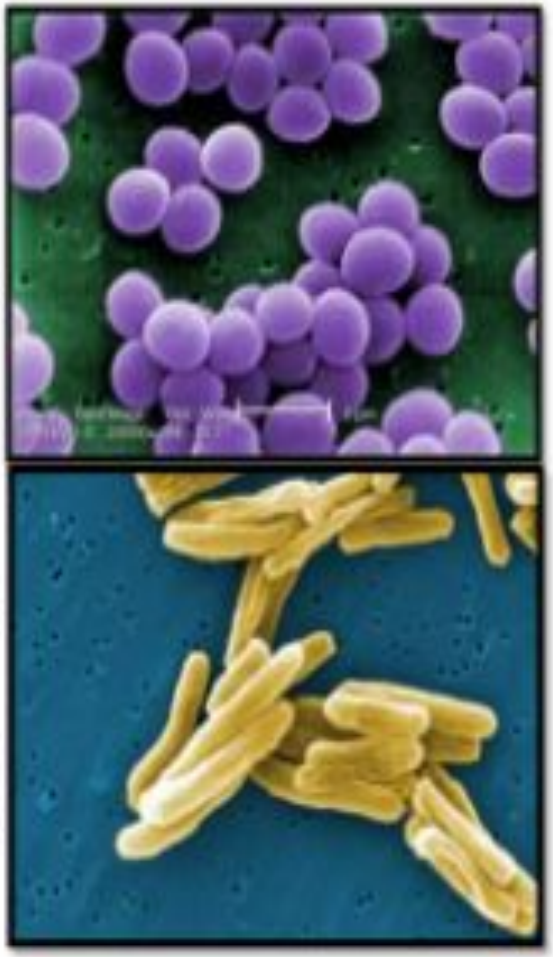
Structure of Bacterial cell

- Bacteria are the first organisms to appear on earth
- That thrive in diverse environments.
- These organisms can live in soil, the ocean and inside the human gut.
- Humans' relationship with **bacteria** is complex.
- Some bacteria are harmful, but most serve a useful purpose.
- They support many forms of life, both plant and animal, and they are used in industrial and medicinal processes.

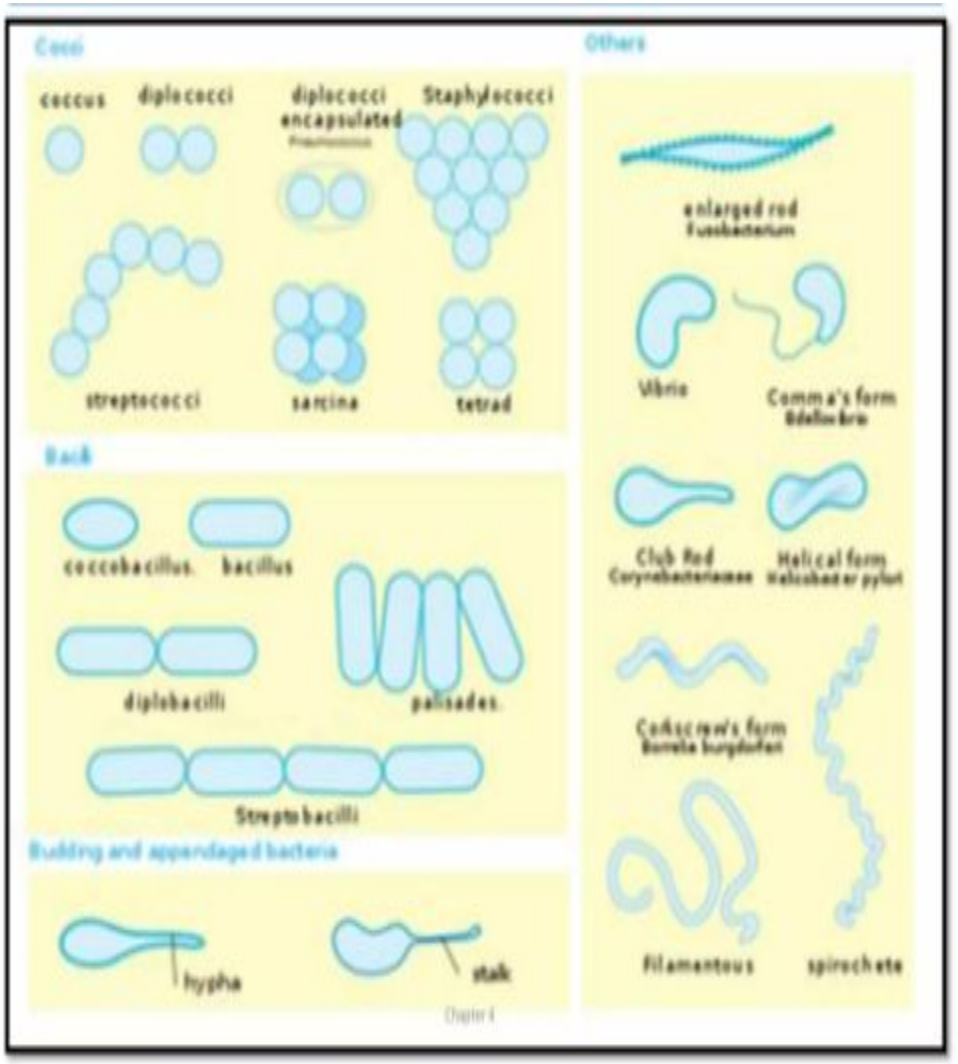


- Bacteria are Microscopic, Single-celled organisms.
- They lack organelles such as chloroplasts and mitochondria, and they do not have the true nucleus.
- Bacteria also have a cell membrane and a cell wall .
- The cell membrane and cell wall are referred to as the cell envelope.
- Asexual Reproduction by binary fission.
- However, some bacteria can also exchange genetic material among one another in a process known as horizontal gene transfer.

Morphology of Bacteria include:

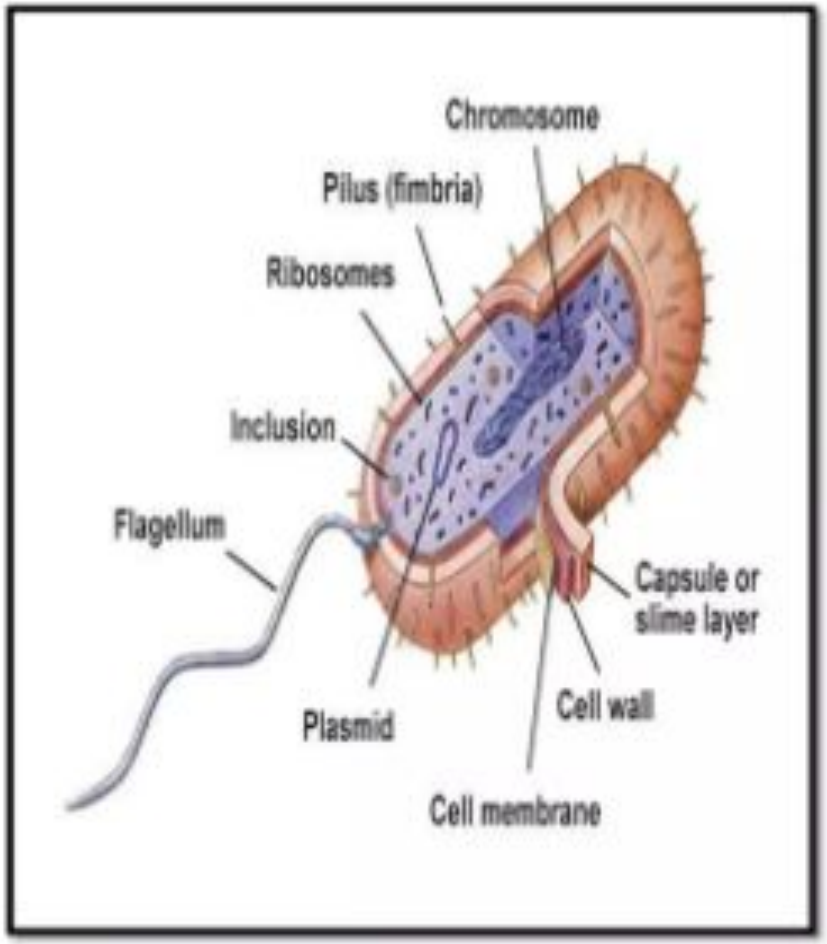
- Size
- Shape
- Arrangement
  - Bacterial cells are about one-tenth the size of eukaryotic cells.
  - typically 0.5–5.0 micrometers in length.
  - *Thiomargarita namibiensis* is up to half a millimeter long
  - *Epulopiscium fishelsoni* reaches 0.7 mm
  - *Mycoplasma*, which measure only 0.3 micrometers.
  - *E. coli* , is 1.1 to 1.5 µm wide by 2.0 to 6.0 µm long.
  - Spirochaetes 500 µm in length.
  - Cyanobacterium *Oscillatoria* is about 7 µm in diameter.

- Coccus
  - Chain = Streptoccus
  - Cluster = Staphylococcus
- Bacillus
  - Chain = Streptobacillus
- Coccobacillus
- Vibrio = curved
- Spirillum
- Spirochete
- Square
- Star



ULTRASTRUCTURE OF BACTERA

- Flagella
- Pili & Fimbriae
- Capsule & Slime Layers
- Cell Wall
- Plasma Membrane
- Mesosomes
- Cytoplasmic Inclusions
- Nucleoid
- Plasmids



Cell wall

The bacteria are surrounding by rigid cell wall. The principle structural component of cell wall is peptidoglycan. **The cell wall consists of polymer of two sugar derivatives N- acetylglucosamine and N- acetylmuramic acid cross linked by short chains of amino acids (peptide), this molecule is a type of peptidoglycan called murein** Peptidoglycan (PG) is complex of polysaccharide and polypeptide. Most bacteria are classified according to reaction of Gram stain with components of cell wall into major groups; Gram positive & Gram negative bacteria based on staining properties. Gram stain developed in 1884 by Christian Gram ,the most widely employed in bacteriology lab.

Function of cell wall:

-Protection the internal structures.

-It maintains the shape of bacterial cell.

-Contain component which toxic to host cell.

- It plays a role in cell division

Example on cell wall deficient bacteria

a- *Mycoplasma*

This is naturally deficient in cell wall. ***Mycoplasma*** is pleomorphic shape and not affected by penicillin treatment

b- L- forms

Some of bacteria under certain condition are fail in synthesis of cell wall when the cells is subjected to penicillin drug or lysozymes.

Gram positive bacteria cell wall composed of :

-Peptidoglycan

This layer is very thick in G +ve bacteria constituting 50-80nm of cell wall and responsible for the rigidity of cell wall and retention of crystal violet dyes during the Gram stain procedure. The large amounts of PG make Gram positive bacteria susceptible to antibiotics (penicillin) that inhibit cell wall synthesis.

-Teichoic acid and thin layer of lipid

B- Gram negative bacteria cell wall composed of :

-Inner layer of peptidoglcan

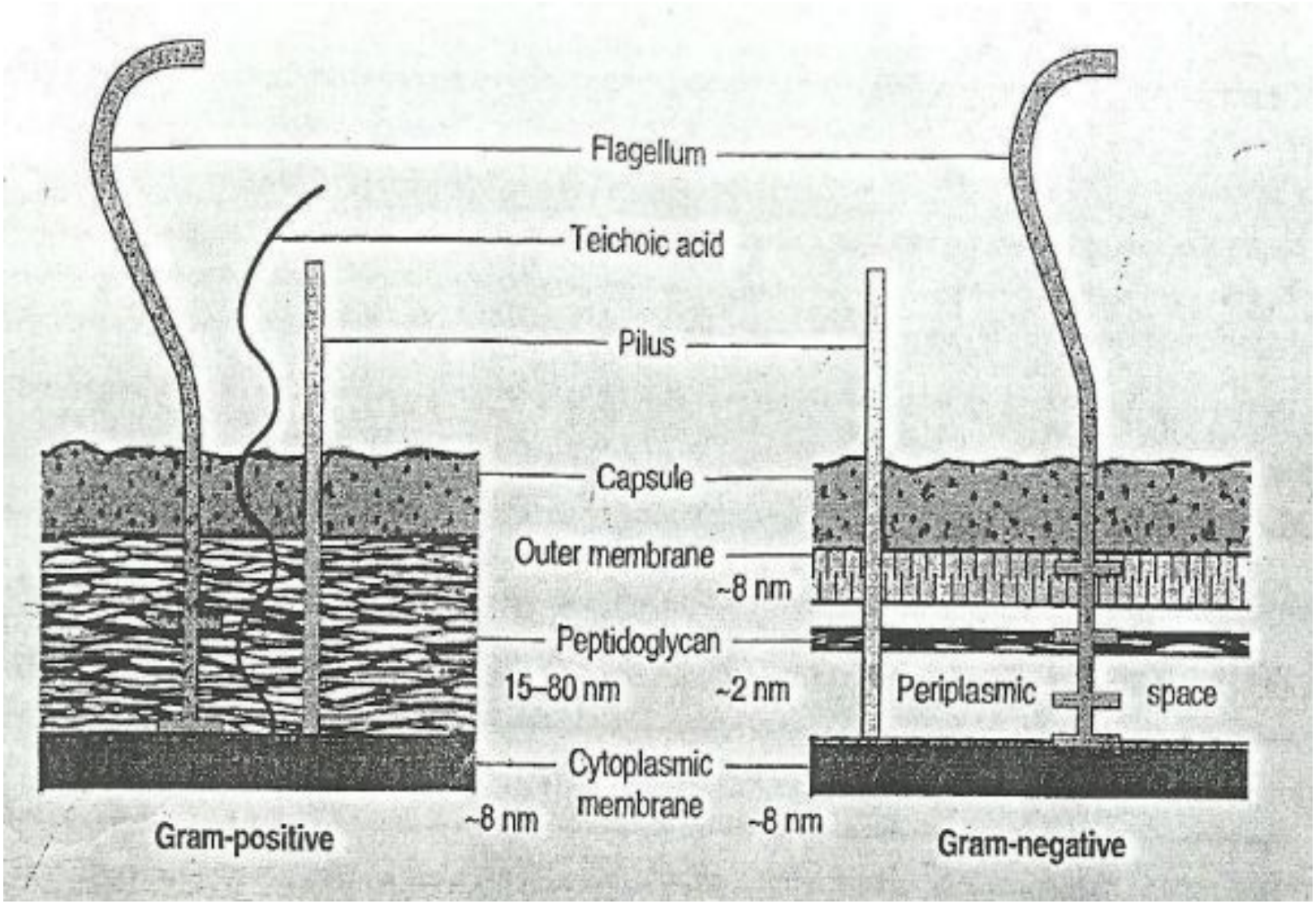
This layer is thin constituting of (5-10) nm of cell wall which cannot retain the crystal violet stain.

-Outer layer of lipopolysaccharides (LPS)

cotaining of lipid A (endotoxin) and polysaccharide (fig.).

-Periplasmic space between the inner and outer layers

It is filled with gel and is crossed by lipoprotein molecules to link the peptidoglycan layer and LPS layer, and no teichoic acid.


Flagellum
Teichoic acid
Pilus
Capsule
Outer membrane
~8 nm
Peptidoglycan
15–80 nm
~2 nm
Periplasmic space
Cytoplasmic membrane
~8 nm
~8 nm
Gram-positive
Gram-negative

Cell membrane (plasma membrane):-

Cell membrane is composed of two layers of lipid (the lipids linked to proteins and to polysacchrides). It is located under cell wall.

Gram negative bacteria have inner and outer mem., whereas Gram positive bacteria have only inner cell membrane. The space between inner and outer membrane called periplasmic space. Outer cell membrane of Gram negative bacteria is composed of lipopolsaccharide (LPS) and lipoproteins. LPS acts as endotoxine.

Function of cell membrane

1-Control on inflow of metabolites from cell by control on active transport of molecules into cell because it has selective permeability.

2-Energy generation by oxidative phosphorylation.

3-Secretion of enzyme and toxin.

Synthesis of precursors of cell wall (have important role in synthesis of cell wall).

Nucleoid :-

The bacterial genome consists of a single chromosome. It is not surrounded by nuclear membrane. Some bacteria have small, circular of DNA (plasmid) as free in cytoplasm.

Ribosome:-

It is composed of several RNA and proteins. The 70s unit is composed of two small subunits (50s and 30s), while eukaryotic ribosome is consist of 80s (60s and 40s).

The important role of it:

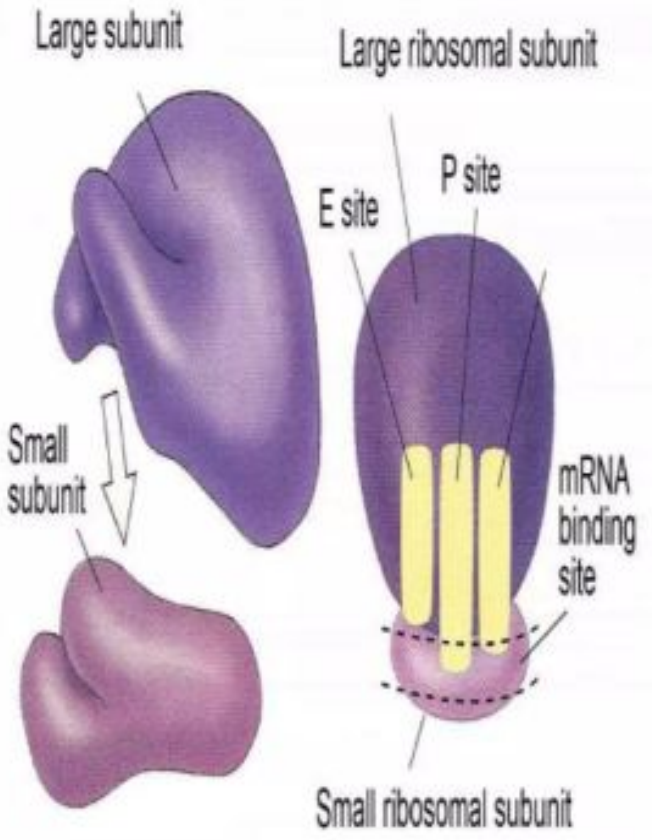
1-The ribosome are site of protein synthesis.

2-The differences in rRNA and protein constitute of bacteria, the basis of selective action of several antibiotics (tetracycline) that inhibit bacterial protein synthesis.

- The cytoplasm contains a large number of solute low and high molecular weigh substunce.
- RNA and approximately 20,000 Ribosomes/cell.
- Bacteria have 70S Ribosomes comprising 30S and 50s subunit.

• Function :-

- Ribosomes as the organelles for protein synthesis.



•Mesosome :-

- Mesosome are covonluted or multilaminated membranous bodies visible in the electron microscope.
- They develop by complex invagination of cytoplasmic membrane into the cytoplasm.

- **Function:-**
- Functioning in the compartment of DNA at cell division and at sporulation.
- Having a function analogous to the eukeryotic cell----providing a cell membranous support for respiratory enzyme.

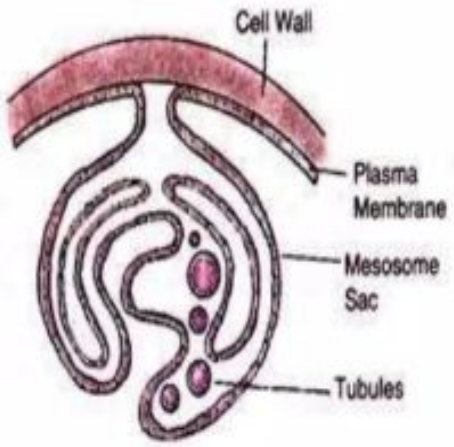


Fig. 4.15 : The bacterial mesosome (diagrammatic)

External structures:-

1-External structures

2-A – Capsule

Some bacteria have capsule. It is a gelatinous layer covering the entire bacterium, may be composed polysaccharide or poly peptide. Encapsulated bacteria grow as " smooth " colonies , where as colonies of bacteria that have lost their capsules appear "rough". Some bacteria produce slime to help them to stick to surfaces , usually made up from polysaccharides, produced by streptococcus mutants enables stick to the surface of teeth, were helps to form plaque , leading to dental carries.

Capsule importance:

1-Protection against deleterious agents (Lytic enzyme).

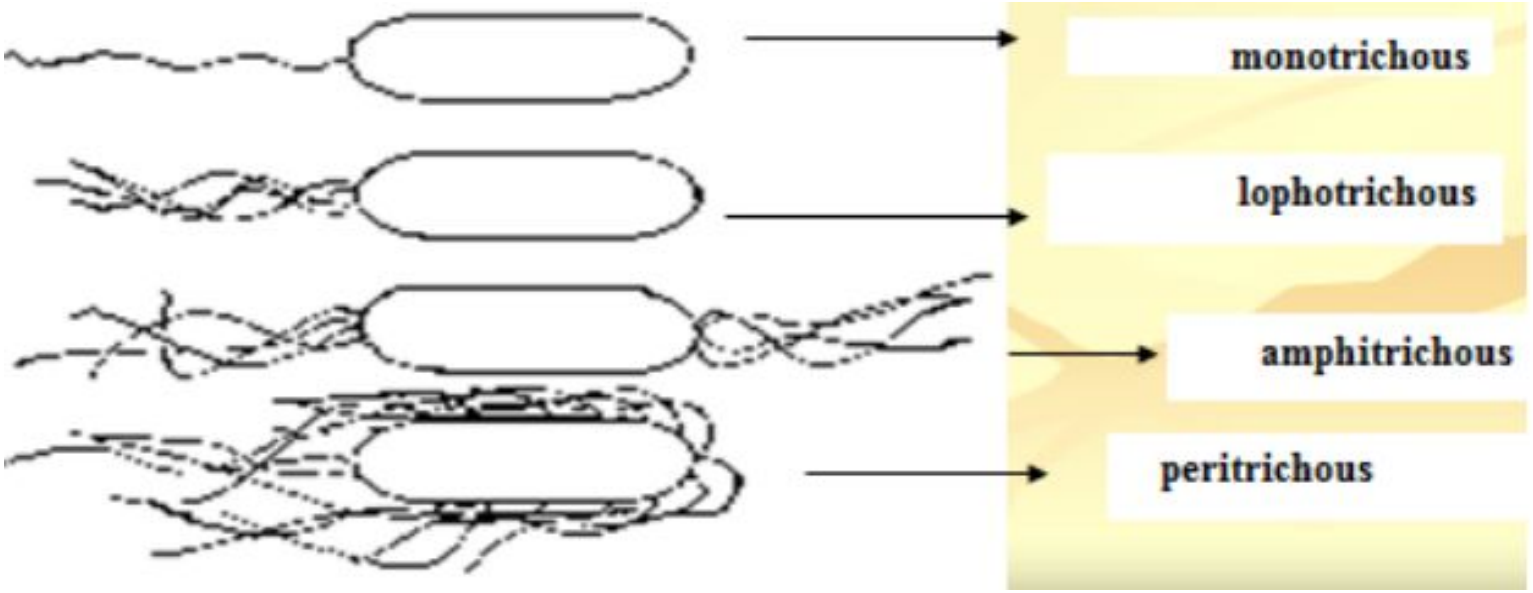
2-Contribute to virulence of many bacteria (inhibiting phagocytosis) &it play role in adherence of bacteria to human tissues, helping to prevent the bacterial cell from being killed.

3-It is used as antigen (K- antigen) in certain vaccines.

4-Specific identification of MO.

B-Flagella:

An extra cellular long thin filamentous structure responsible for motility of pathogenic bacteria, can play role in production of disease because has an antigenic property. Most rod bacteria have flagella (motile), while most cocci are non-motile. Bacterial cells may carry a single flagellum described monotrichous. If the single flagellum at one end of a rod – shaped cell it is known as a polar flagellum. if the bacterium carries a single tuft of flagella it is said to be lophotrichous When the tuft appears at both ends of the cell, the bacteria is amphitrichous. Bacteria that are covered all over body in flagella are said to be peritrichous as shown in the figure below.



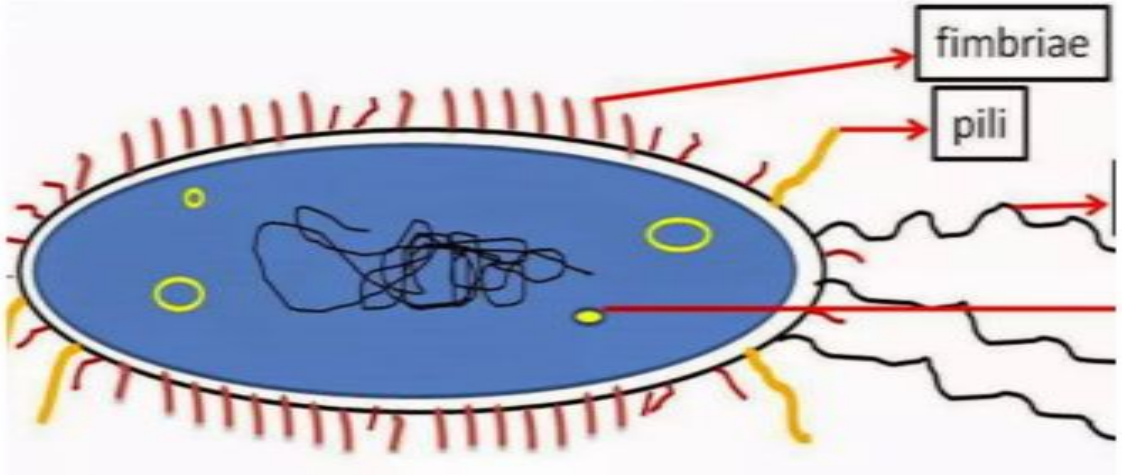
C- Pili (Fimbriae)

It is hair like filaments that extend from cell membrane. They are shorter and straighter than flagella. They are found mainly in Gram negative bacteria helps to stick to body surfaces (Fig) .

They are two types of pilli divided according to their **functions** :

-Ordinary pili which play a role in attachment of mucous membrane (specific receptor) on human cells.

-Sex pili their function was transfer DNA between conjugated bacteria



D. Storage granules

The cytoplasm contains granules which represent accumulation of food or energy reserve e.g. the metachromatic granules

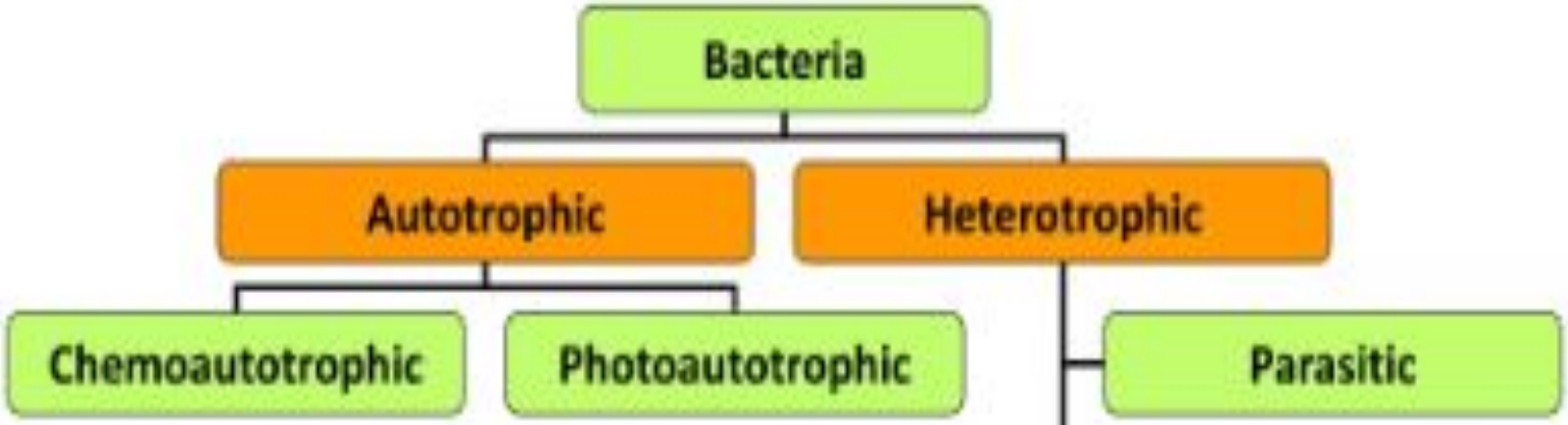
Spores

Some bacteria can develop a highly resistant structure called endospore as a response to unfavorable growth environmental condition such as radiation , heat , and desiccation for ex., *Clostridium* , *Bacillus*. The spore is formed inside the parent vegetative cell incorporating the nuclear material ,acquiring a thick covering layer is called cortex and an outer spore coat that contains calcium and is impermeable to water as shown in figure . Spores may vary in :

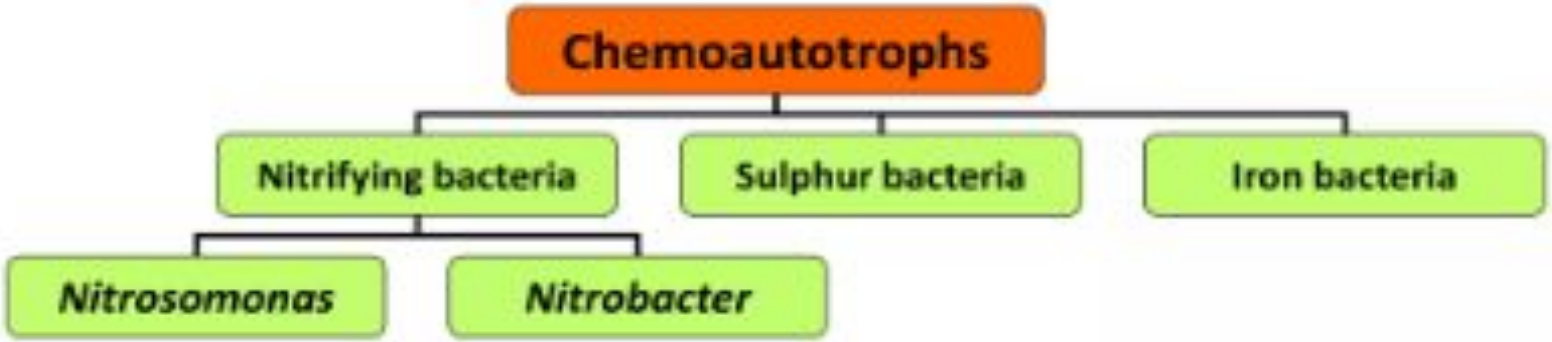
-Shape : oval or round.

-Site : terminal , sub terminal or central as seen in figure below .

-Size : the same size or bulging of the vegetative cell .



- Autotrophs
  - They are able to synthesize their own organic food from inorganic substances.
  - Can use CO_2 as a sole carbon source (Carbon fixation)
- Heterotrophs
  - They are unable to manufacture their own organic food and hence are dependent on external source.
  - Cannot use CO_2 as a carbon source



- *Nitrosomonas*

$$3NH_3 + 3O_2 \longrightarrow 2HNO_2 + 2H_2O + \text{Energy}$$

- *Nitrobacter*

$$2HNO_2 + O_2 \longrightarrow 2HNO3 + \text{Energy}$$

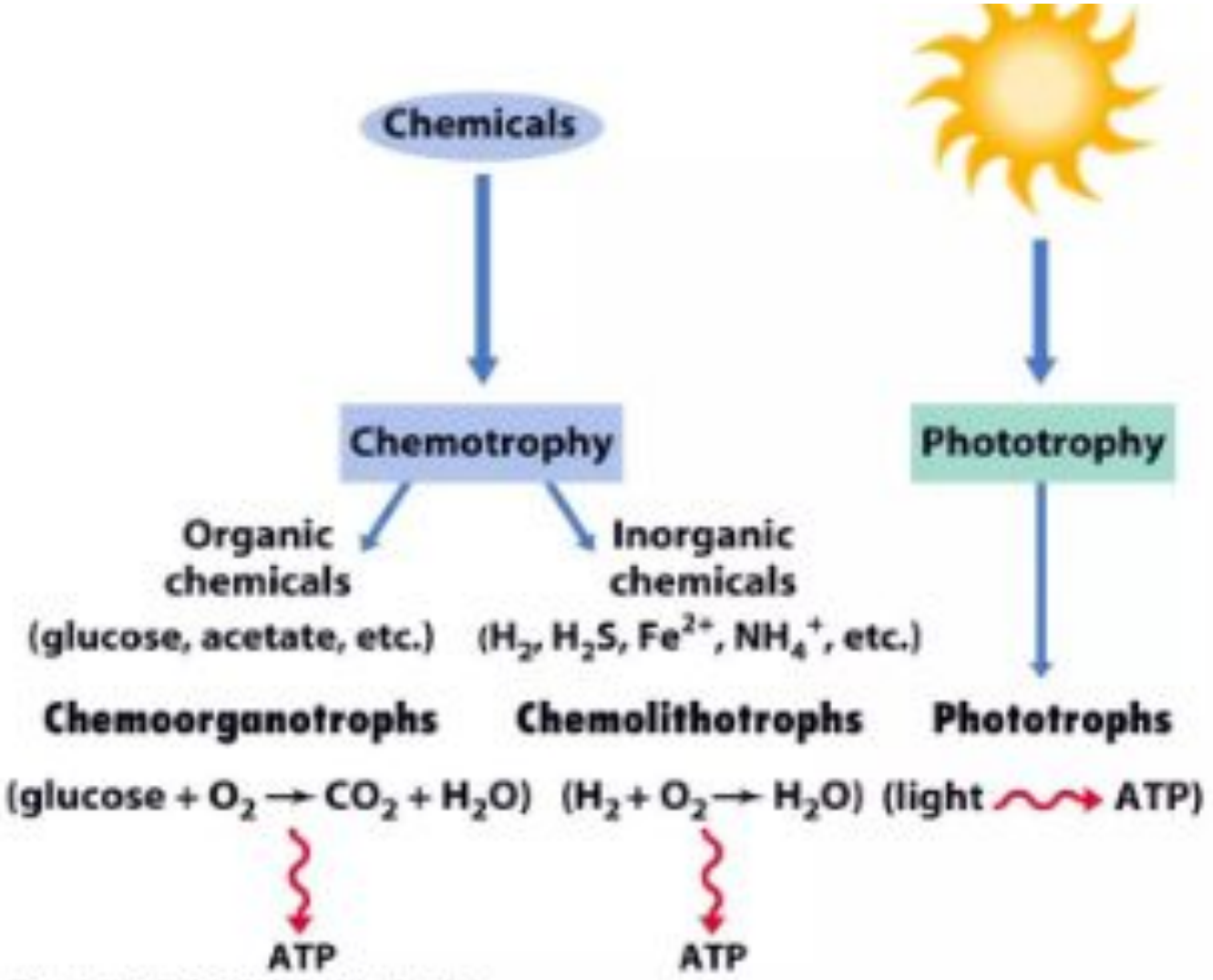


Figure 2-8 Brock Biology of Microorganisms 11/e

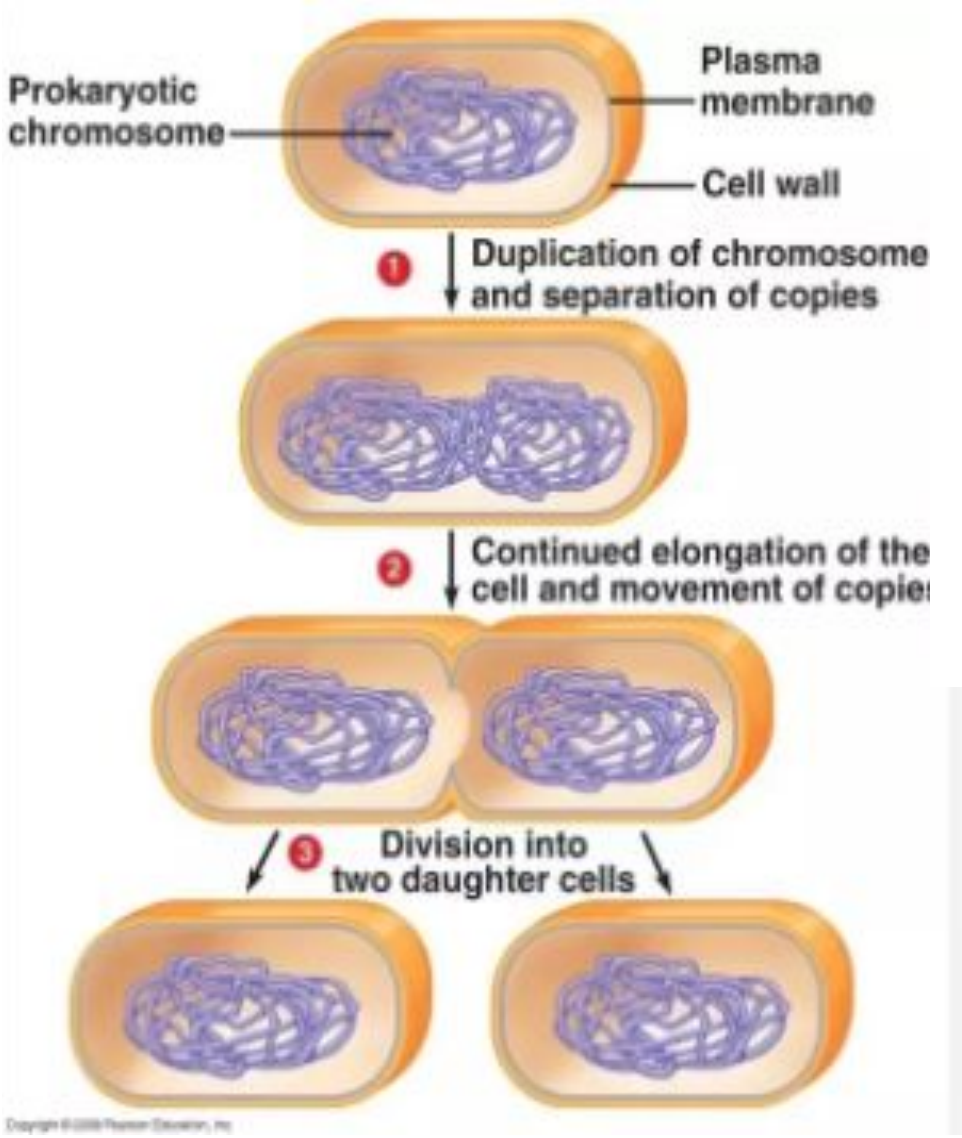
Nutrient Requirements

- Carbon source
- Nitrogen source
- Minerals (phosphorus, sulfur, etc.)
- Growth factors (vitamins, amino acids and enzymatic cofactors)

Bacterial Growth

- Bacteria require certain conditions for growth, and these conditions are not the same for all bacteria.
- Factors such as oxygen, pH, temperature, and light influence microbial growth.
- Additional factors include osmotic pressure, atmospheric pressure, and moisture availability.
- A bacterial population's **generation time**, or time it takes for a population to double, varies between species and depends on how well growth requirements are met.

Bacterial Division



Generation Time

- Time required for cell to divide/for population to double.
- Average for bacteria is 1-3 hours
- *E. coli* generation time = 20 min
  - 20 generations (7 hours), 1 cell becomes 1 million cells!

Standard Growth Curve

Lag phase – making new enzymes in response to new medium. The length of lag phase depend upon

a. Type of bacteria.

b. Better the medium, shorter the lag phase.

c. The phase of culture from which inoculation is taken.

d. Size or volume of inoculum.

e. Environmental factors like temperature.

Log phase – Logarithmic (Exponential) phase: In logarithmic phase the bacterial cell start dividing and their number increase by geometric progression with time.

During this period...

a. Bacteria have high rate of metabolism

b. Bacteria are more sensitive to antibiotics and radiation during this period.

Stationary phase – nutrients becoming limiting or waste products becoming toxic.
death rate = division rate

In stationary phase after some time a stage comes when rate of multiplication and death becomes almost equal. It may be due to:

a. Depletion of nutrients.

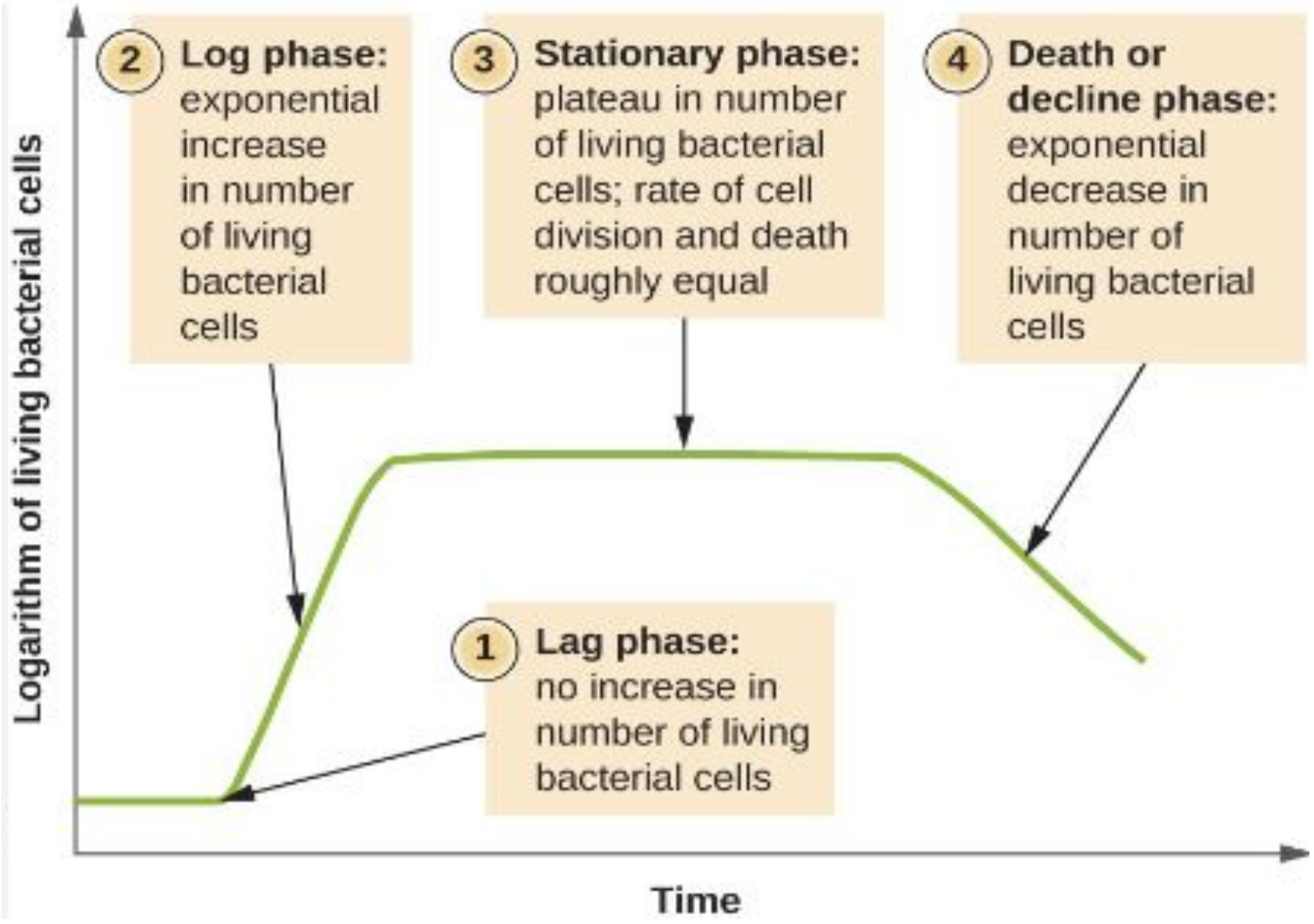
b. Accumulation of toxic products and sporulation may occur during this stage.

Death or Decline phase – In decline (death) phase, death exceeds division. During this phase population decreases due to death of cells. The factors responsible are:

a. Nutritional exhaustion

b. Toxic accumulation

c. Autolysinenzymes


2 Log phase: exponential increase in number of living bacterial cells
3 Stationary phase: plateau in number of living bacterial cells; rate of cell division and death roughly equal
4 Death or decline phase: exponential decrease in number of living bacterial cells
1 Lag phase: no increase in number of living bacterial cells
Logarithm of living bacterial cells
Time