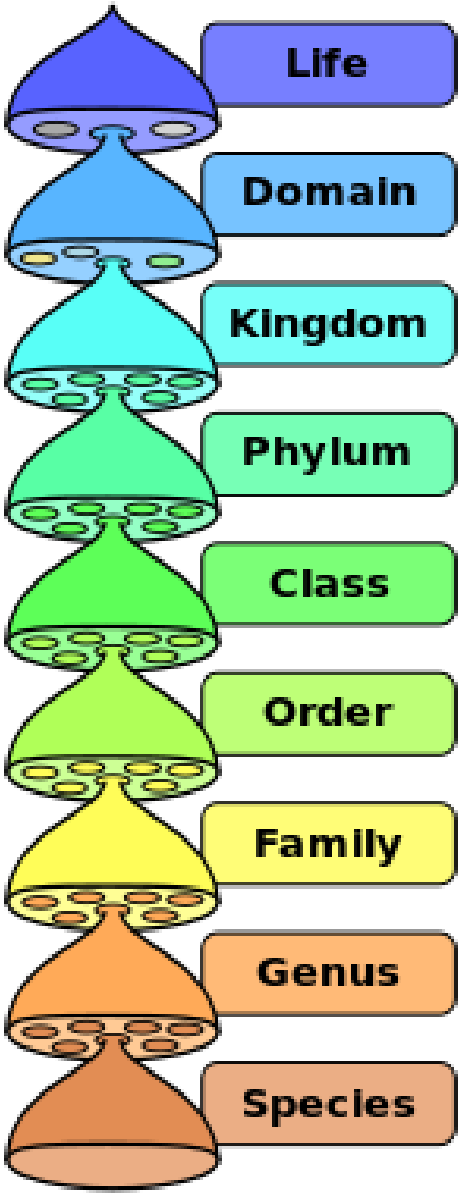
BACTERIAL CLASSIFICATION



Rank	Suffix	Example
Genus		*Elusimicrobium*
Subtribe (disused)	-inae	(*Elusimicrobiinae*)
Tribe (disused)	-inae	(*Elusimicrobiieae*)
Subfamily	-oideae	(*Elusimicrobioideae*)
Family	-aceae	*Elusimicrobiaceae*
Suborder	-ineae	(*Elusimicrobineae*)
Order	-ales	*Elusimicrobiales*
Subclass	-idae	(*Elusimicrobidae*)
Class	-ia	*Elusimicrobia*
Phylum	see text	*Elusimicrobia*

Basis of classification

- **Phenotypic classification**
  - Morphological
  - Anatomical
  - Staining
  - Cultural characteristics
  - Nutrition
  - Environmental factors
  - Biochemical reactions
  - Antigenic structure
- **Genotypic classification**
  - DNA-DNA hybridization
  - G+C content

Morphological classification

- Bacteria can be classified into **six** major groups on morphological basis.

1. TRUE BACTERIA

- **Cocci** – These are spherical or oval cells. On the basis of arrangement of individual organisms they can be described as
  - **Monococci** (Cocci in singles) – *Monococcus* spp.
  - **Diplococci** (Cocci in pairs) – *Streptococcus pneumoniae*
  - **Staphylococci** (Cocci in grape-like clusters) – *Staphylococcus aureus*
  - **Streptococci** (Cocci in chains) – *Streptococcus pyogenes*
  - **Tetrad** (Cocci in group of four) - *Micrococcus* spp.
  - **Sarcina** (Cocci in group of eight)-*Sarcina ventriculi*

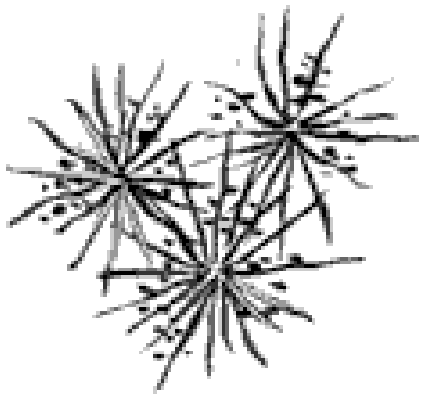
- **Bacilli** – These are rod-shaped bacteria. On the basis of arrangement of organisms, they can be described as
  - **Diplobacilli**
  - **Streptobacilli**
  - **Palisades**
  - **Chinese-letter form**
  - **Coccobacilli**
  - **Comma-shaped**

Morphological classification

2. ACTINOMYCETES (actin- ray, mykes-fungus)

These are rigid organisms like true bacteria but they resemble fungi in that they exhibit branching and tend to form filaments.

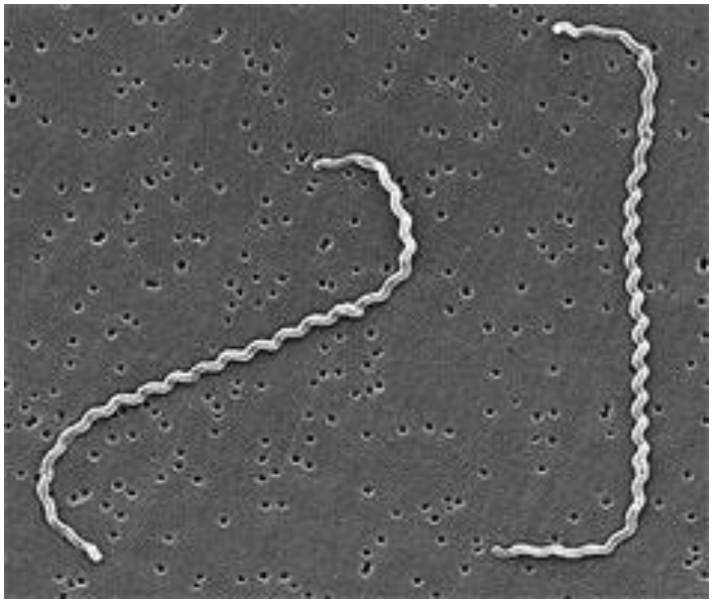
They are termed such because of resemblance to sun rays when see sections.



Morphological classification

3. Spirochaetes

These are relatively longer, slender, non-branched microorganisms of spiral shape having several coils.



Morphological classification

4. Mycoplasmas

These bacteria lack in rigid cell wall (cell wall lacking) and are highly pleomorphic and of indefinite shape.

They occur in round or oval bodies and in interlacing filaments.

5. Rickettsiae and Chlamydiae

These are very small, obligate parasites, and at one time were considered closely related to the viruses. Now, these are regarded as bacteria.

Based on Anatomical features

- Capsule
  - **Capsulate**– *Streptococcus pneumoniae*
  - **Non-capsulate** – Viridans streptococci
- Flagella
  - **Flagellate** –
    - **Monotrichous**
    - **Lophotrichous**
    - **Amphitrichous**
    - **Peritrichous**
  - **Aflagellate** – *Shigella* spp.
- Spore
  - **Spore-forming** – *Bacillus* spp.
  - **Non-sporing** – *Escherichia coli*

Based on Staining reaction

- **GRAM'S STAIN**
  - **Gram-positive cocci –** *Staphylococcus aureus*
  - **Gram-negative cocci –** *Neisseria gonorrhoeae*
  - **Gram-positive rods –** *Clostridium* spp.
  - **Gram-negative rods –** *E. coli*
  - **No Gram staining-** *Mycoplasma*

- **ACID FAST STAIN**
  - **Acid-fast bacilli –***Mycobacterium tuberculosis*
  - **Non-acid-fast bacilli –** *Staphylococcus aureus*

Based on Cultural characteristics

- Extra growth factors requirements
  - **Fastidious** – *Hemophilus influenzae*
  - **Non-fastidious** – *Escherichia coli*

- Hemolysis on Sheep Blood Agar
  - **Alpha-hemolysis** – *Streptococcus pneumoniae*
  - **Beta-hemolysis** – *Streptococcus pyogenes*

- Utilization of carbohydrates
  - **Oxidative** - *Micrococcus*
  - **Fermentative** – *Escherichia coli*

Based on Cultural characteristics

- Growth rate

Rapid growers– *Vibrio cholerae* –

Slow growers – *Mycobacterium tuberculosis* –

- Pigment production

Pigment producer – *Staphylococcus aureus* –

Pigment non-producer – *Escherichia coli* –

Based on Nutrition

- **Autotrophs**
- **Heterotrophs**

Based on environmental factors

- **Temperature**
- **Oxygen dependence**
- **pH**
- **Salt concentration**
- **Atmospheric pressure**

Temperature

- **Psychrophiles** (15-20^{0}C) – *Pseudomonas fluorescens*
- **Mesophiles** (20-40^{0}C) – *Escherichia coli*, *Salmonella enterica*, *Staphylococcus aureus*
- **Thermophiles** (50-60^{0}C)- *Bacillus stearothermophilus*
- **Extremely thermophiles** (as high as 250^{0}C)

Oxygen dependence

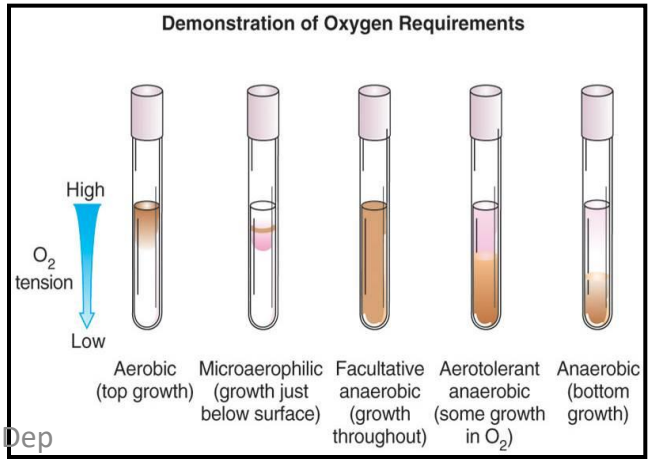
- **Aerobe** (grow in ambient temperature, which contains 21% O_2 and a small amount of CO_2, 0.03%)
- **Obligate aerobes** – Strictly require O_2 for their growth (*Pseudomonas aeruginosa*)
- **Microaerophilic** (grow under reduced O_2, 5-10% and increased CO_2, 8-10%)- *Campylobacter jejuni*, *Helicobacter pylori*

Oxygen dependence

- **Facultative anaerobe** (capable of growing either in presence or absence of O_2)- *E. coli*
- **Obligate anaerobe** – *Clostridium* spp.
- **Capnophilic** (require increased concentration of CO_2, i.e., 5-10%) –

  H. influenzae,

  N. gonorrhoeae
- **Aerotolerant**



pH

- **Acidophiles** (*Lactobacillus acidophilus*)
- **Alkaliphiles** (*Vibrio*)
- **Neutralophiles** (pH 6-8)

Majority of the medically important bacteria grow best at neutral or slightly alkaline reaction (pH 7.2-7.6)

Salt concentration

- **Halophiles**
- **Non-halophiles**

Other ways of classification

- **Motile/Non-motile**
- **Pathogenic/Non-pathogenic**
- **Sensitive/Resistant (to particular antibiotic/ chemicals)**
- **Lactose fermenter/Lactose non-fermenter**
- **Bergey's Manual of Determinative Bacteriology**
  - **Gram-negative eubacteria that have cell walls**
  - **Gram-positive eubacteria that have cell walls**
  - **Cell wall-less eubacteria: *Mycoplasma***
  - **Archaeobacteria**

Anaerobic bacteria

- Gram positive sporulating bacilli
- Gram positive non-sporulating bacilli
- Gram negative non-sporulating bacilli(nm)
- Gram negative non-sporulating bacilli(m)
- Gram positive anaerobic cocci
- Gram negative anaerobic cocci

Gram positive non-sporulating bacilli

- *Actinomyces*
- Bifidobacterium
- *Proprionbacterium* (*Corynebacterium*)
- *Arachnia* (*Proprionbacterium propionica*)
- *Eubacterium*

Gram negative non-sporulating bacilli.(non motile)

- *Bacteroides* (*Bacteroides fragilis).*
- *Fusobacterium*
- *Porphyromonas*
- *Prevotella*

Gram negative non-sporulating bacilli (motile)

- *Treponema*
- *Borrelia*
- *Campylobacter*

Anaerobic cocci

Gram positive anaerobic cocci

- *Peptostreptococcus*
- *Peptococcus*

Gram negative anaerobic cocci

- *Veillonella*
- *Acidaminococcus*

Gram negative non-sporulating bacilli

- **Prototype- *Bacteroides fragilis***
- ***Fusobacterium***

Murray classification of bacteria

18 ***Staphylococcus*** and Related Gram-Positive Cocci
19 ***Streptococcus*** and ***Enterococcus***
20 ***Bacillus***
21 ***Listeria*** and Related Gram-Positive Bacteria
22 ***Mycobacterium*** and Related Acid-Fast Bacteria
23 ***Neisseria*** and Related Genera
24 ***Haemophilus*** and Related Bacteria
25 Enterobacteriaceae
26 ***Vibrio*** and Related Bacteria
27 ***Pseudomonas*** and Related Bacteria
28 ***Campylobacter*** and ***Helicobacter***
29 Miscellaneous Gram-Negative Rods
30 ***Clostridium***
31 Non–Spore-Forming Anaerobic Bacteria
32 ***Treponema***, ***Borrelia***, and ***Leptospira***
33 ***Mycoplasma*** and ***Ureaplasma***
34 ***Rickettsia***, ***Ehrlichia***, and Related Bacteria
35 ***Chlamydia*** and ***Chlamydophila***