Bacterial structure and functions

The Cell

The cell can be defined as a basic functional unit of life. The cell was first observed by a scientist named **Robert Hook** in the 1665. All living organisms are composed of one or many cells to perform their individual functions. All living organisms may composed of one cell (single cell) which called uni-cellular organisms, like prokaryotic organisms including bacteria, or composed from more than one cell (multi-cellular organisms), like eukaryotic organisms including human, animals and plants.

Types of Cells

There are two primary types of cells:

Prokaryotic Cell and Eukaryotic cells

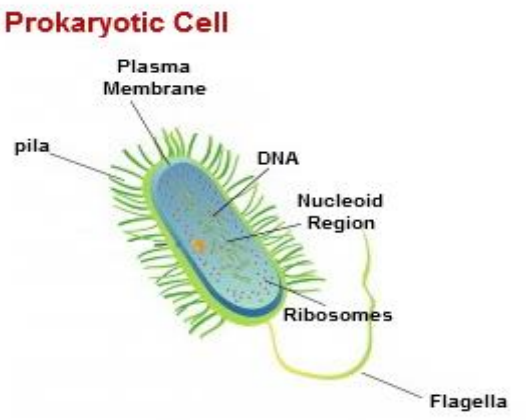
Differences between Prokaryotic cells and Eukaryotic cells

Prokaryotic Cells	Eukaryotic Cells
They are very minute in size.	They are larger in size.
Nuclear region (nucleoid) is not enveloped by a nuclear membrane.	Nucleus is surrounded by a double membrane layer.
Single chrmosome present.	More than one chromosome are present.
Nucleolus is absent.	Nucleolus is present.
Membrane bound organelles are absent.	Membrane bound organelles are present.
Multiplication of cell is by fission or budding.	Cell division by mitosis or meiosis.
Cell type is usually unicellular.	Usually multicellular cells.
Cell size is 1-10µm	Cell size 10 - 100µm.
Example: Bacteria, archaea	Example: animal cells and plant cells

Prokaryotic Cell

Prokaryotic cells are simpler and smaller than the eukaryotic cells. The term prokaryote is derived from the Greek word- **"prokaryote"** meaning before nuclei.

These cells lack membrane bound organelles. Prokaryotic cells are unicellular organisms, which reproduce through binary fission. In some cases few prokaryotic organisms also reproduce by budding. Prokaryotic cells have a cell envelope, which generally consists of a capsule, cell wall, cytoplasm, plasma membrane, nnucleiod region, ribosome, plasmids, pili and flagella



Basic structure of Prokaryotic Cell (Bacteria)

Inner structure

Cytoplasm: Cytoplasm is the storehouses for all types of chemicals and components that are used to sustain the life of a bacterium. It helps in cellular growth, metabolism and replication.

Plasma membrane: It is also known as a cell membrane. It is mainly composed of proteins, phospholipids and carbohydrates, which forms into a fluid-mosaic. Plasma membrane surrounds the bacteria and it is a most important organelle and plays a vital role in controlling the movement of substances in the cell.

Cytoplasm region (or) nucleiod region: An area of the cytoplasm that contains the single bacterial DNA molecule.

Ribosome: They are the smallest part of cell organelle. Ribosome plays a vital role in protein synthesis as they consist of protein and RNA. They are located freely in the cytoplasm of attached to the rough endoplasmic reticulum.

Mesosomes: They are the folding, present inside the plasma membrane. Mesosome plays a vital role in cellular respirations, replication of DNA, cell division, separation of chromosomes during cell division and also performs the role of Golgi bodies and mitochondria.

Plasmids: They are a small circle of DNA. Plasmid plays a vital role in exchanging DNA between the bacterial cells. Bacterial cells have many plasmids.

Spores (endospores): Metabolically inert bacterial forms adapted for long-term survival in the environment, which are able to regrow under suitable conditions

Outer structure

Capsule: It is composed of a thick polysaccharide which covers the outside of the cell wall. It is used to stick cells together and works as a food reserve and it also protects the cell from dryness and from chemicals.

Cell wall: It is made from the glycoprotein murein. Cell wall provides strength and rigidity to the cell and it is permeable to solutes.

Pili: They are short protein appendages, which fixes bacteria to surfaces. These pili are smaller than those flagella and are used in conjugation to exchange the genetic information.

Flagella: They are rigid rotating tail. The clockwise rotation moves the cell forward and anticlockwise rotation helps the cell to spin. The rotation is powered by H+ gradient across the cell membrane.

Common Shapes of Bacteria

- **Coccus** - spherical or round
- **Bacillus** - rod shaped
- **Spiral** - curve, spiral, or twisted

Bacteria can also have different arrangements of cells. So the common bacterial Cell Arrangements are:

- **Diplo** - cells remain in pairs after dividing.
- **Strepto** - cells remain in chains after dividing.
- **Tetrad** - cells remain in groups of four and divide in two planes.
- **Sarcinae** - cells remain in groups of eight and divide in three planes.
- **Staphylo** - cells remain in clusters and divide in multiple planes.

Growth of Bacteria

Bacteria are prokaryotic organisms that most commonly replicate by the asexual process of **binary fission**. Bacteria require certain conditions for growth, and these conditions are not the same for all bacteria. Factors such as **oxygen**, **pH**, and temperature influence microbial growth. Additional factors include osmotic pressure, atmospheric pressure, and moisture availability.

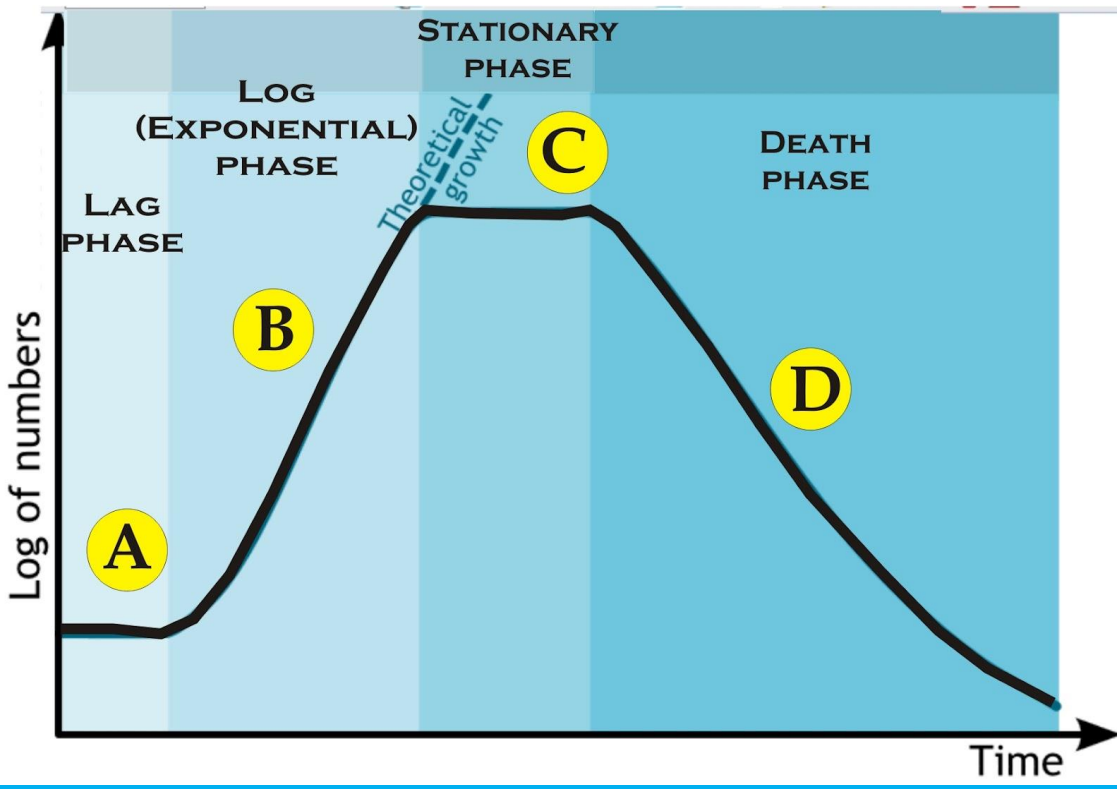
A bacterial population's **generation time**, or time it takes for a population to double, varies between species and depends on how well growth requirements are met.

The **bacterial growth curve** represents the number of live cells in a bacterial population over a period of time.

- **Lag (Adaptation) Phase:** This initial phase is characterized by cellular activity but not growth. These cells increase in size, but no cell division occurs in the phase.

- **Log (Exponential) Phase:** This is the time when the cells are dividing by binary fission and doubling in numbers after each generation time. It is in this growth phase that antibiotics and disinfectants are most effective as these substances typically target bacteria cell walls or the protein synthesis processes.
- **Stationary Phase:** Bacterial cell growth reaches a stationary phase, where the number of dividing cells equal the number of dying cells. Spore forming bacteria produce endospores in this phase and pathogenic bacteria begin to generate substances (virulence factors) that help them survive harsh conditions and consequently cause disease.

- **Death Phase:** As nutrients become less available and waste products increase, the number of dying cells continues to rise. Spores are able to survive the harsh conditions of the death phase and become growing bacteria when placed in an environment that supports life.



Bacterial Growth and Oxygen

Bacteria can be categorized based on their **oxygen requirement** or tolerance levels to the following:

1- **Obligate aerobes** -- Bacteria that cannot survive without oxygen. These microbes are dependent upon oxygen in their activity.
2- **Obligate anaerobes** -- Unlike bacteria that require oxygen, other bacteria cannot live in its presence.
3- **Facultative anaerobes**-- Bacteria that can grow with or without oxygen.
4- **Aerotolerant anerobes** -- Utilize anaerobic respiration but are not harmed in the presence of oxygen.
5- **Microaerophilic bacteria** require oxygen but only grow where oxygen concentration levels are low.

Bacterial Growth and pH

Another important factor for bacterial growth is pH. According to pH can classified bacteria to the following:

1- **Acidophiles** : Bacteria that are thrive in areas where the pH is less than 5, with an optimal growth value close to a pH of 3. These microbes can be found in the human body in acidic areas such as the vagina.
2- **Neutrophiles** : The majority of bacteria are and grow best in sites with pH values close to 7.
3- **Alkaliphiles** grow optimally at pH ranges between 8 and 10. These microbes thrive in basic environments such as alkaline soils and lake.

Bacterial Growth and Temperature

Temperature is another important factor for bacterial growth.

1- **Psycrophiles** -- Bacteria that grow best in cooler environments. These microbes prefer temperatures ranging between 4°C and 25°C. Extreme psycrophiles thrive in temperatures below 0°C and can be found in places such as arctic lakes and deep ocean waters.
2- **Mesophiles** -- Bacteria that thrive in moderate temperatures (20-45°C).These include bacteria that are part of the human microbiome which experience optimum growth at or near body temperature (37°C).
3- **Thermophiles** -- grow best in hot temperatures (50-80°C) and can be found in hot springs and geothermal soils. Bacteria that favor extremely hot temperatures (80°C-110°C) are called **hyperthermophiles**.

Classification of bacteria

We identify microorganisms to predict their pathogenicity. Bacteria are identified using phenotypic, immunological or molecular characteristics that including :

1- **Gram reaction:** Gram-positive and Gram-negative bacteria respond to different antibiotics.

2- Cell shape: Bacteria may be shaped as cocci, bacilli or spirals.

3- Endospore: The presence, shape and position of the endospore within the bacterial cell are noted.

4- Fastidiousness: Certain bacteria have specific O2/CO2 requirements, need special media or grow only intracellularly.

5- Key enzymes: Some bacteria lack certain enzymes, for example, lack of lactose fermentation helps distinguish salmonellae from E. coli.

6- Serological reactions: Interaction of antibodies with surface structures may for example help to distinguish subtypes of bacterial species.