General Microbiology Course

Lecture 2

(Bacterial Structure and Classification)

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Objectives

To study:

- **Shapes of Bacteria.**
- **Structure external to cell wall.**
- **Structure internal to cell wall.**
- **The history of Gram stain.**

Shapes of Bacteria

Different shapes have been recognized:

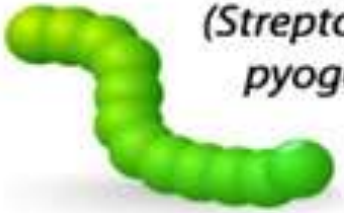
1. Spherica/Cocci:

- Cocci has originated from a greek word; kokkos = grain or kernel.
- (0.5µ -1.25µ in diameter)
- On the basis of arrangements cocci are further classified as follows:
  a. Micrococci: appears singly.
  b. Diplococcus: appear in a pairs of cells.
  c. Streptococci: appear in rows of cells or in chains.
  d. Staphylococci: arrange in irregular clusters like bunches of grapes.
  e. Tetracoccus: arrange in a sequence of four.
  f. Sarcinae: arrange in cuboidal or in a different geometrical or packet arrangements.

Shapes of Bacteria

SPHERES (COCCI)

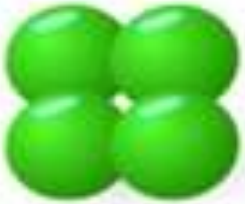
Diplococci
(Streptococcus pneumoniae)



Streptococci
(Streptococcus pyogenes)

Staphylococci
(Staphylococcus aureus)

Tetrad

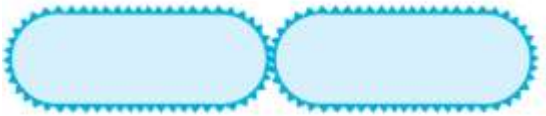


Shapes of Bacteria

2. Rod Shaped Bacteria or Bacillus:

bacilli

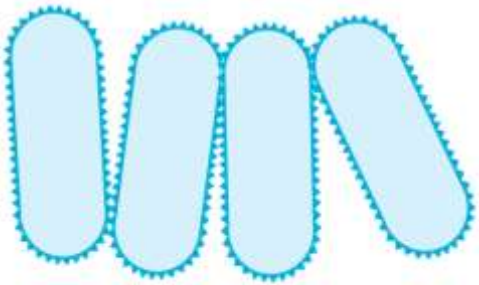
- From greek word, bacilli means rod or stick.
- Their ends are rounded flat or pointed.
- 0.5-1.2µ in diameter and 3-7µ in length.
- Flagellated or non-flagellated.



diplobacilli

Streptobacilli

- Types:
  - ✓Monobacillus: arrange singly.
  - ✓Diplobacillus: present in a group of two.
  - ✓Streptobacillus : in chains.
  - ✓Palisade: Very rarely the bacillus arrange in a palisade arrangement.

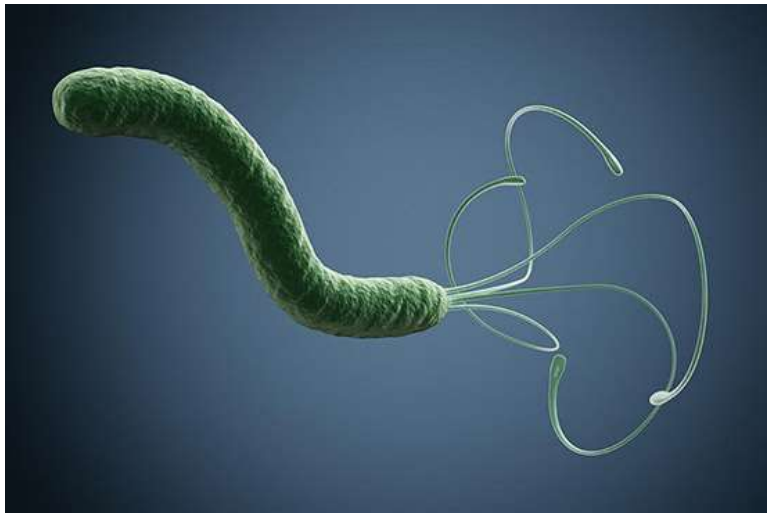


palisades.

Shapes of Bacteria

3. Spiral or Helical

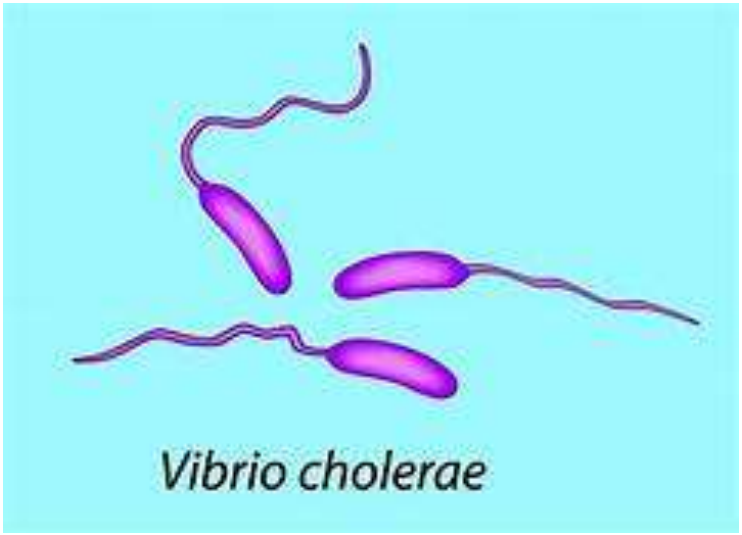
- From greek word; spira means coiled.
- A single spirillum has more than one turn of helix.
- There size ranges from 10-50µ in length and 0.5-3µ in diameter.
- They are flagellated

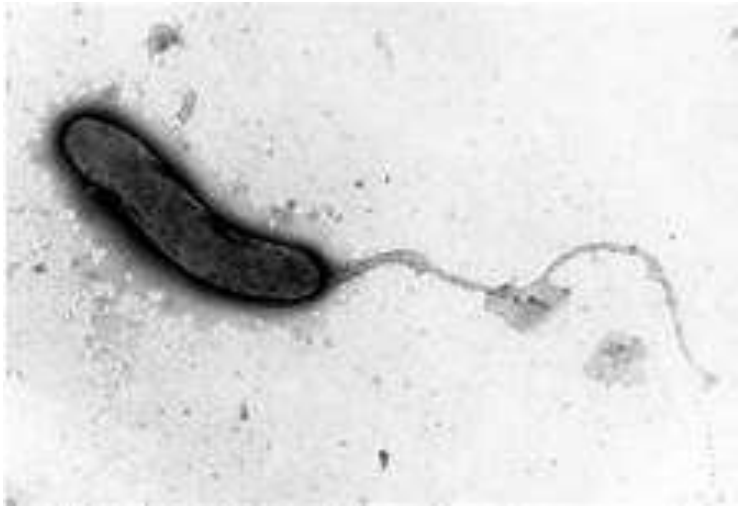


Shapes of Bacteria

4. Vibrio or Coma:

- They bear flagella at their end.
- Their size ranges from 1.5-1.7µ in diameter and upto 10µ in length
- e.g. *Vibrio cholarae.*





Shapes of Bacteria

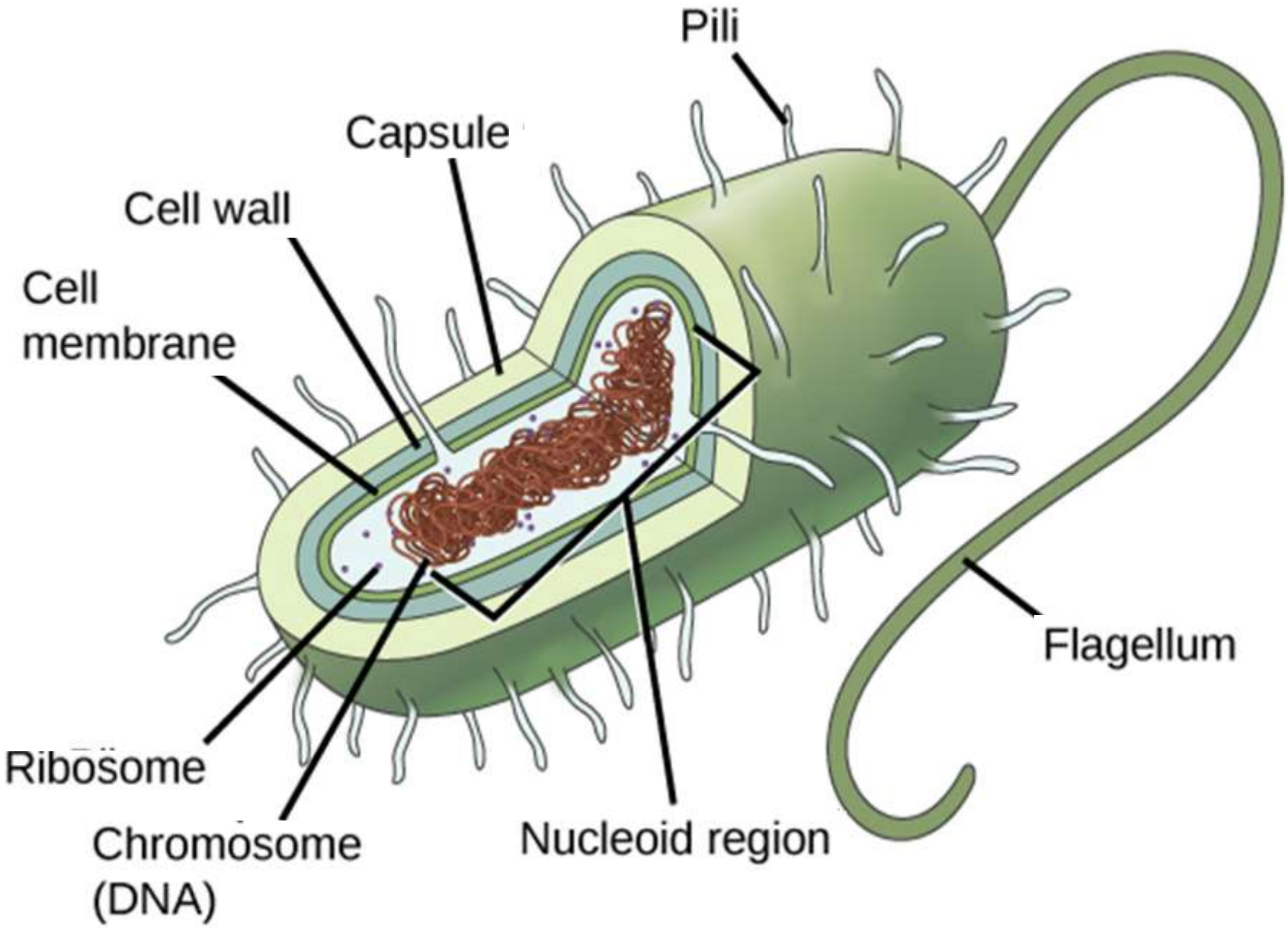
5. Spirochaeta:

- These bacteria appears like a cork screw and atrichous.
- Their length is more as compared to their diameter.
- Their body is more flexible.

Ultrastructure of Bacterial Cell

- Some of these are external to the cell wall whileother are internal to the cell wall.
- **Structure external to cell wall:**
  a. Flagella
  b. Pili (Fimbriae)
  c. Capsules
  d. Sheaths
  e. Prostheceae and stalks
  F. Cell wall
- **Structure internal to cell wall**
  a. Cytoplasmic membrane
  b. Mesosomes
  c. Cytoplasm
  d. Cytoplasmic inclusions and vacuoles
  e. Ribosomes
  f. Nuclear material
  g. Plasmid

Ultrastructure of Bacterial Cell

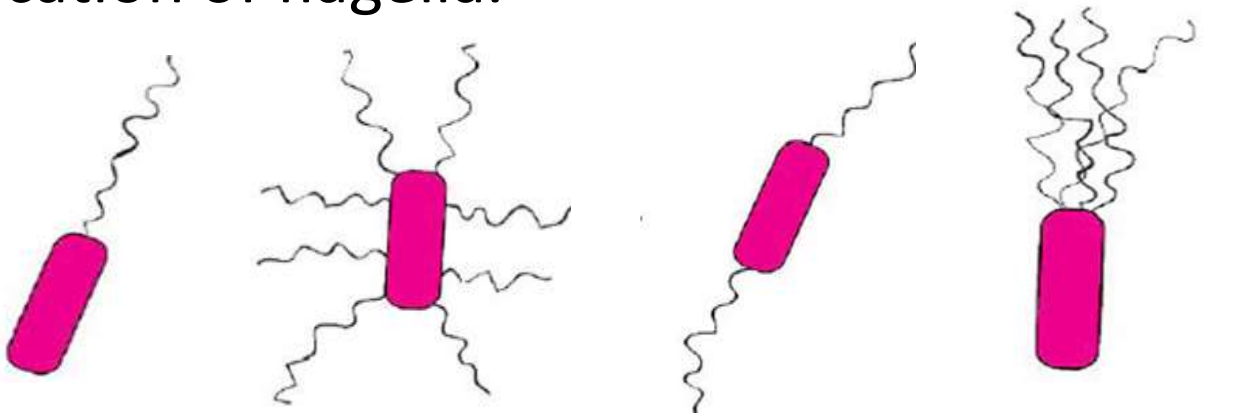


Ultrastructure of Bacterial Cell

Flagella

- They are flexible, whip like appendage (singular flagellum).
- A typical bacterial flagellum measures 4-5 µ long.
- They are made up of protein flagellin.
- The location of flagella varies in various bacteria.
- The bacteria which lack flagella are referred as atrichous.
- Bacteria can be divided into following types based on the the location of flagella.

Flagella



Monotrichous **Peritrichous** **Amphirichous** **Lophotrichous**

Pili

- These are hair like appendages present on the surface of most of the gram negative bacteria.
- They are smaller than flagella, have no role in the motility of bacteria.
- A single bacterial cells bears about 100-500 pili which are arranged peritrichously.
- They are composed of protein named pilin.
- Two types: Somatic pili and sex pili or conjugate pili

Pili

Somatic pili:

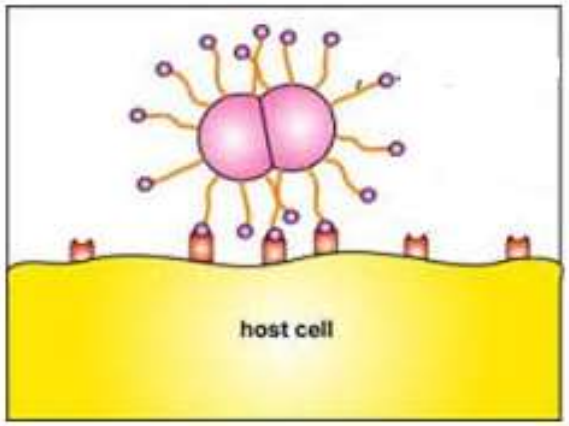
- Each bacterial cell bears about 100 somatic pili.
- Function: is to help the bacterium for attachment to a substratum.

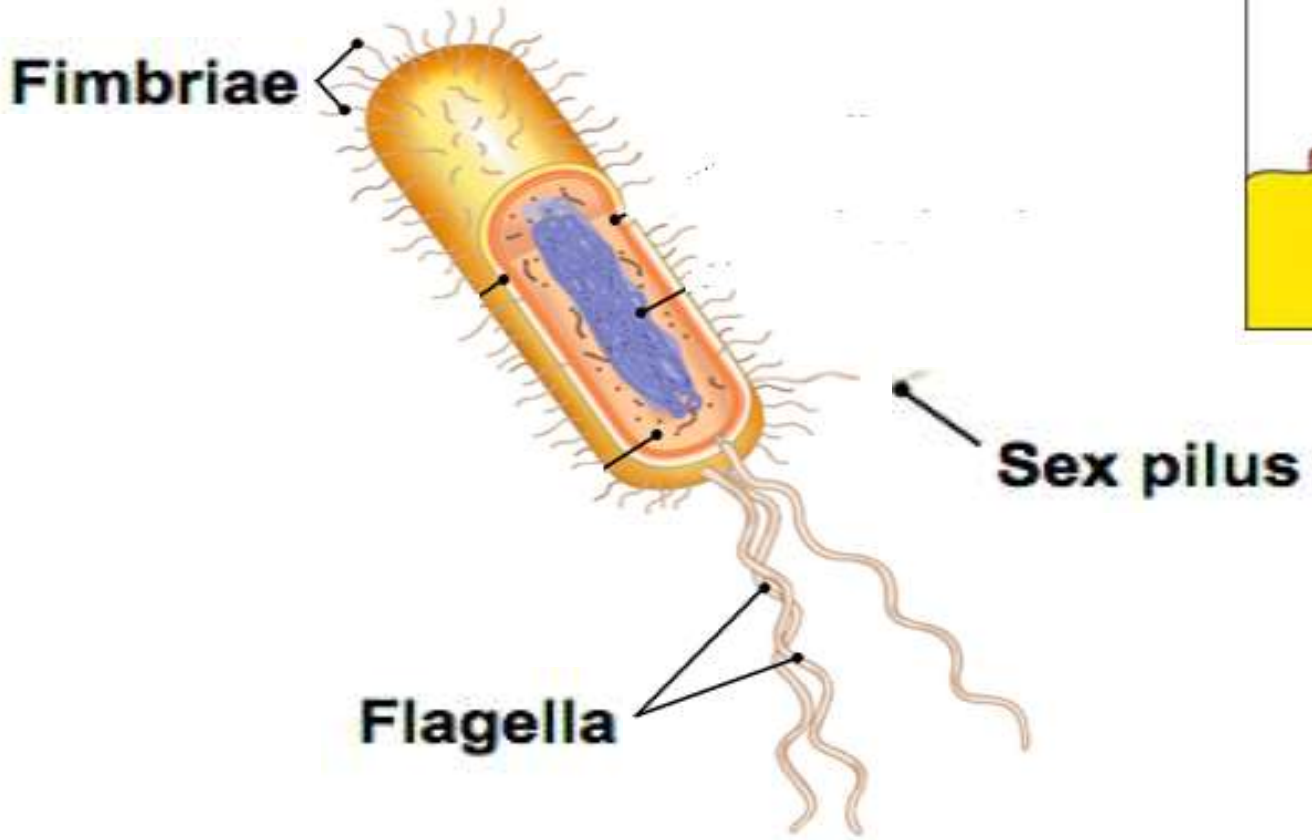
Sex Pili or Conjugate Pili :

- known as F pili.
- They are comparatively long (20 µ) and broad in width.
- There number ranges from 1-10 in male or donor bacterium.
- Male donor (+ factors) or female receptor/ receiver (- factor).
- The sex pili of male donor recognize the receptor protein on the surface of female or recipient.

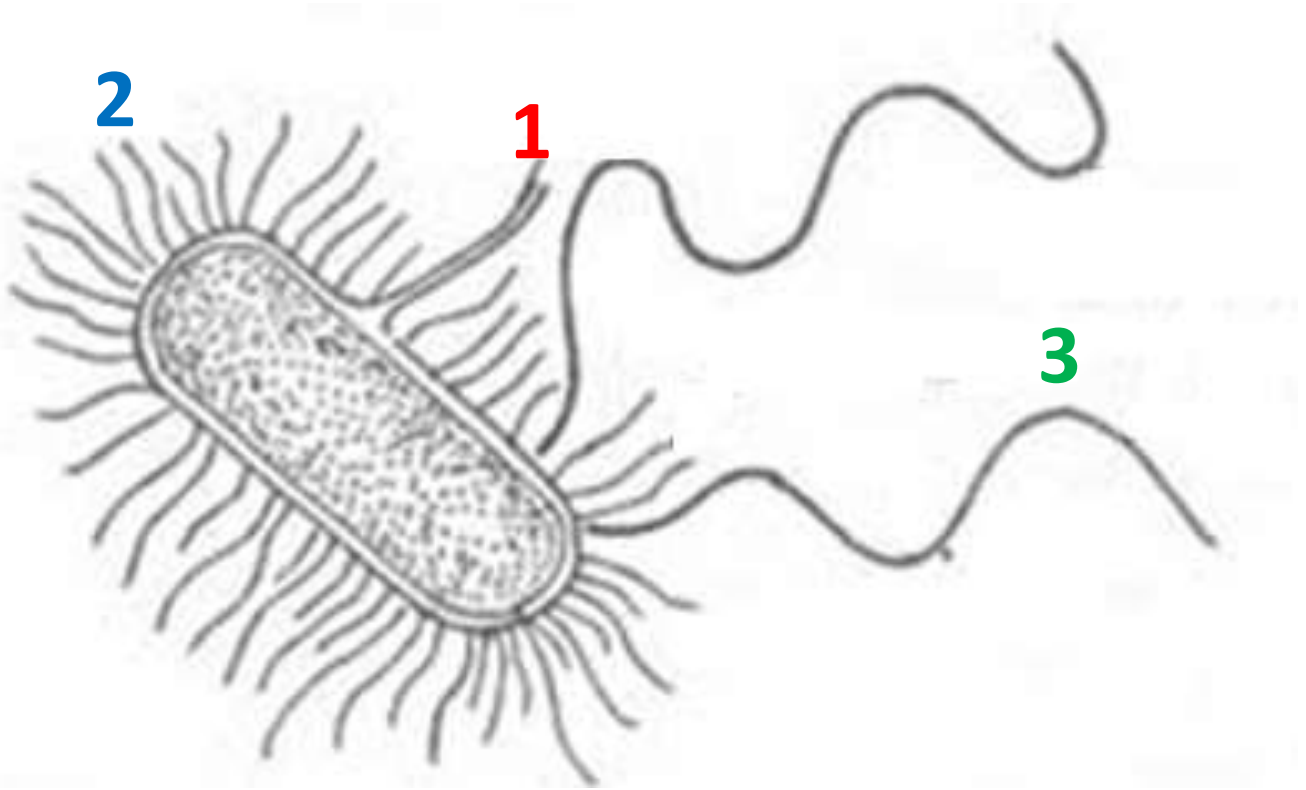
Fimbriae

- A fimbria is a short pili that is used to attach the bacterium to a surface. They are sometimes called "attachment pili".
- Fimbriae are either located at the poles of a cell, or are evenly spread over its entire surface.





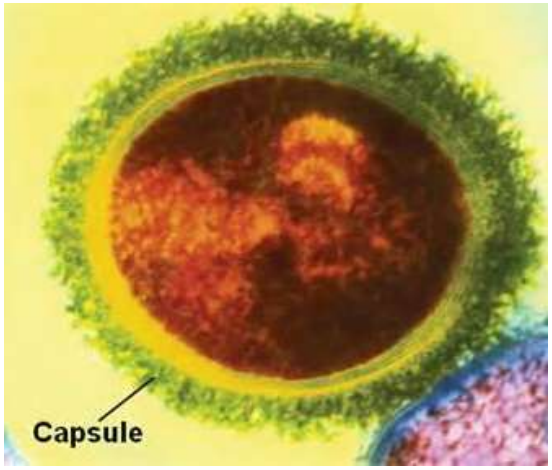
The Ultrastructure of bacterial cell

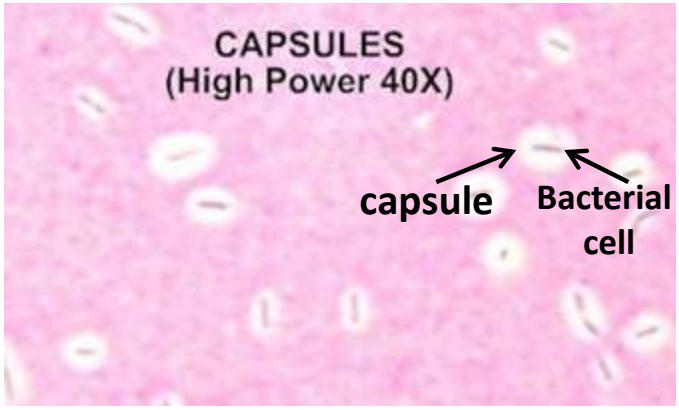


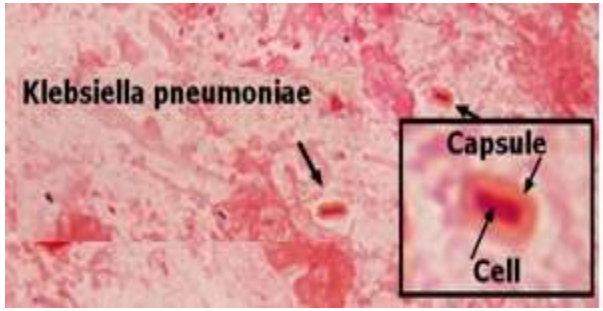
Capsule

Is a network of di- or polysaccharide or polypeptides forming a covering layer around the bacterial cell wall.

- **Functions**
  - ✓ They provide **protection against temporary drying** by binding water molecules.
  - ✓ They may be **antiphagocytic** i.e. they inhibit the engulfment of pathogenic bacteria by white blood cells







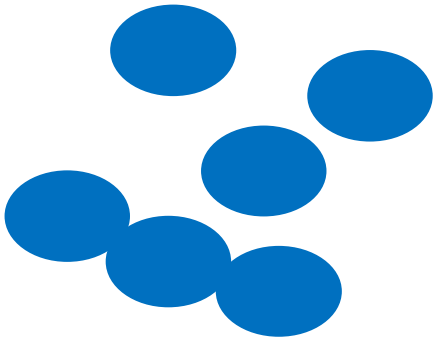
The Cell Wall

History

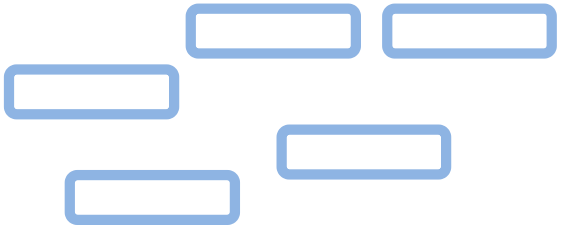
- The Gram stain was first used in 1884 by the Danish scientist Hans Christian Gram (Gram,1884).
- Gram was searching for a method that would allow visualization of bacteria in tissue sections of lungs of those who had died of pneumonia.
- He did this with both Streptococcus pneumoniae and Klebsiella pneumoniae bacteria, observing that Streptococcus pneumoniae retained the stain after washing with alcohol whereas Klebsiella pneumoniae did not.

History of Gram Staining

Danish scientist Hans Christian Gram (1853–1938)

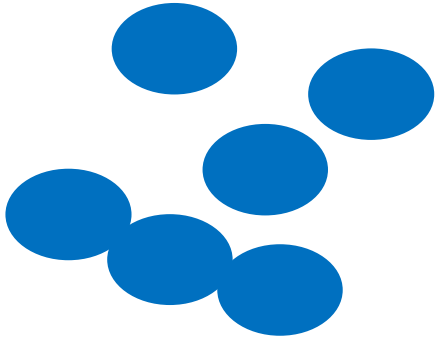


S. pneumoniae

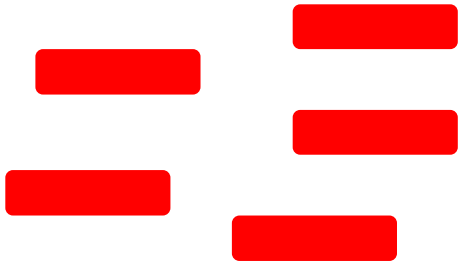


K. pneumoniae

German pathologist Carl Weigert (1845- 1904)



S. pneumoniae

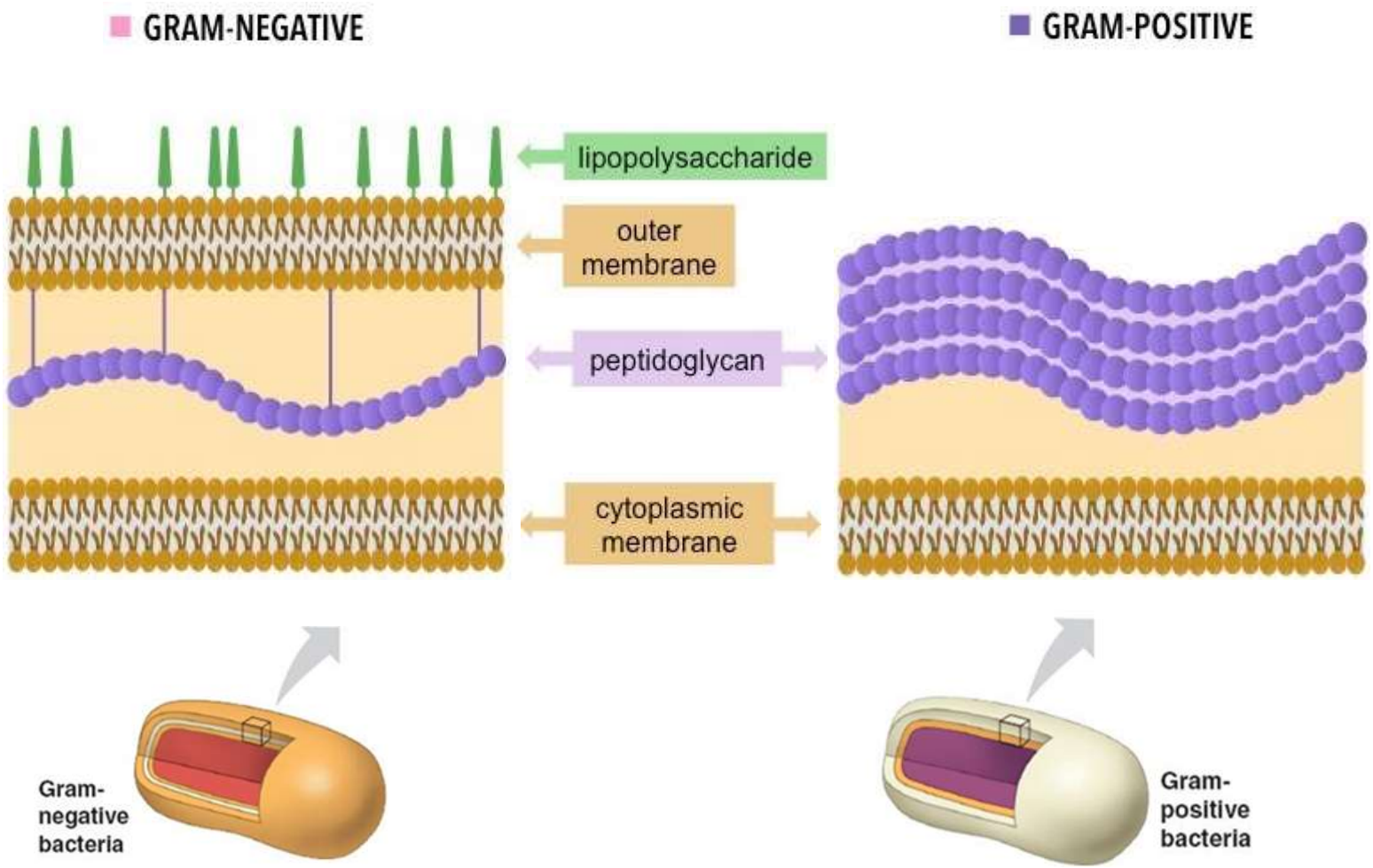


K. pneumoniae

The Cell Wall

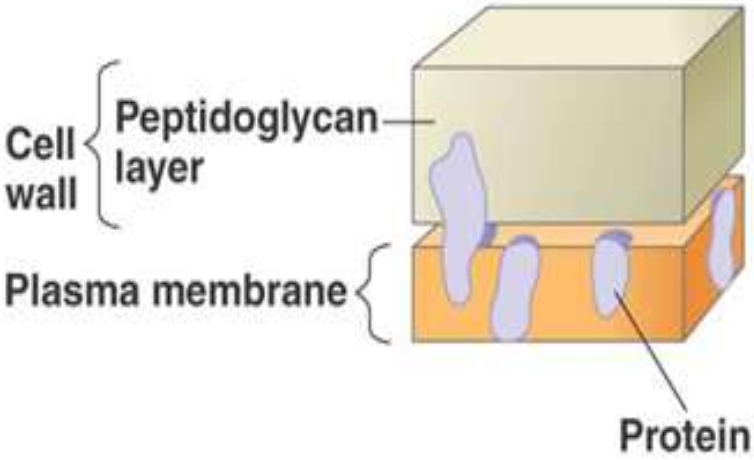
1. Located below the external structures and above to the cytoplasmic membrane is the cell wall.
2. Function:
   a) Very rigid structure and provide definite shape to the cell.
   b) Prevent the cell from expanding and bursting due to the hypotonic environment that the bacteria live in.
3. It may account for as such 10-40% of the dry weight of bacterial cell.
4. Generally the cell wall is made up of large number of layers.
5. The thickness of these different layers varies both in gram +ve and gram -ve bacteria.

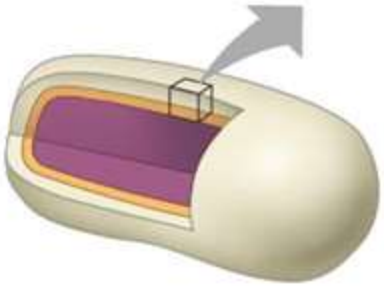
Gram-Negative Versus Gram-Positive Cell Walls



Gram positive vs. Gram negative bacteria

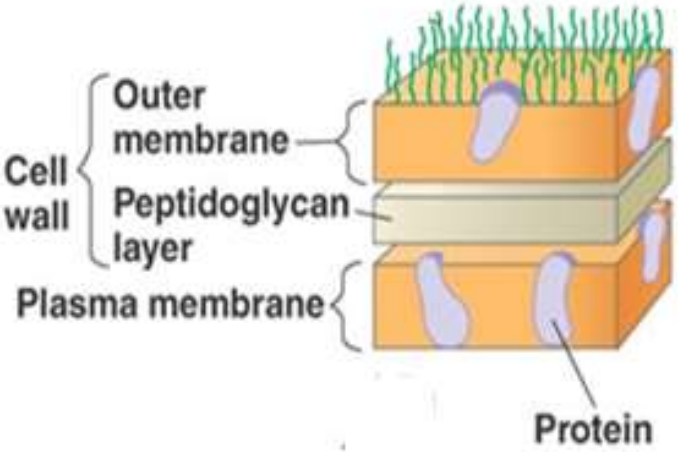
Gram positive

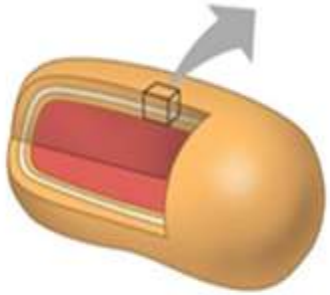




(a) Gram-positive: peptidoglycan traps crystal violet.

Gram negative





(b) Gram-negative: crystal violet is easily rinsed away, revealing red dye.

The Cell Wall

Gram negative bacteria

Functions of LPS:

- Protection from host defenses (O antigen).
- Contributes to negative charge on cell surface (core polysaccharide).
- Helps stabilize outer membrane structure (lipid A).
- Can act as an endotoxin (lipid A).

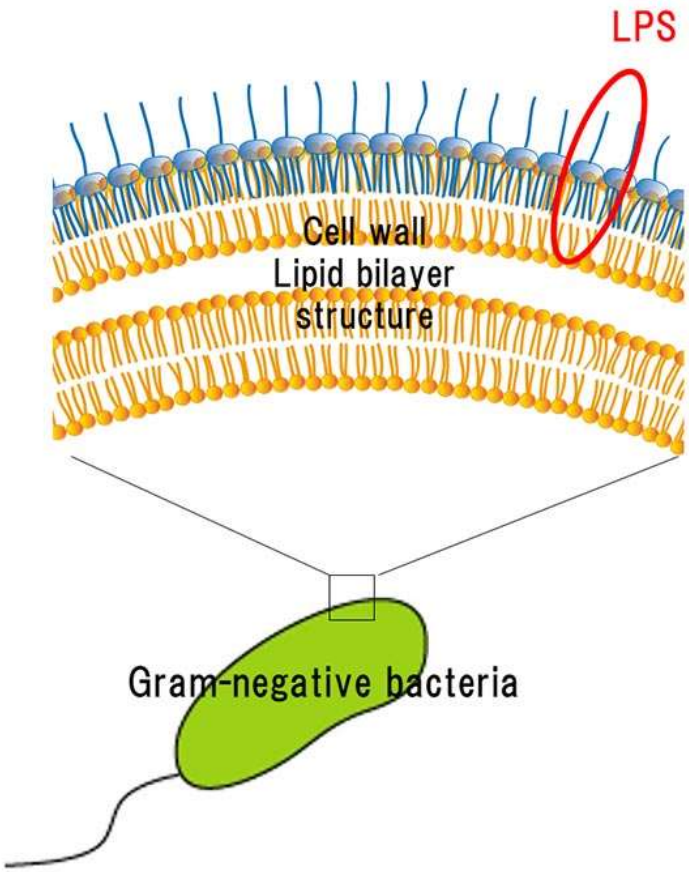
Pathogenic effect of LPS:

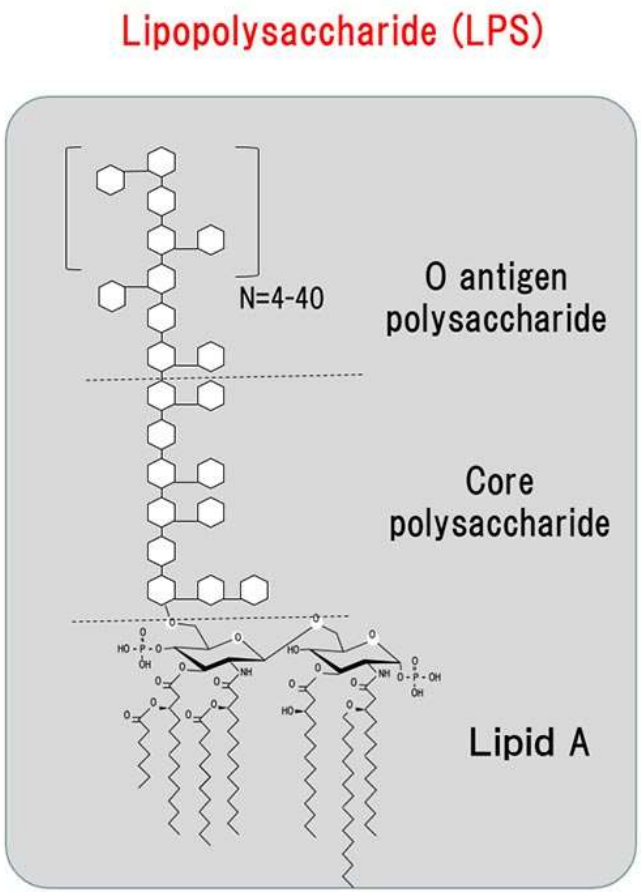
Lipid A may cause uncontrolled activation of mammalian immune systems with production of inflammatory mediators that may lead to septic shock

The Cell Wall

Gram negative bacteria

Functions of LPS:





To remember the differences in the cell wall of gram positive & negative organisms - think of a boring, *long powerpoint presentation.*
Long ppt will be your mnemonic guide =D

Lipopolysaccharide
Outer membrane
Negative
Gram?

Positive
Peptidoglycan (thick)
Teichoic acid

Structure Internal to Cell Wall

Ultrastructure of Bacterial Cell

- Some of these are external to the cell wall whileother are internal to the cell wall.
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  b. Pili (Fimbriae)
  c. Capsules
  d. Sheaths
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- **Structure internal to cell wall**
  a. Cytoplasmic membrane
  b. Mesosomes
  c. Cytoplasm
  d. Cytoplasmic inclusions and vacuoles
  e. Ribosomes
  f. Nuclear material
  g. Plasmid

Structure Internal to Cell Wall

Inclusion Bodies:

- Granules of organic or inorganic material that are stocked by the cell for future use.
- Some are enclosed by a singlelayered membrane – membranes vary in composition – some made of proteins; others contain lipids

Structure Internal to Cell Wall

Inclusion Bodies

Inclusion	Composition	Function
Glycogen	poly-glucose	Reserve carbon and energy source
Poly-betahydroxybutyric acid (PHB)	lipid	Reserve carbon and energy source
Poly-phosphates	polymers of PO_4	Reserve phosphate, possibly high-energy PO_4
Sulfur globules	elemental S	Reserve energy and or electrons
Magnetosomes	magnetite (iron oxide)	Provide orientation in magnetic field
Gas vesicles	protein shells inflated with gases	Provide buoyancy in aquatic environments
Parasporal crystals	protein	Produced by endospore-forming Bacilli - toxic to insects

Classification of Bacteria

Different methods are used to Classify bacteria:

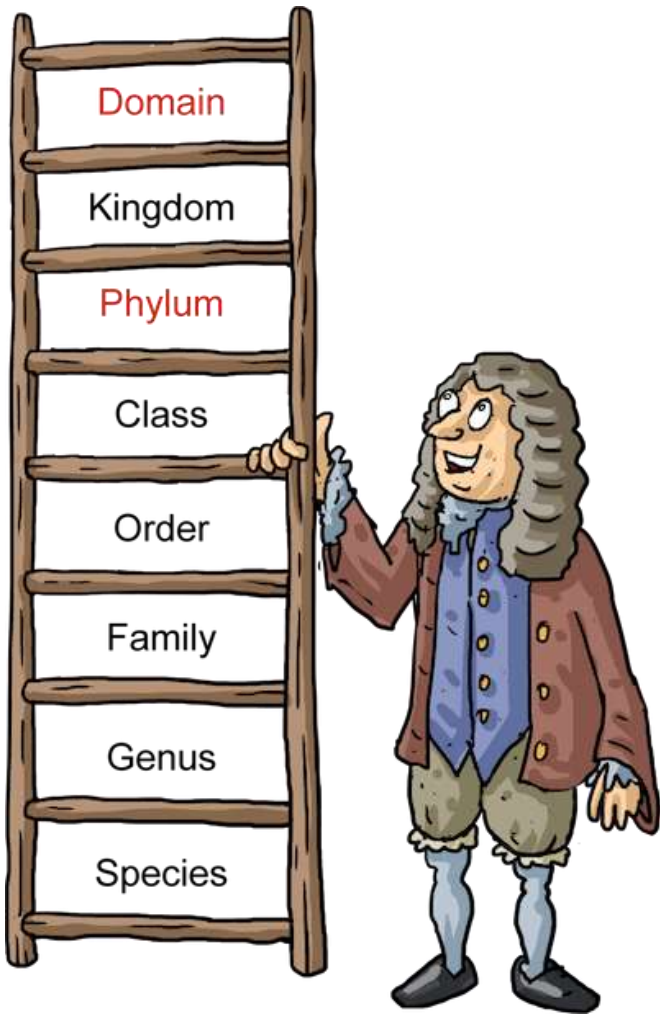
1. **Hierarchical classification**
2. **Shapes and Forms of Bacteria**
3. **Physiology**
4. **Molecular techniques: DNA , RNA, and protein analysis**

Classification of Bacteria

Hierarchical classification

Taxonomy: Defined as the science of classification of organisms

- Species: It is a group of related isolates or strains.
- Genus : It is a collection of related species.
- Family: A collection of similar genera. The name of the family ends in the suffix-aceae.
- Order: A collection of similar families. The name of the family ends in the suffix-ales.
- Class: It is a collection of similar orders. In prokaryotic nomenclature the name of the class ends in the suffix-ia.
- Phylum or Division: A collection of similar classes.
- Kingdom: A collection of similar phyla or division.
- Domain: A collection of similar kingdom



Remember: King Philip Came Over For Good Spaghetti

Classification of Bacteria

Hierarchical classification

Example: the taxonomic classification of *Escherichia Coli*

Formal rank	Example
Kingdom	Prokaryotae
Division	Gracillicutes
Class	Scotobacteria
Order	Eubacteriales
Family	Enterobacteriaceae
Genus	*Escherichia*
Species	*Coli*

Classification of Bacteria

Naming Microorganisms

- Binomial (scientific) nomenclature
- Gives each microbe 2 names:
  - **Genus**: always capitalized
  - **Species**: lowercase
- Both italicized or underlined
  - ✓ *Staphylococcus aureus (S. aureus)*
  - ✓ *Bacillus subtilis (B. subtilis)*
  - ✓ *Escherichia coli (E. coli)*