Bacteria Definition ."Bacteria are unicellular organisms belonging to the prokaryotic group where the organisms lack a few organelles and a true nucleus". Bacteria can be classified into various categories based on their features and characteristics .

Bacteria display a wide diversity of shapes and sizes. Bacterial cells are about one -tenth the size of eukaryotic cells and are typically 0.5–5.0 micrometers in length .

Bacteria: *Classification*

Classification: Placing organisms in groups of related species. Lists of characteristics of known organisms.

1. Based on shape
2. cell wall structure and Gram stain
3. cellular respiration
4. Growth factors (*Energy Source and Nutrient Source*)
5. Based on Temperature
6. Based on PH

Shapes of Bacteria

- Cocci – spherical/ oval shaped major groups
- Bacilli – rod shaped
- Vibrios – comma shaped
- Spirilla – rigid spiral forms
- Spirochetes – flexible spiral forms
- Actinomycetes – branching filamentous bacteria
- Mycoplasmas – lack cell wall

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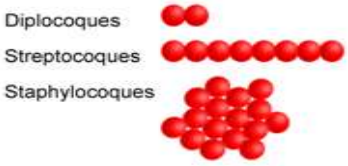
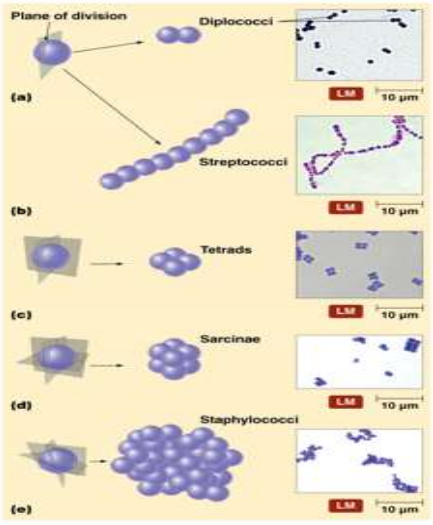
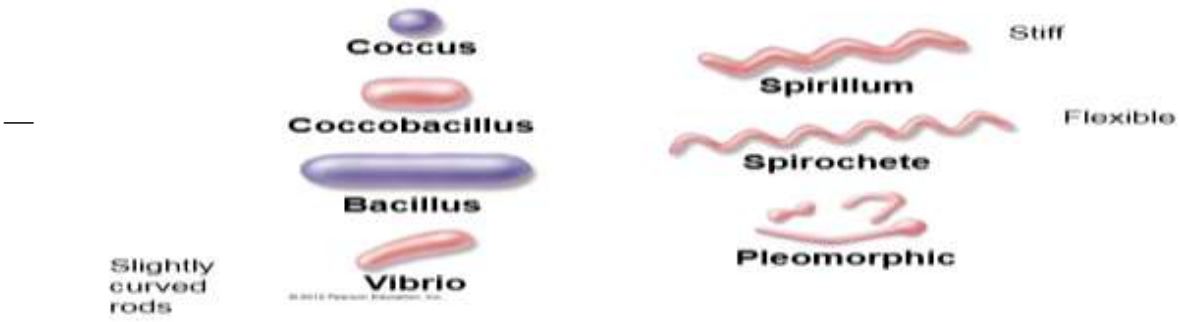
- Some are:
  - Round – cocci
    - Streptococci – chains
    - Staphlococci – in groups or clusters
    - Diplococci – in pairs
    - Micrococci

Strep Staph



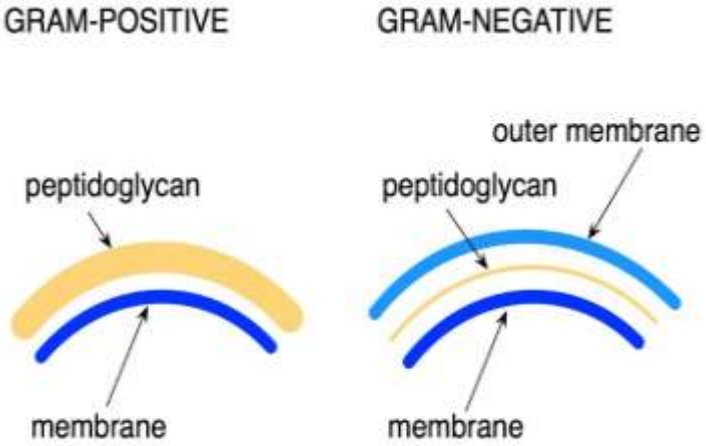


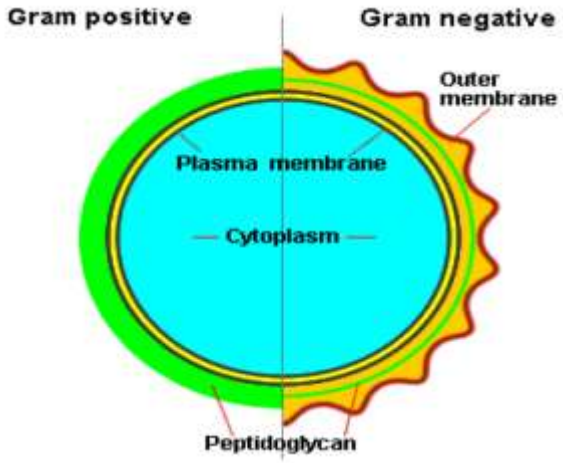


2- Classify based on Gram stain .

- **Gram positive or Gram negative**
- The stain is named for Hans Christian Gram, a Danish physician who invented it in 1884.
  - The **Gram stain**, which divides most clinically significant bacteria into two main groups, is the first step in bacterial identification.
  - Bacteria stained **Purple are Gram +** their cell walls have thick petidoglycan and teichoic acid.
  - Bacteria stained **pink are Gram –** their cell walls have thin peptidoglycan and lipopolysaccharides with no teichoic acid .
  -

In **Gram-positive bacteria, the purple crystal violet stain is trapped by the layer of peptidoglycan** which forms the outer layer of the cell. In **Gram -negative bacteria, the outer membrane of Lipopolysaccharide prevents the stain from reaching the peptidoglycan layer**. The outer membrane is then permeabilized by acetone treatment, and the **pink safranin counterstain** is trapped by the peptidoglycan layer.





	Microscopic Appearance of Cell	Chemical Reaction in Cell Wall (very magnified view)
Step	Gram (+) Gram (–)	Gram (+) Gram (–)
1. Crystal violet (primary dye)		Both cell walls stain with the dye
2. Gram's iodine (mordant)		Dye crystals trapped in cell / No effect of iodine
3. Alcohol (decolorizer)		Crystals remain in cell / Outer membrane weakened; cell loses dye
4. Safranin (red dye counterstain)		Red dye has no effect / Red dye stains the colorless cell

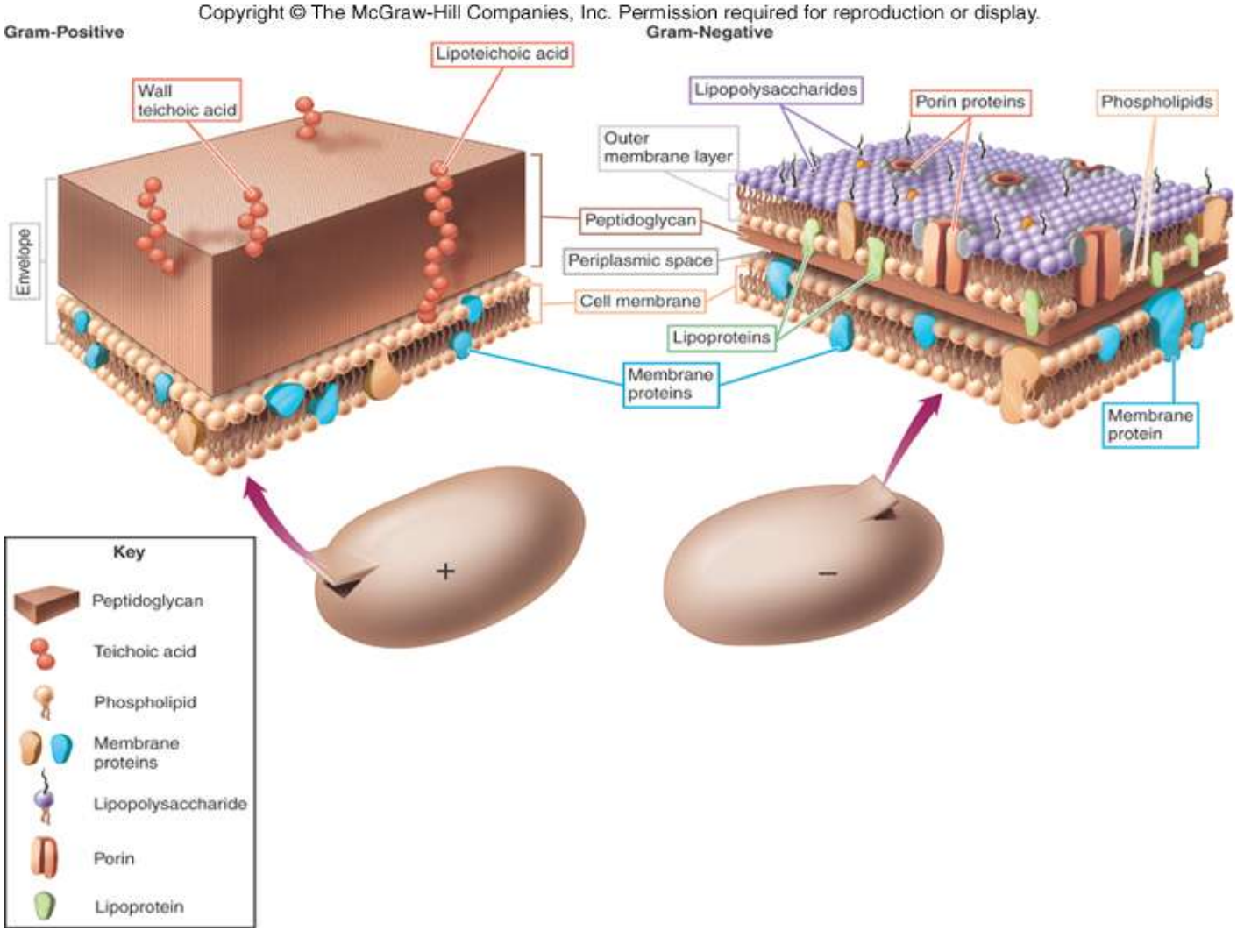


TABLE 4.1

Comparison of Gram-Positive and Gram-Negative Cell Walls

Characteristic	Gram-Positive	Gram-Negative
Number of major layers	1	2
Chemical composition	Peptidoglycan Teichoic acid Lipoteichoic acid	Lipopolysaccharide Lipoprotein Peptidoglycan
Overall thickness	Thicker (20–80 nm)	Thinner (8–11 nm)
Outer membrane	No	Yes
Periplasmic space	Narrow	Extensive
Porin proteins	No	Yes
Permeability to molecules	More penetrable	Less penetrable

Examples of Gram Positive bacteria

- *Streptococcus pyogenes* - causes strep throat
- *Staphylococcus aureus* - causes skin infections and may be responsible for boils .

Examples of Gram Negative Bacteria

- *Treponema pallidum* - causes syphilis
- *Escherichia coli* - may cause severe gastrointestinal problems .

Atypical Cell Walls

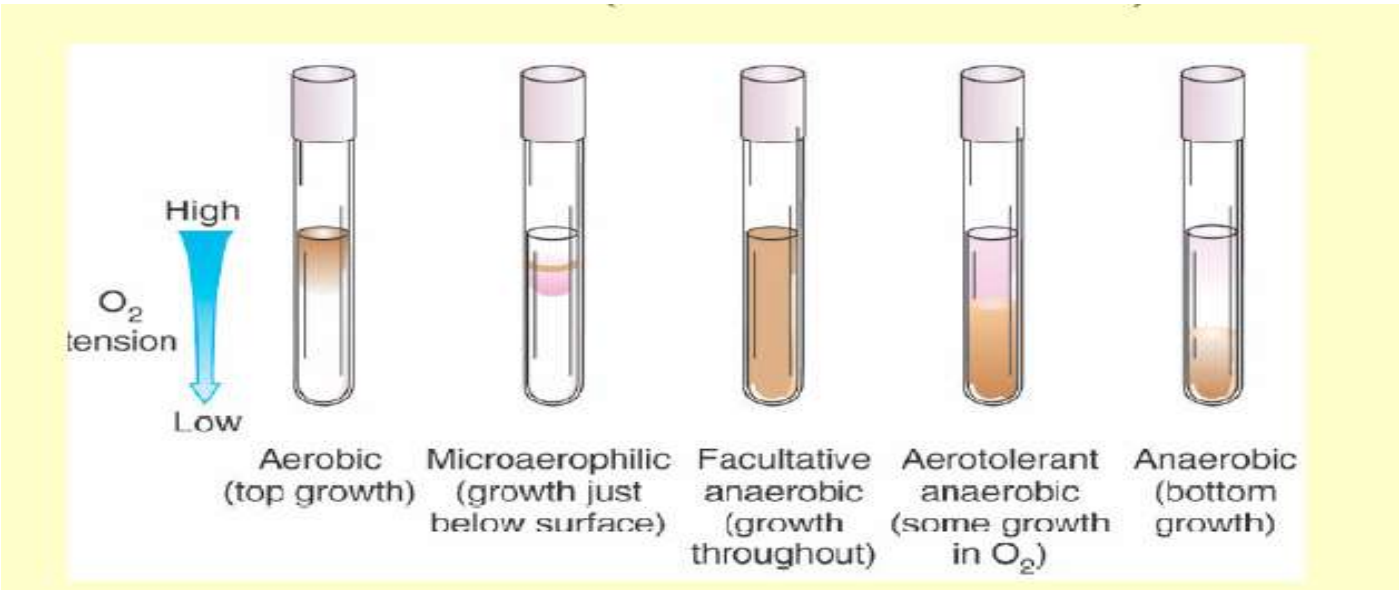
- Some bacterial groups lack ***typical*** cell wall structure :-
  - *Mycobacterium* and *Nocardia*
  - Gram-positive cell wall structure with lipid **mycolic acid**
    - pathogenicity
    - high degree of resistance to certain chemicals and dyes
    - basis for **acid-fast stain** .

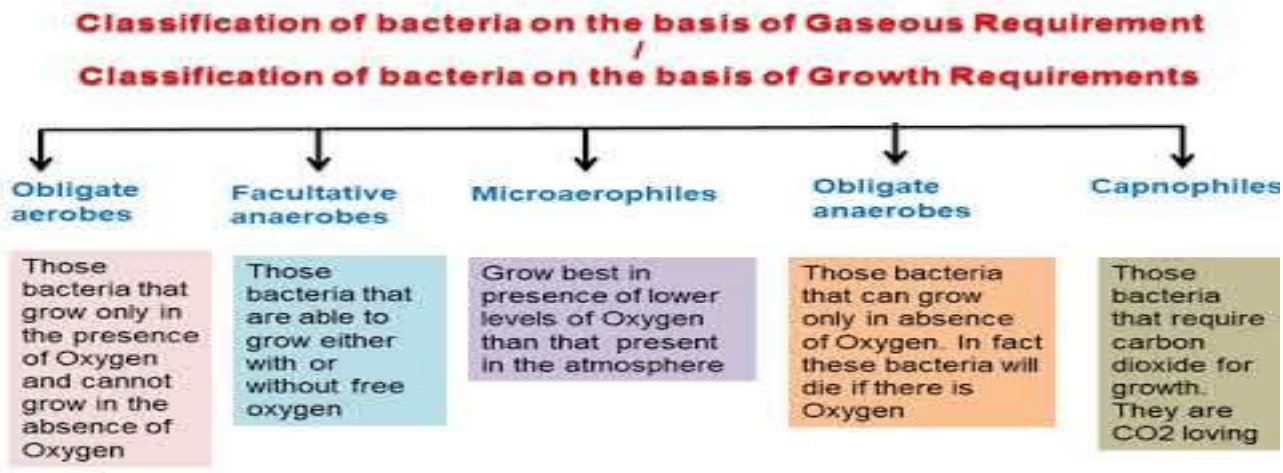
3- Classifying Bacteria by Cellular Respiration .

- **Ability to grow with / without air**
- **Aerobic bacteria ,** or **strict aerobes** - require oxygen
- **Anaerobic bacteria ,** or **strict anaerobes** - cannot tolerate oxygen
- **Facultative anaerobic –** are generally aerobes, but have the capacity to grow in the absence of oxygen .

Examples of Bacteria Classified by Cellular Respiration :-

- **Aerobic :** *Bacillus cereus*
- **Anaerobic :** *Clostridium* spp. (botulism, tetanus)
- **Facultative anaerobes :** *Staphylococcus* spp.





4- Classifying Bacteria by Growth Factors.

Under this scheme, they are generally classified according to :-

- Energy source
- Nutrient source

*** Energy Source**

- **Chemotroph** – chemical compounds as an energy source (most pathogenic bacteria are chemotrophs.)
- **Phototroph** - light as energy source

*** Nutrient Source**

- **Heterotroph** – derive carbon from preformed organic nutrients such as sugar (most pathogenic bacteria are heterotrophs.)
- **Autotroph** – derive carbon from inorganic sources such as carbon dioxide .

5- Temperature Adaptation Groups .

- **Psychrophiles**
  - optimum temperature 15 ^{o}C
  - capable of growth at 0 - 20 ^{o}C
- **Mesophiles**
  - optimum temperature 40 ^{o}C
  - Range 10 ^{o} - 40 ^{o}C (45)
  - most human pathogens
- **Thermophiles**
  - optimum temperature 60 ^{o}C
  - capable of growth at 40 - 70 ^{o}C
- **Hyperthermophiles**
  - *Archaea* that grow optimally above 80°C
  - found in seafloor hot-water vents .

6- Base on PH .

- Acidophiles
  - optimum pH is relatively to highly acidic
- Neutrophiles
  - optimum pH ranges about pH 7 (plus or minus)
- Alkaphiles
  - optimum pH is relatively to highly basic .