



General Microbiology

Lecture 3

(Bacterial Structure, Classification, and Growth)

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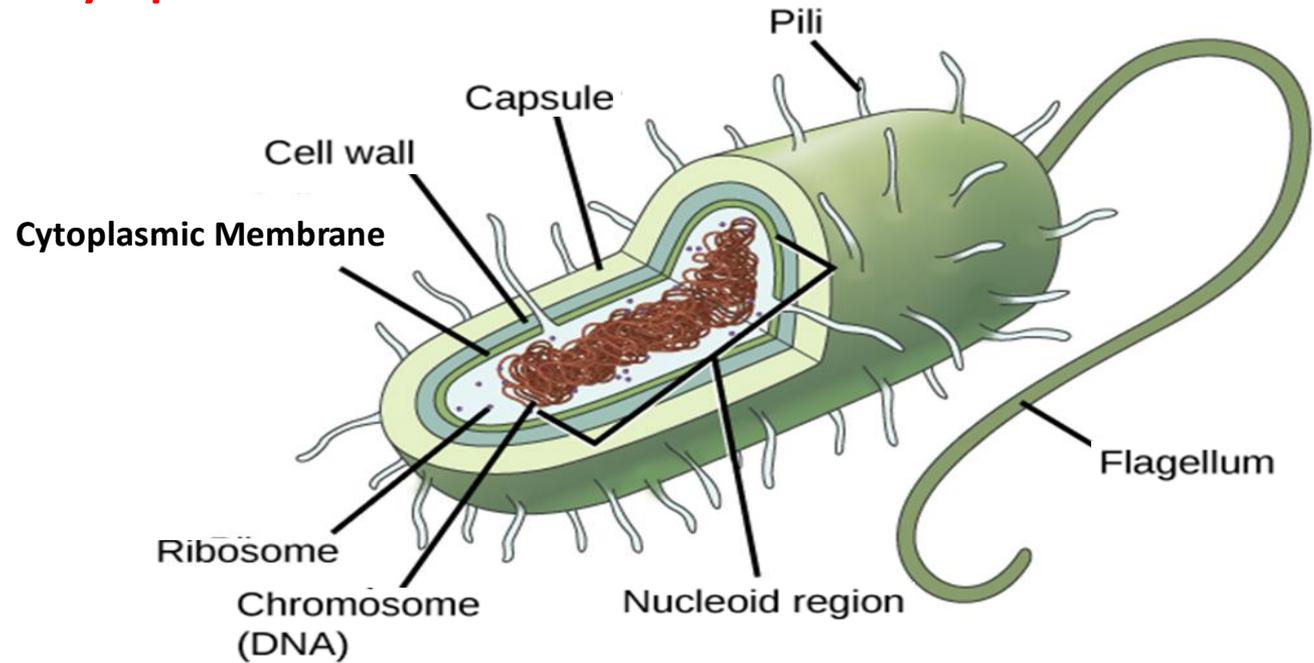
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The Ultrastructure of bacterial cell

Structures external to the cytoplasmic membrane:

- Cell wall
- Capsule
- Flagella
- Pili (Fimbriae)



Structures internal to the cell wall:

- Cytoplasmic Membrane
- Mesosomes
- Ribosomes
- Cytoplasm
- Inclusion Bodies
- Chromosome (DNA)
- Plasmid
- Episome

Capsules

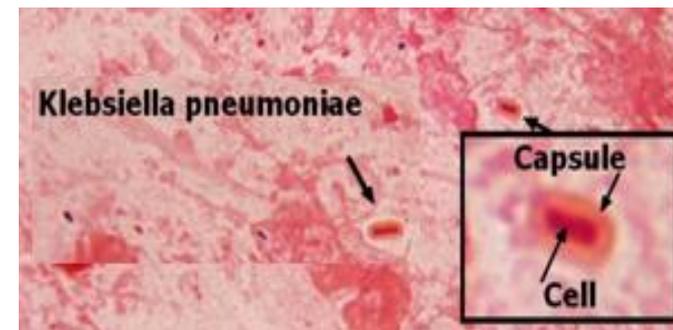
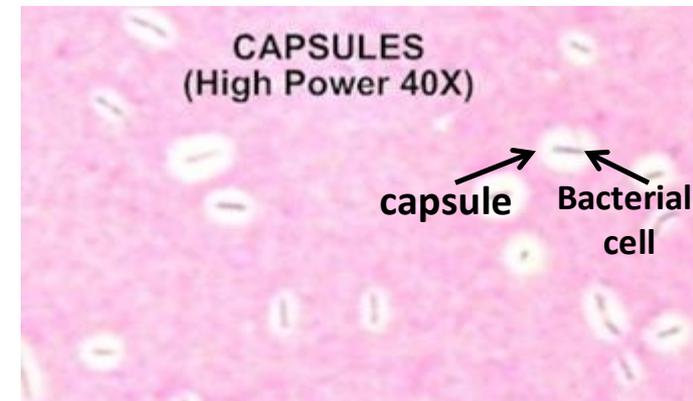
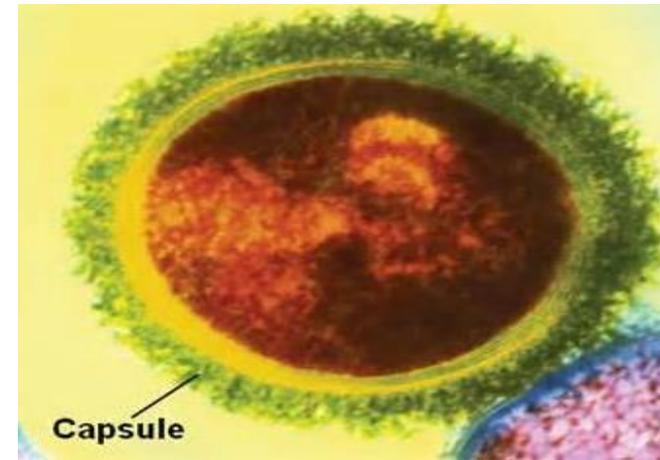
- Capsule consists of a mesh or network of fine strands.
- Capsules are divided into two groups:
 - a. Macrocapsule: It is about $0.2\mu\text{m}$ thick and can be seen under light microscope.
 - b. Microcapsule: It can't be seen under light microscope but can be demonstrated immunologically.

Chemical composition:

- They are made up of di or polysaccharide or polypeptide.
- The polysaccharide may be homopolysaccharide or heteropolysaccharide.

Functions

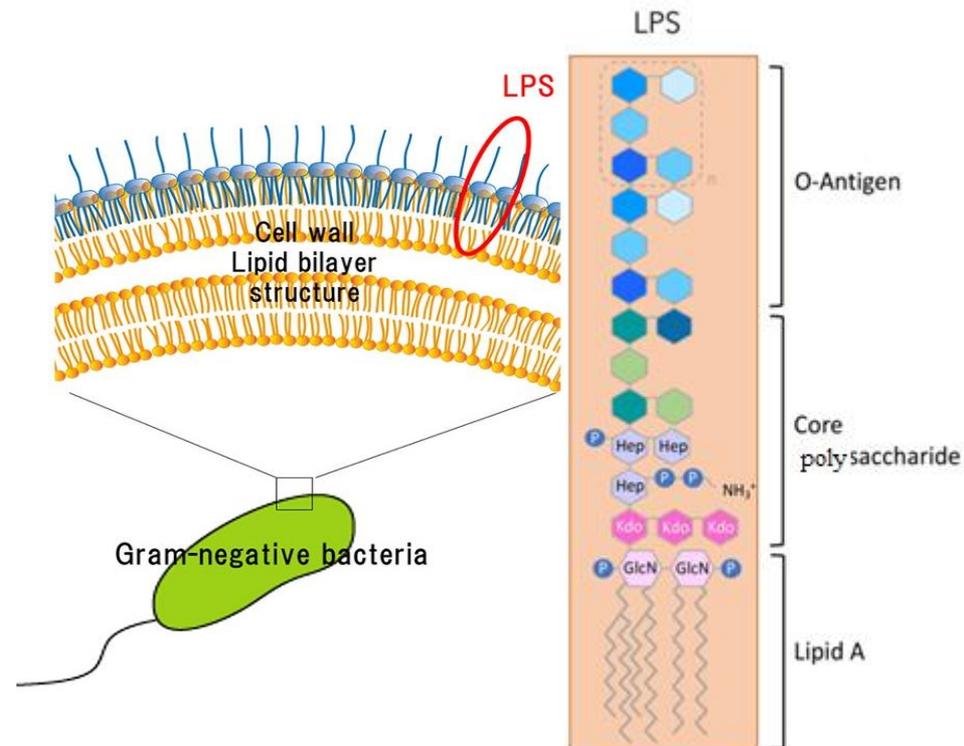
- a. They provide protection against temporary drying by binding water molecules..
- b. They may be antiphagocytic



Lipopolysaccharides (LPS)

Structures external to the cell wall of the Gram negative bacteria

- Lipopolysaccharides (LPS) occurs only in the outer layer of the membrane and is composed of three covalently linked parts :
 - i. Lipid A = firmly embedded in the membrane.
 - ii. Core polysaccharide = located at the membrane surface.
 - iii. O-antigens = which extend like whiskers from the membrane surface into the surrounding medium
- Many antigenic properties of gram -ve bacteria are attributable to O-antigens



The Cell Wall

Gram negative bacteria

Lipopolysaccharides (LPS)

Functions:

O antigen:

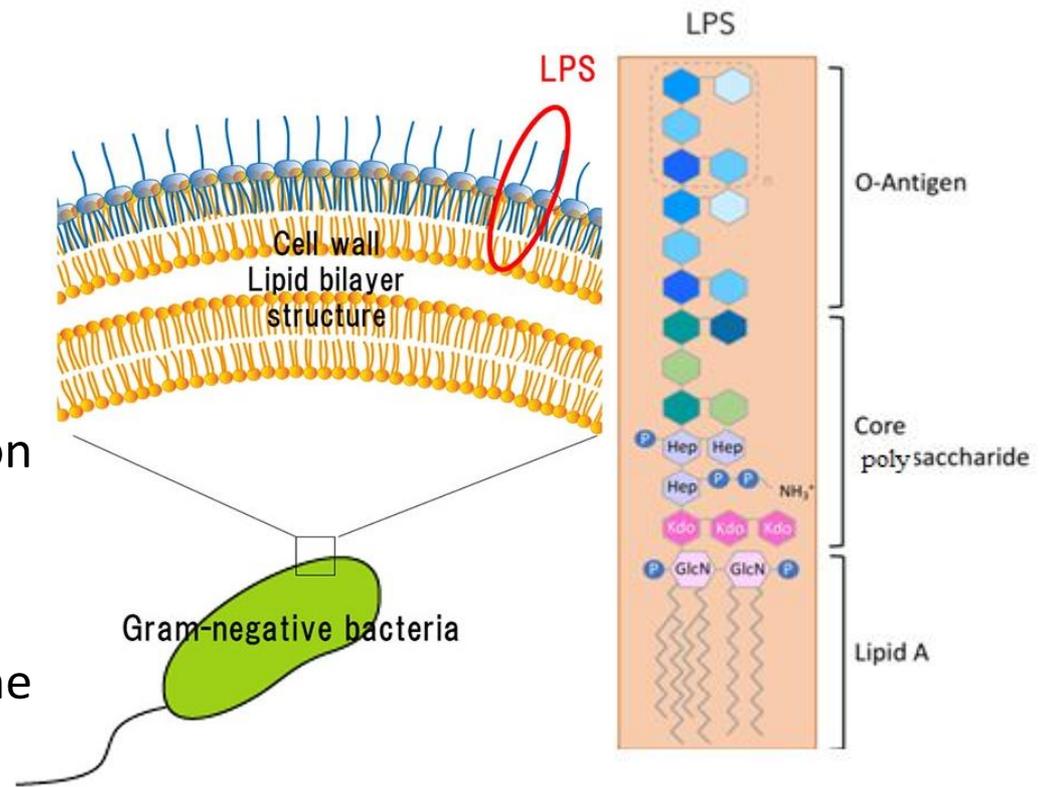
- Protection from host defenses

Core polysaccharide

- Contributes to negative charge on cell surface .

lipid A:

- Helps stabilize outer membrane structure.
- Can act as an endotoxin.



The Cell Wall

Gram negative bacteria

Pathogenic effect of LPS:

LPS has an endotoxin effect:

- Lipid A released when cells lyse
- Causes systemic effects – Fever, Shock, Blood coagulation, Weakness, Diarrhea, Inflammation, Intestinal Hemorrhage, Fibrinolysis
- Activating white cells, especially macrophages and monocytes

To remember the difference in the cell wall
of **Gram positive** and **negative bacteria**

Lipopolysaccharide

Outer membrane

Negative

Gram?

Positive

Peptidoglycan (thick)

Teichoic acid



Structure Internal to Cell Wall

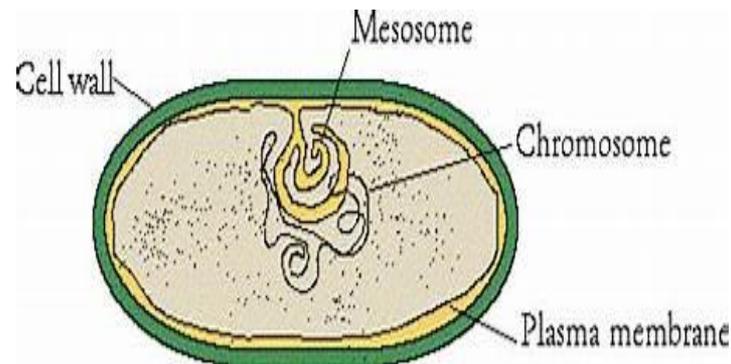
Structure Internal to Cell Wall

Cytoplasmic Membrane:

- Immediate below the cell wall is cytoplasmic membrane.
- Similar in both gram + ve and -ve bacteria.

Mesosomes:

- The mesosome was thought to increase the surface area of the cell, aiding the cell in cellular respiration. This is analogous to cristae in the mitochondrion in eukaryotic cells, which are finger-like protrusions and help eukaryotic cells undergo cellular respiration. A site for oxidative phosphorylation



Structure Internal to Cell Wall

Inclusion Bodies:

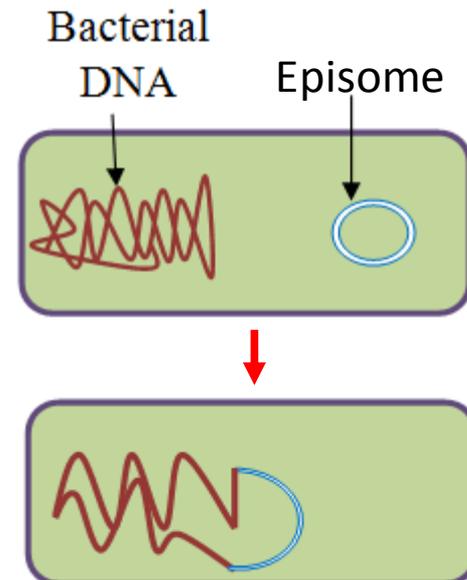
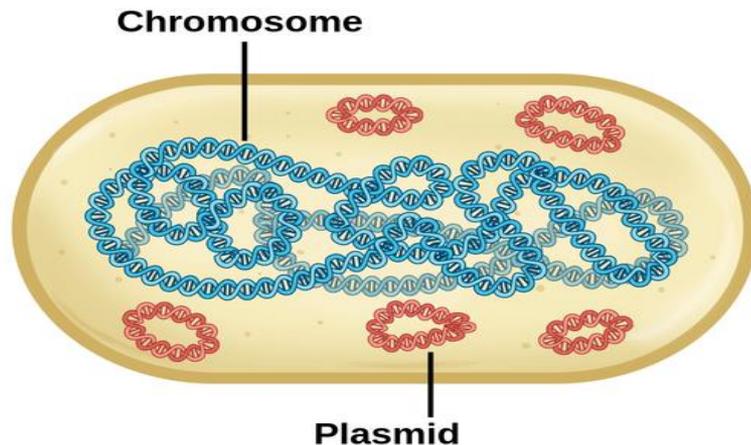
- Granules of organic or inorganic material that are stocked by the cell for future use.

Inclusion	Composition	Function
Glycogen	poly-glucose	Reserve carbon and energy source
Poly-beta-hydroxybutyric 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

Structure Internal to Cell Wall

Episome vs. Plasmid:

- Plasmid and episome are two types of DNA elements which exist independently of the genome.
- The main difference between plasmid and episome is that plasmid does not integrate into the genome, whereas episome can integrate into the genome.

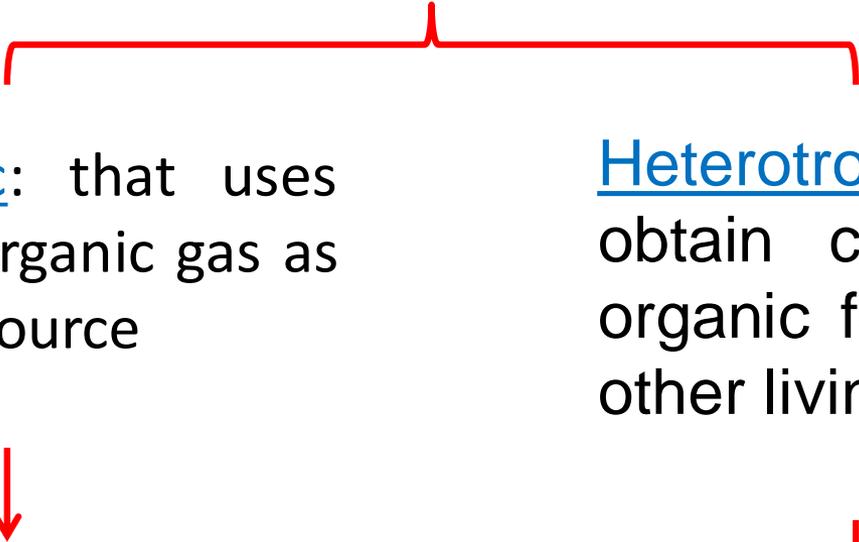


Nutrition

Microbial nutrition

Types of microbial nutrition

Bacteria are classified in two nutritional types on the basis of their carbon requirement into:



Autotrophic: that uses CO₂, an inorganic gas as its carbon source

- ✓ Photosynthetic bacteria.
- ✓ Chemosynthetic bacteria

Heterotrophic must obtain carbon in an organic form made by other living organisms

- 
- ✓ Saprophytic
 - ✓ Symbiotic
 - ✓ Parasitic bacteria

Nutrition

Heterotrophic bacteria

Saprophytic bacteria

- They survive on dead and deteriorating organic compound.
- They convert the complex organic compound into soluble compound with the help of enzymes and then absorb them according to their requirement

Nutrition

Heterotrophic bacteria

Symbiotic bacteria

- Bacteria grow and develop in close beneficial partnership or association with other living organism
- A phenomenon is termed as symbiosis.
- For example, bacteria occur in the root nodules of certain plants where they fix free atmospheric nitrogen in the soil which is utilized by plants and plants in turn provide them carbohydrate and shelter for proper development .

Nutrition

Heterotrophic bacteria

Parasitic bacteria

- Those bacteria which feed themselves on living tissues (host) are called parasitic bacteria.
- They are transmitted to the host by means of air, water and food.

Reproduction **in** Bacteria

Reproduction in Bacteria

- Bacteria reproduce very commonly by vegetative and asexual mode of reproduction.
- No sexual reproduction was reported.
- Reproduction in bacteria includes the following methods



Vegetative reproduction including (asexual reproduction):

- i. Binary fission
- ii. Budding
- iii. Cyst
- iv. Gonidia or segmentation
- v. Endospore formation

Sexual Reproduction:

- transformation.
- Bacterial transduction.
- Bacterial conjugation.

Reproduction **in** Bacteria

Binary fission:

- The most common mode of bacterial division .
- Cell divides after developing a transverse septum (cross wall).
- Bacilli and spiral bacteria divide along the longitudinal axis of the cell while in coccus this division can be on any axis.
- Binary fission occurs in following steps:
 - a. Division of nuclear or genetic material.
 - b. Division of cytoplasm and septum formation.

Reproduction **in** Bacteria

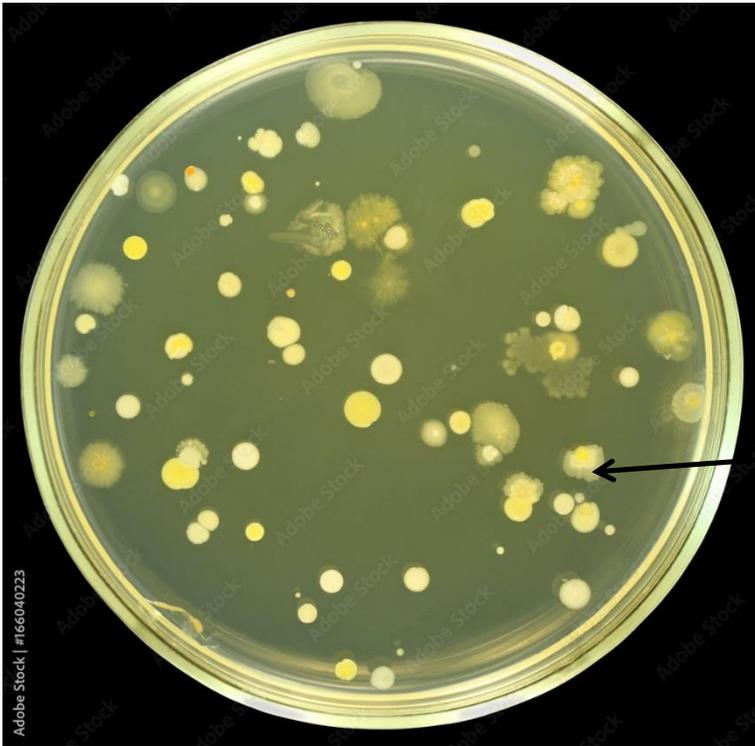
Binary fission:

- Under favourable conditions a single binary fission is completed within 18-20 minutes.
- Bacterial growth is inhibited due to following reasons :
 - a. Lack of space, food, water, oxygen other salts and accumulation of their own harmful waste products in the medium.
 - b. Environmental factors like light, temperature, moisture becomes unfavourable.
- Therefore survival rate of bacteria in nature is only 1 %.

Microbial Growth

Reproduction of microbes

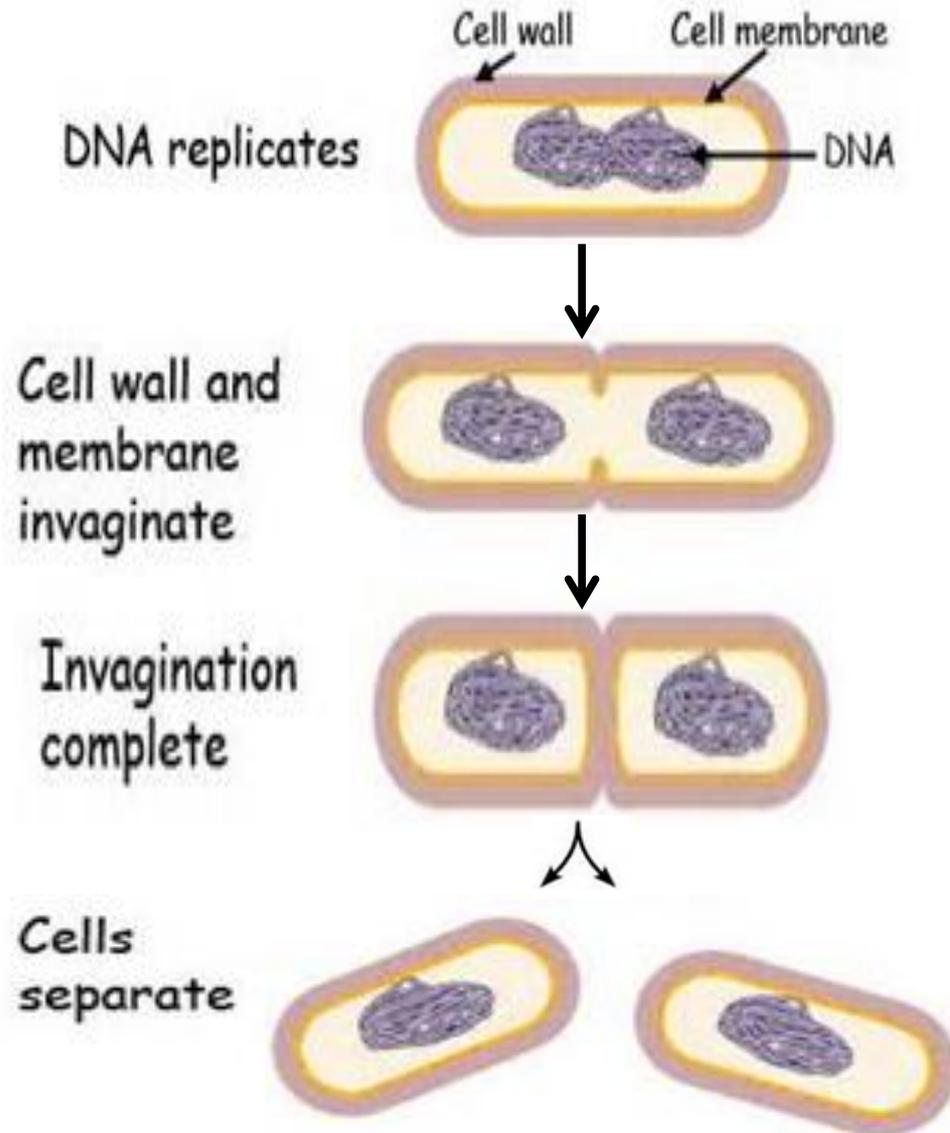
- Result of microbial growth is discrete colony – an aggregation of cells arising from single parent cell



Bacterial colony
(The result of one bacterial cell division)

Microbial Growth

Binary Division



Microbial Growth

Bacteria grow in four stages

1. **lag phase** – “flat” period of adjustment, enlargement; little growth
2. **exponential or log phase** – a period of maximum growth will continue as long as cells have adequate nutrients and a favorable environment
3. **stationary phase** – rate of cell growth equals rate of cell death caused by depleted nutrients and O_2 , excretion of organic acids and pollutants
4. **death phase** – as limiting factors intensify, cells die exponentially in their own wastes

Bacterial physiology

Bacteria grow in four stages

