



## INTRODUCTION AND CLASSIFICATION OF BACTERIA

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### Medical microbiology

Is the large subset of microbiology that is applied to medicine, is a branch of medical science concerned with the prevention, diagnosis and treatment of infectious diseases. There are four kinds of microorganisms that cause infectious disease: bacteria, fungi, parasites and viruses, and one type of infectious protein called prion.

All living organisms on earth are composed of one or the other of two types of cells: prokaryotic and eukaryotic cells based on differences in cellular organization and biochemistry. There are many differences between the two major divisions: prokaryotes and eukaryotes, of cellular organisms. These include the following:

#### **In prokaryotes:**

- A distinct nucleus is absent.
- DNA is in the form of a single circular chromosome.
- Additional 'extra-chromosomal' DNA is carried in plasmids.
- Transcription and translation can be carried out simultaneously.

#### **In eukaryotes:**

- DNA is carried on several chromosomes within a nucleus.
- The nucleus is bounded by a nuclear membrane.



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- Transcription requires formation of messenger RNA (mRNA) and movement of mRNA out of the nucleus into the cytoplasm.
- Translation takes place on ribosomes.
- The cytoplasm is rich in membrane-bound organelles (mitochondria, endoplasmic reticulum, Golgi apparatus and lysosomes) which are absent in prokaryotes.

Bacteria are prokaryotes cells usually unicellular, in structure and vary in sizes, measure approximately 0.1 to 10.0  $\mu\text{m}$ . The bacteria are single-celled organisms that reproduce by simple division, i.e. binary fission. Most are free living and contain the genetic information (DNA) free within the cytoplasm, energy-producing and biosynthetic systems necessary for growth and reproduction.

The bacteria were inactivated by:

- boiling
- at 120°C under pressure (autoclaved)
- at 170°C (hot air oven).

### Bacterial Classification

Bacteria can be classified by their wall structure, intracellular/extracellular invasive, cell morphology, growth characteristics and finally by their genotype (Phylogenetic tree).

**A: Wall structure:** The bacterial cell wall is complex, consisting of one of two basic forms: a gram positive cell wall with a thick peptidoglycan layer (**Staphylococcus**,



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**Streptococcus, Clostridium, Bacillus**), and a gram-negative cell wall with a thin peptidoglycan layer and an overlying outer membrane such as Enteric rods (**Escherichia, Shigella, Salmonella and Enterobacter**). Gram staining is not a dependable test for bacteria that are starved (e.g., old or stationary-phase cultures) or treated with antibiotics.

- **Mycobacterium** contain large amounts of lipid substances within their cell walls called mycolic acids. These acids resist staining by ordinary methods such as a Gram stain. It can also be used to stain a few other bacteria, such as Nocardia.

- **Mycoplasma** are a mollicute genus of bacteria that lack a cell wall around their cell membranes.

**B: Intracellular/extracellular** invasion Pathogenic bacteria can be grouped into two categories on the basis of their invasive properties for eukaryotic cells.

1. Extracellular bacteria
2. Obligate intracellular bacteria

- **Extracellular bacteria:** Extracellular bacterial pathogens do not invade cells and proliferate instead in the extracellular environment which is enriched with body fluids. Some of extracellular bacteria even don't penetrate body tissues (e.g. *Vibrio cholera*, *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus pyogenes*), but adhere to epithelial surfaces and cause disease by secreting potent toxins.



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- **Obligate intracellular:** This group of bacteria can't live outside the host cells. For e.g. Chlamydial cells are unable to carry out energy metabolism and lack many biosynthetic pathways, therefore they are entirely dependent on the host cell to supply them with ATP and other intermediates. Because of this dependency Chlamydiae were earlier thought to be virus (All viruses are obligate intracellular parasites). Obligate intracellular bacteria cannot be grown in artificial media (agar plates/broths) in laboratories but requires viable eukaryotic host cells (e.g. cell culture, embryonated eggs and susceptible animals).

### C: Cell morphology

**1- Shape of bacteria** Based on the shape of the bacterial cell, bacteria can be mainly classified into four major categories namely:

- Spherical bacteria or Coccus
- Rod-shaped bacteria or Bacillus
- Spiral bacteria
- Filamentous bacteria.

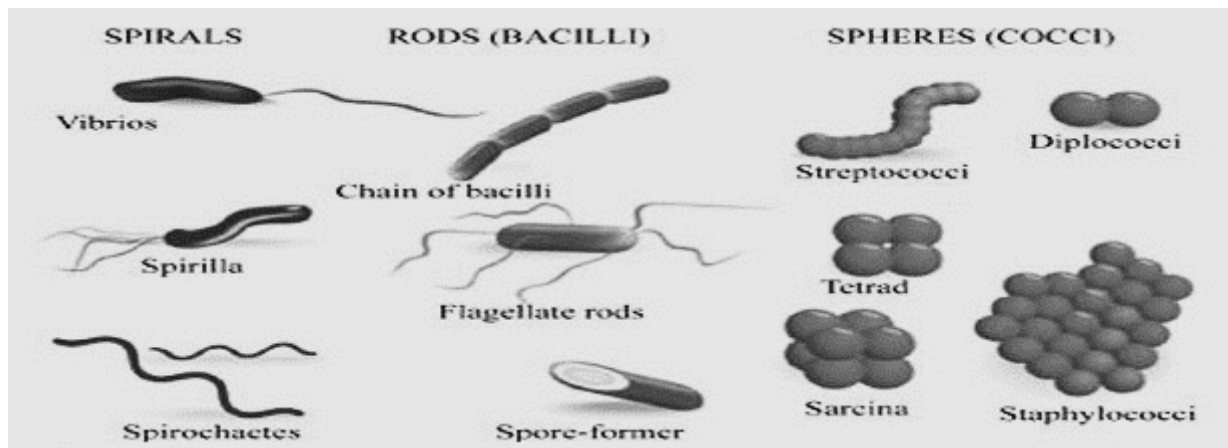
### 2- Arrangement of bacteria

**i. Diplococci:** Cocci may be arranged in pairs (diplococci) when cocci divide and remain together.



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- ii. Long chains:** Long chains (Streptococcus and Enterococcus) when cells adhere after repeated divisions in one plane.
  - iii. Grape like clusters:** Grape like clusters (staphylococci) when cocci divide in random planes.
  - iv. Tetrads:** Square groups of four cells (tetrads) when cocci divide in two planes as in members of the genus Micrococcus.
  - v. Cubical packets:** Cubical packets of eight of cells (genus Sarcina) when cocci divide in three planes.



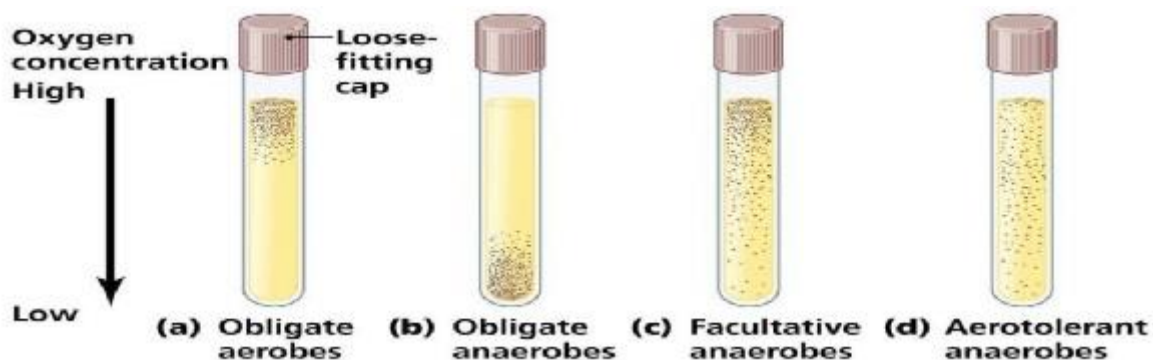
### D: Growth characteristics

**A. Oxygen requirement** Oxygen requirements of bacteria reflect the mechanism used by them, to satisfy their energy needs. On the basis of oxygen requirements, bacteria can be divided into following different categories:



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**1- Aerobes:** Aerobe grow in ambient air, which contains 21% oxygen and small amount of (0.03%) of carbon dioxide. Aerobes require molecular oxygen as a terminal electron acceptor so cannot grow in its absence (e.g., *Bacillus*)



**2- Obligate aerobes:** They have absolute requirement for oxygen in order to grow (*Pseudomonas aeruginosa* and *Mycobacterium tuberculosis*).

**3- Anaerobes:** Usually bacteria of this group cannot grow in the presence of oxygen, oxygen is toxic for them.

**4- Obligate anaerobes:** These bacteria grow only under condition of high reducing intensity and for which oxygen is toxic (*Clostridium perfringens* and *Clostridium botulinum*).

**5- Facultative anaerobes:** They are versatile organisms, capable of growth under both aerobic and anaerobic conditions. They preferentially use oxygen as terminal electron acceptor (e.g. *Enterobacteriaceae* group and *Staphylococcus aureus*).



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**6- Aerotolerant anaerobes:** Are anaerobic bacteria that are not killed by exposure to oxygen.

**B. Spore formation** Spore forming bacteria are tougher than the average microscopic unicellular organism. These species, which include the genera *Bacillus* and *Clostridium*, can surround themselves with durable coats of protein that allow them to survive in hostile environmental conditions.

**C. Fastidious/non-fastidious** The difference between fastidious and nonfastidious bacteria is that fastidious bacteria require special nutritional supplements and conditions to grow while nonfastidious bacteria do not need such special nutritional supplements or conditions.

**E: Universal Phylogenetic Tree** Developing a “universal phylogenetic tree” for bacteria, based on a comparison of 16s ribosomal RNA sequences. These sequences are highly conserved and undergo change at a slow, gradual and consistent rate.