MICROBIOLOGY

Morphology & structure of Microorganisms

Lecture 1

Microbiology

Microbiology is the study of organisms that too small to be seen without magnification.

Microbiology derived from:

Micro: too small to be seen with naked eye.

Bio: life

Logy: study of

History of Microbiology

1. Robert Koch was notable for his discovery of the bacterium *Bacillus anthracis* in 1876 and such had launched the new scientific field of bacteriology.

- His discoveries about microscopic techniques and different pathogenic bacteria like the *Bacillus anthracis, Staphylococcus, Mycobacterium tuberculosis, Vibrio cholerae*, etc. ensued the "golden age" of scientific discovery.
- In honor of his phenomenal discoveries, Koch was called

2. Robert Hooke: Known for his discovery of the first ever compound microscope, Robert Hooke is often called the “Father of Cytology“. He used such invention to view and observe the most minute and previously unknown structures called as the cells.

- Aside from his discoveries in biology, Hooke also has made several significant contributions to the field of agriculture, physics, chemistry, and mechanical engineering.

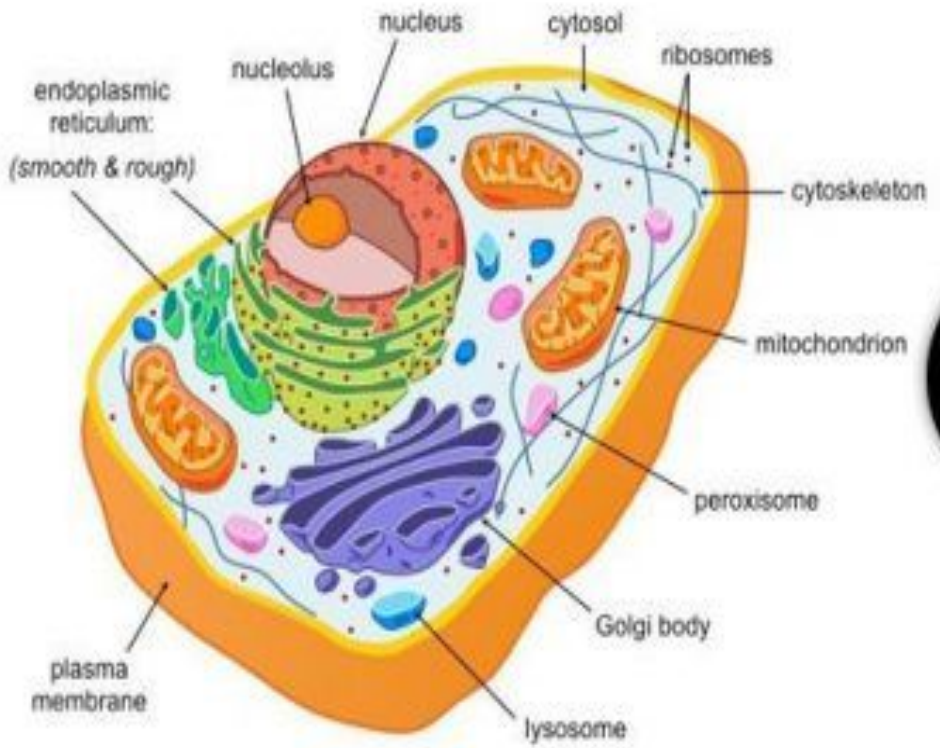
Microorganisms Are Ubiquitous

Microorganisms include:

- Bacteria
- Viruses
- Fungi
- Parasites (protozoa & helminthes)
- Algae

Introduction

- There are several classes of living organisms.
- Based on the organization of their cellular structures, all living cells can be divided into two groups:
- **Eukaryotic cell**: animals, plants, fungi, protozoa and algae.
- **Prokaryotic cell:** bacteria & blue green algae



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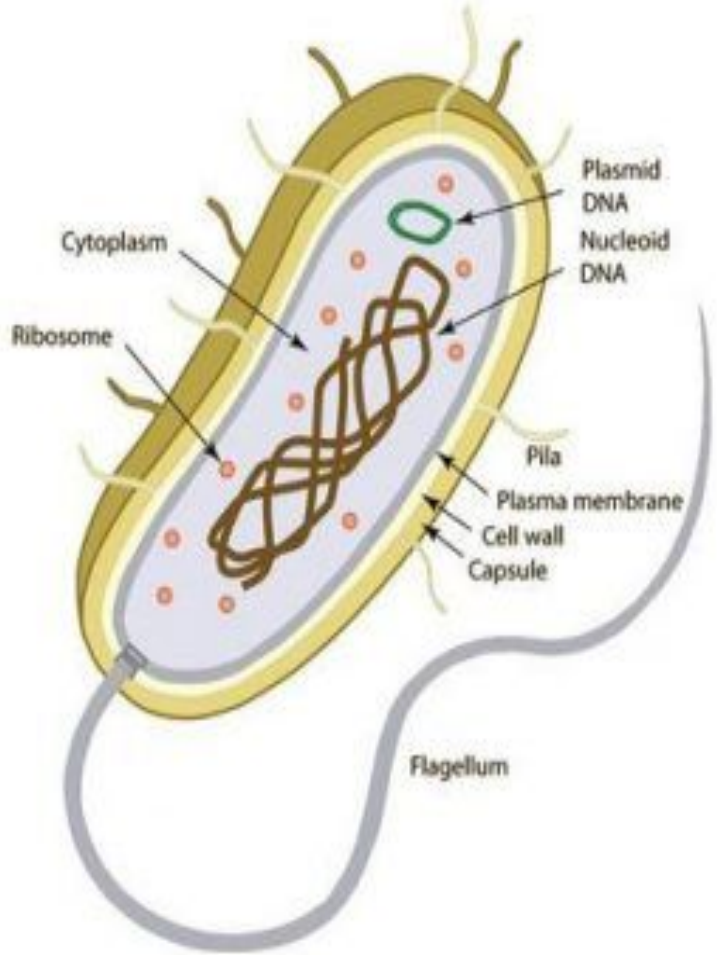


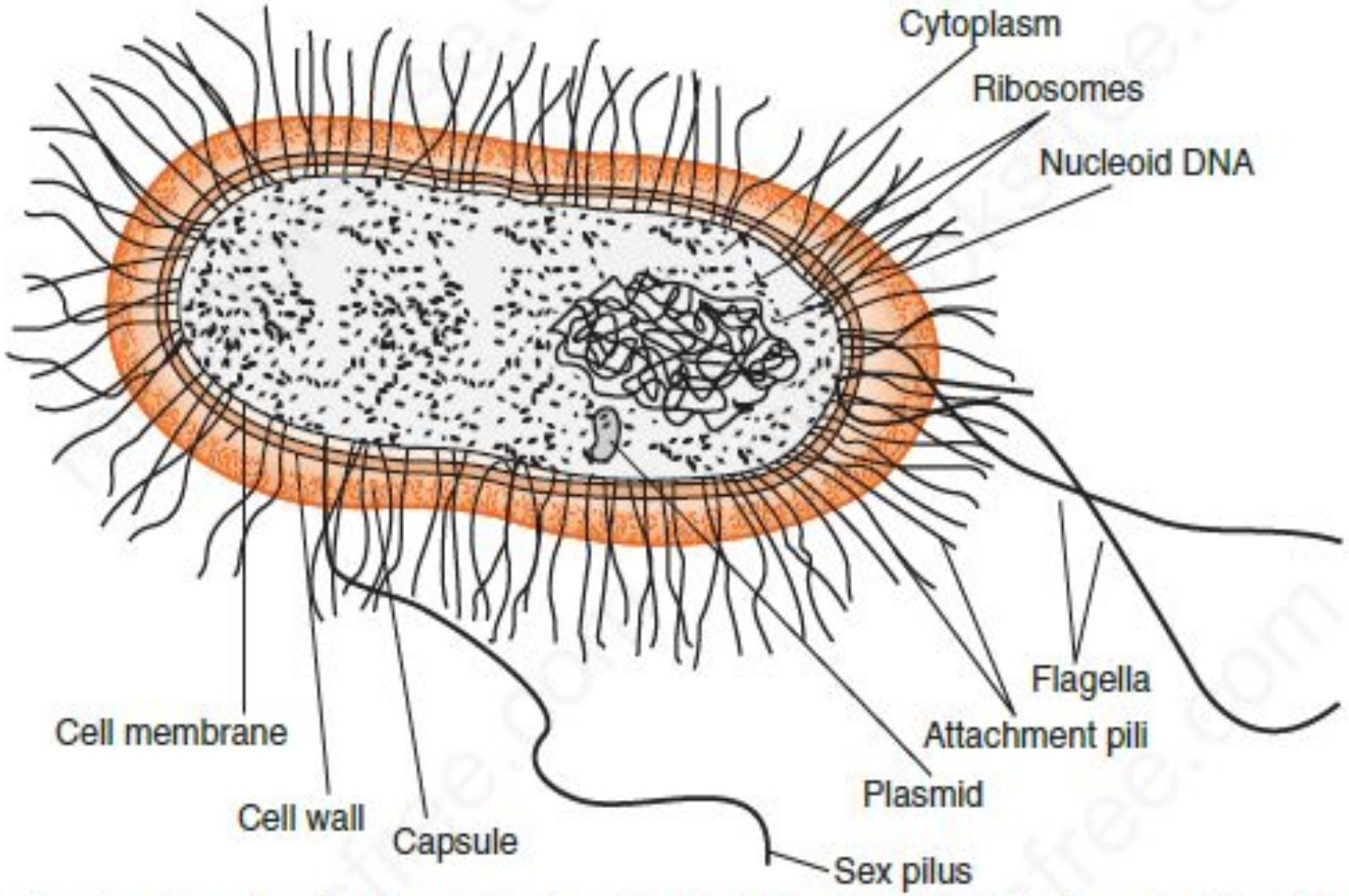
Eukaryotic Cell vs. Prokaryotic Cell

TABLE 1-3 Characteristics of Prokaryotic and Eukaryotic Cells

Characteristic	Prokaryotic Bacterial Cells	Eukaryotic Human Cells
DNA within a nuclear membrane	No	Yes
Mitotic division	No	Yes
DNA associated with histones	No	Yes
Chromosome number	One	More than one
Membrane-bound organelles, such as mitochondria and lysosomes	No	Yes
Size of ribosome	70S	80S
Cell wall containing peptidoglycan	Yes	No

Prokaryotic Cells

- Much smaller (microns) and more simple than eukaryotes.
- Prokaryotes are molecules surrounding by a membrane and cell wall.
- They lack true nucleus and don't have membrane bound organelles like mitochondria, Golgi complex, etc.
- Large surface to volume ratio: nutrients can easily



Bacterial structure. (Reproduced with permission from Ryan K et al. *Sherris Medical Microbiology*. 4th ed. Copyright 2004, McGraw-Hill.)

Size of bacteria

- Unit of measurement in bacteriology is micron (micrometer) (µm) .
- Bacteria of medical importance
- 0.2-1.5 µm in diameter
- 3-5 µm in length

Shape of Bacteria

- **Cocci:** spherical / oval shaped (major groups)
- **Bacilli:** Rod shaped
- **Vibrios:** comma shaped
- **Spirilla:** rigid spiral forms
- **Spirochetes:** flexible spiral forms
- **Actionomycetes:** branching filamentous bacteria

Shape of Bacteria

Bacterial shapes and arrangements

Outer layer:

consist of two components

1- Rigid cell wall.

2-Cytoplasmic (cell or plasma membrane) present beneath well wall.

- **Cytoplasm:** gel-like substance enclosed within the cell membrane contain cytoplasmic inclusions, ribosomes, mesosomes, and nucleoid.
- **Additional structures:** plasmid, slime layer, capsule, flagella, fimbriae (pili) and spores.

Structure & Function of Cell Components

1- Cell wall:

- Outermost layer, encloses cytoplasmic membrane.

1- Confers shape and rigidity.

2- **Peptidoglycans** is responsible for the rigidity of bacterial cell wall and for determination of cell shape.

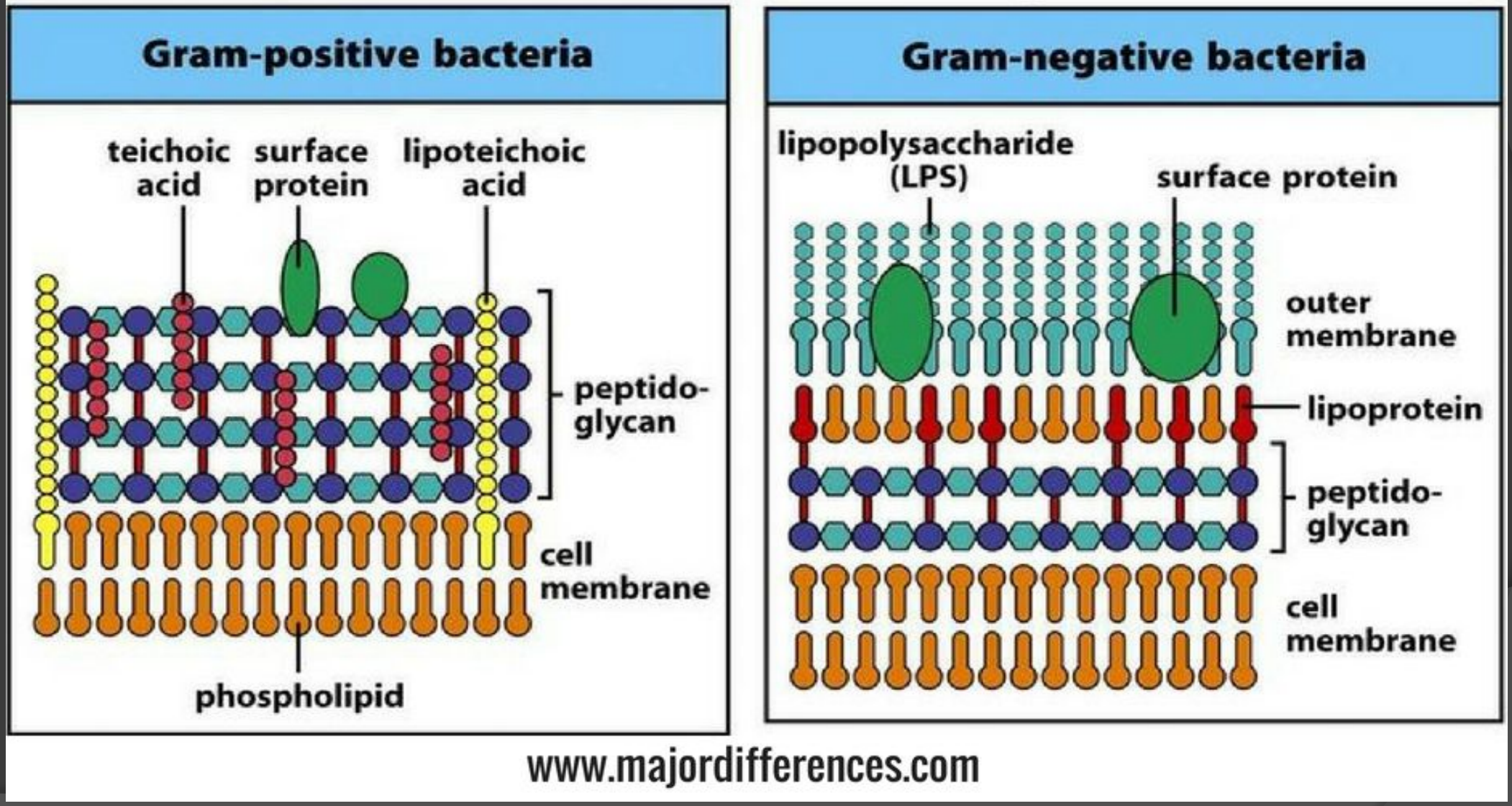
4- Cell wall cannot be seen by direct light microscope and do not stain with simple stain.

5- Carries bacterial antigens (important in virulence & immunity)

6- Chemical nature of the cell wall helps to divide bacteria into two broad groups (Gram positive & Gram negative).

7- Gram +ve bacteria have simpler chemical nature than –ve bacteria.

Cell wall of Gram Positive vs Gram Negative Bacteria



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Gram Positive Cell Wall

- The Gram +ve cell wall is composed of a thick, multilayered Peptidoglycan sheath outside of the cytoplasmic membrane.
- Teichoic acids are linked to and embedded in the peptidoglycan.
- lipoteichoic acids extend into the cytoplasmic membrane.

Gram negative Cell Wall

- The Gram -ve cell wall is composed of an outer membrane linked to thin single-layered peptidoglycan by lipoproteins.
- The peptidoglycan is located within the periplasmic space that created between the outer and inner membrane.
- The outer membrane includes Porins, which allow the passage of small hydrophilic molecules across the membrane and lipopolysaccharides molecules that

Comparison

Property of bacteria	Gram positive bacteria	Gram negative bacteria
Thickness of wall	20-80 nm	10 nm
Number of layer in wall	1	2
Peptidoglycan content	>50%	10-20%
Teichoic acid in wall	+	-
Lipid & lipoprotein content	0-3%	58%
Protein content	0%	9%
Lipopolysaccharide	0%	13%
Sensitive to penicillin	Yes	Less sensitive
Digested by lysosome	Yes	weakly

2- Cytoplasmic (Plasma) Membrane

- **Thin layer 5-10 nm, separates cell wall from cytoplasm**
- Acts as a semi-permeable membrane: controls the inflow and outflow of metabolites
- Composed of lipoproteins with small amount of carbohydrates

3- Cytoplasm

- **Colloidal system of variety of organic & inorganic solutes in viscous watery solution.**

- Cytoplasmic components

1- Ribosomes: function in protein synthesis (70s).

2- Mesosomes

1- Multi-laminated structures formed as invaginations of plasma membrane.

2- Principle sites of **respiratory enzyme.**

3- coordinate nuclear & cytoplasmic division during binary fission.

4- more prominent G+ve bacteria

4- Nucleus

- No nucleolus
- No nuclear membrane
- Oval or elongated bodies generally 1 per cell
- Genome- single, circular bodies double stranded DNA.
- Haploid- divides by binary fissions.

Additional Organelles

1-Plasmid:

- Extra-nuclear genetic elements consisting of DNA.
- Transmitted to daughter cells during binary fission
- May ne transferred from one bacterium to another
- Not essential for life of cell.
- Confer certain properties e.g. drug resistant gene.

2-Capsule & Slime Layer

- Viscous layer secreted around the cell wall.
- Polysaccharide or polypeptide in nature..

1- Capsule:

Sharply defined structure, antigenic in nature.

- Protects bacteria from lytic enzyme.
- Inhibit phagocytosis.
- Stained by negative staining using India Ink.

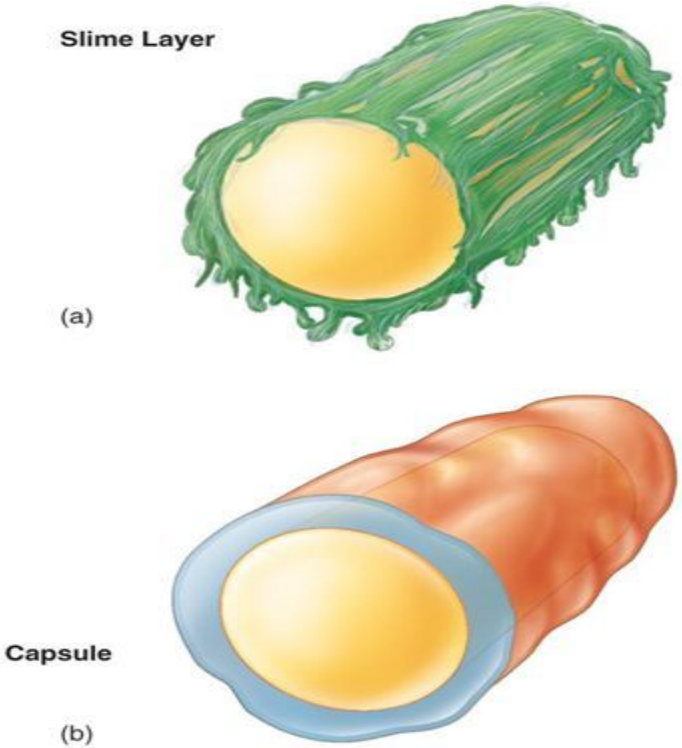
B- Slime layer:

Is loosely associated with bacterium and can be easily washed off, whereas a capsule is attached tightly to the bacterium and has definite boundaries.

Bacterial cell structure

External structures – Capsule/slime layer

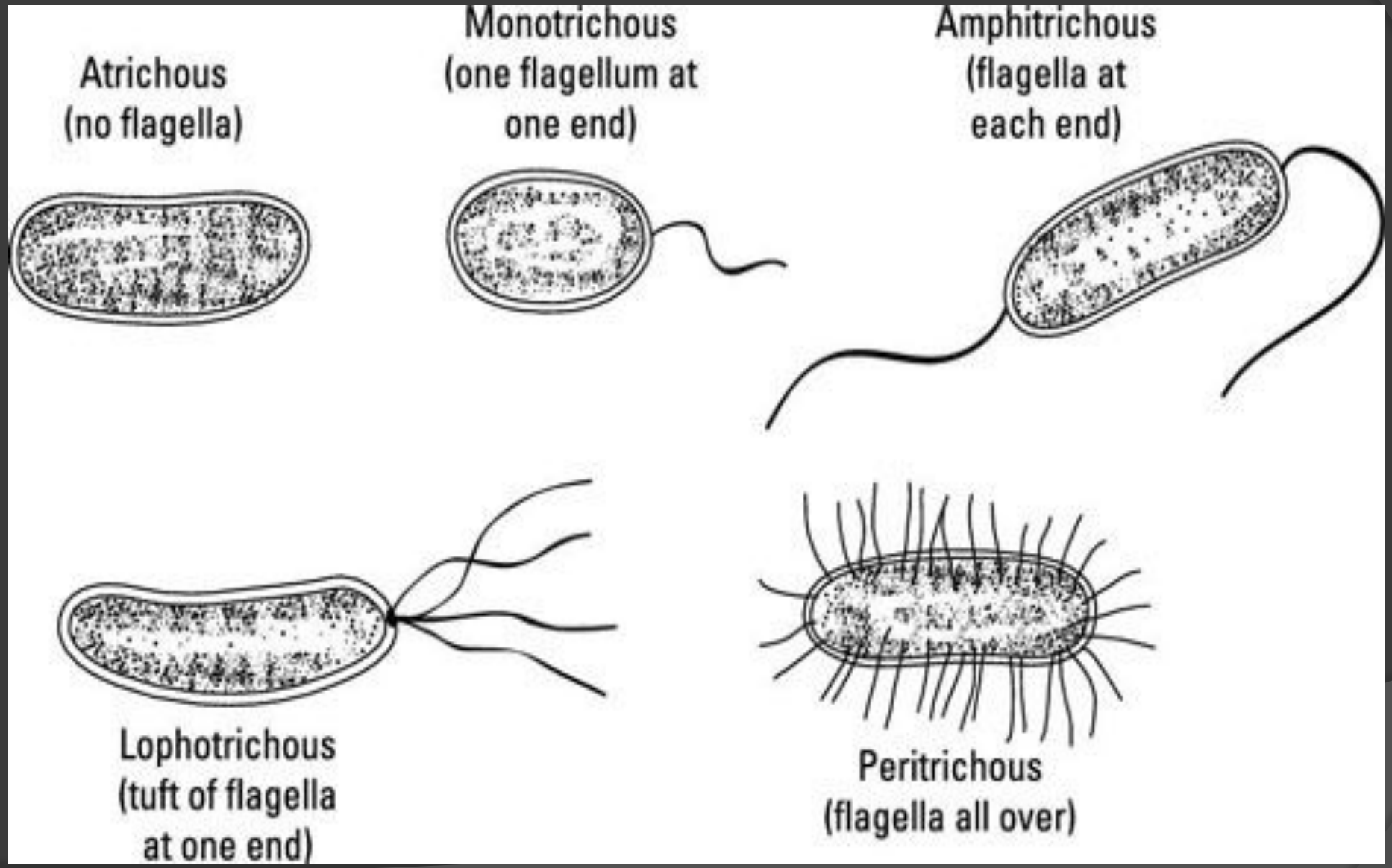
- Capsule → condensed layer; closely surrounds the bacterium
- Slime layer → loosely adherent; nonuniform in density and thickness
- Capsule/slime layer: also called **glycocalyx**



3- Flagella

- Long (3-12µm) filamentous surface appendages.
- Organs of locomotion.
- Composed of protein called flagellins
- The number and distribution of flagella on the bacterial surface are characteristic for given species –hence are useful in identifying and classifying bacteria.
- Flagella may serve as antigenic detriments (e.g

- Presence shown by motility e.g. hanging drop preparation test.
- Each flagellum consist of 3 part: 1- Filament 2-Hook 3- Basal body.


Atrichous
(no flagella)
Monotrichous
(one flagellum at
one end)
Amphitrichous
(flagella at
each end)
Lophotrichous
(tuft of flagella
at one end)
Peritrichous
(flagella all over)

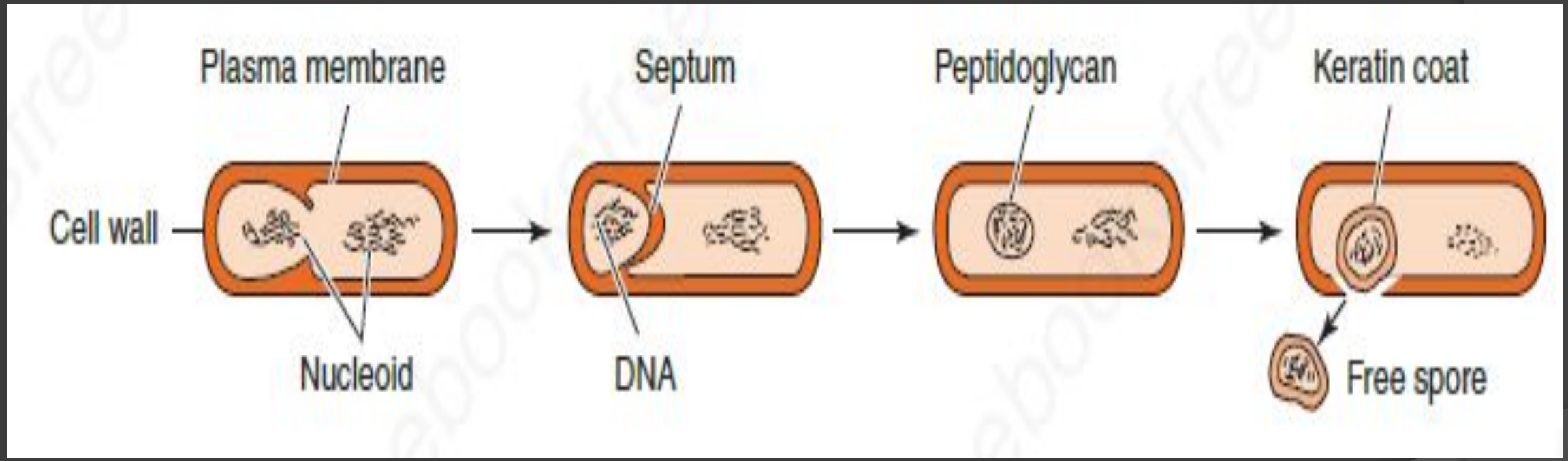
4- Fimbriae (Pili)

- Thin, hair like appendages on the surface of many Gram –ve bacteria
- 10-20μ long, acts as organs of adhesion (attachment)-allowing bacteria to colonize environmental surface or cells and resist flushing.
- Made up of proteins called Pilins.
- Pili can be of two types:

A. Common pili- short & abundant.
B. Sex pili- very long pili & small number (1-6), help

5- Spores

- Highly resistant resting stages formed during adverse environmental (depletion of nutrients).
- Formed inside the parent cell, hence called endospores.
- Very resistant to heat, radiation and drying and can remain dormant for hundreds of years.
- Formed by bacteria like *Clostridium* and *Bacilius* .


Plasma membrane
Septum
Peptidoglycan
Keratin coat
Cell wall
Nucleoid
DNA
Free spore

- **Cell Division :** most bacteria divide by binary fission into two equal cells.

- In a growing culture of a rod-shaped bacterium such as

E coli, cells elongate and then form a partition that eventually separates the cell into two daughter cells.

The partition is referred to as a septum and is a result of the inward growth of the cytoplasmic membrane and cell wall from opposing directions until the two

- **Growth** is the orderly increase in the sum of all the components of an organism. The increase in size that results when a cell takes up water or deposits lipid or polysaccharide is not true growth.
- Cell multiplication is a consequence of cell division of unicellular organisms, growth leads to an increase in the number of single bacteria making up a population, referred to as a culture.

- **Death** means the irreversible loss of the ability to reproduce (grow and divide).
- The empirical test of death is the culture of cells on solid media: A cell is considered dead if it fails to give rise to a colony on any medium.