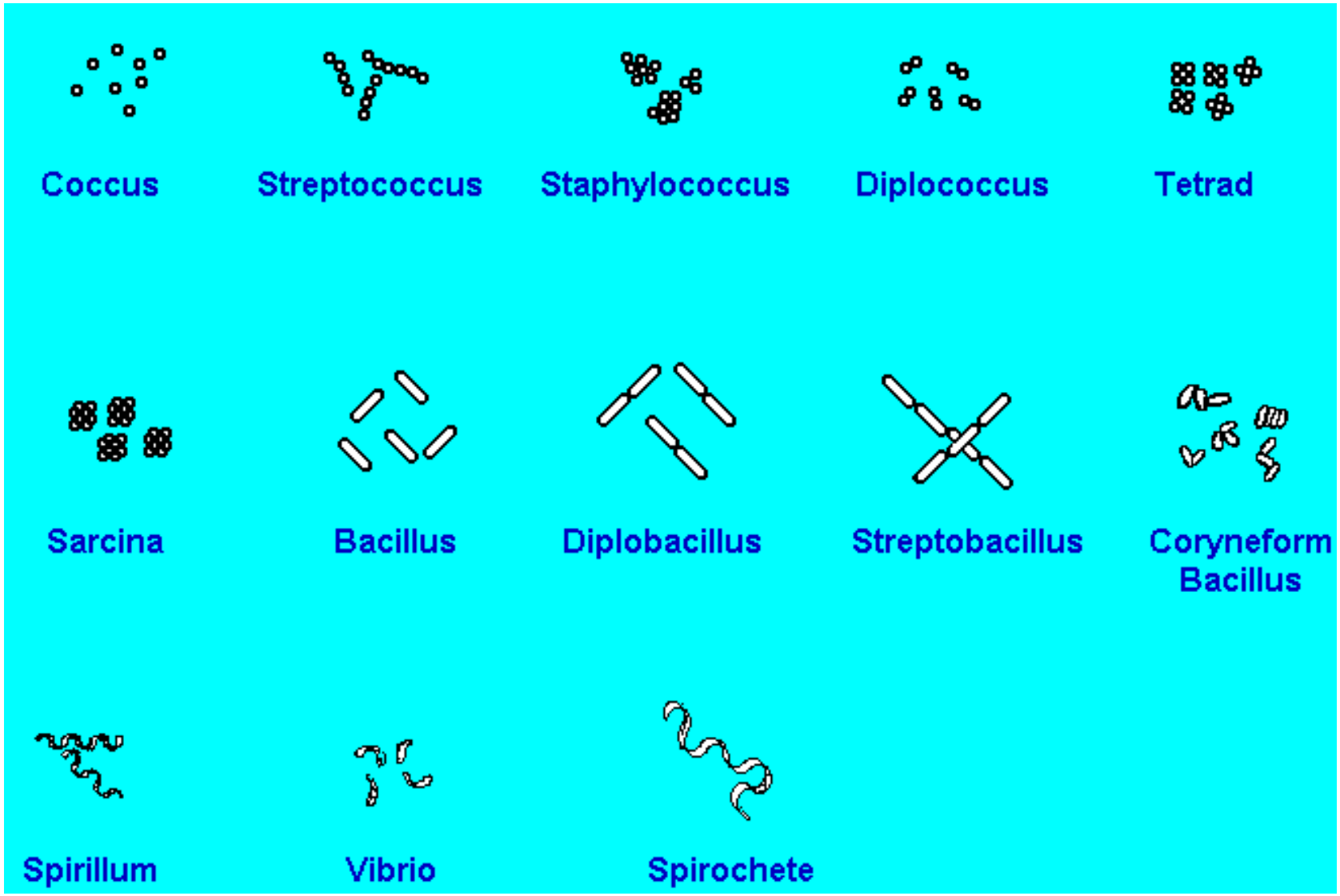


Fig. different bacterial arrangements

Any Last questions ???

