CHAPTER III : PRINCIPALES of BACTERIAL TAXONOMY

(*Bergey's Manual of Systematic Bacteriology*"2013)

Bacterial systematics has undergone several changes and is continuously in a state of flux as our knowledge of microorganism is far from complete and new information is being added every day. In 1923 David Bergey, professor of bacteriology at the University of Pennsylvania and four colleagues published a classification of bacteria that could be used for identification of bacterial species. The *Bergey's Manual of Determinative Bacteriology* has been a widely used reference since publication of the first edition in 1923. The manual does not classify bacteria according to evolutionary relatedness but provides identification (determining) schemes, based on such criteria as cell wall composition, morphology, differential staining, oxygen requirement and biochemical testing.

From 1984, the Bergey's Manual was renamed *Bergey's Manual of Systematic Bacteriology* which is being published in separate volumes. The classification presented in 9th eds. of *Bergey's manual of determinative bacteriology* (1994) is especially designed to be used in the identification of bacteria and it is different from the classification system presented in *Bergey's Manual of Systematic Bacteriology*.

1. First edition

Since phylogenetic relationships were not able to classify bacteria in a satisfactory manner, the system used in the first edition of *Bergey's Manual of Systematic Bacteriology* is primarily phenetic. Each of the 33 sections across the four volumes contains prokaryotes that share a few easily determinable characteristics and are titled either according to these properties or by providing the vernacular names of the described prokaryotes. The characteristics used to define the sections include common traits such as shape and general morphology, Gram staining properties, oxygen dependency, motility, presence of endospores, mode of energy production, and so on. The prokaryote groups are distributed across the four volumes as follows: (1) Gram-negative bacteria in general, medical or industrial importance; (2) Gram-positive bacteria other than actinomycetes; (3) Gram-negative bacteria with distinct properties, cyanobacteria, and archaebacteria; (4) Actinomycetes (Gram-positive filamentous bacteria).

The response to Gram staining plays a particularly important role in this phenetic classification, even determining which volume a species is placed in. Gram staining generally reflects fundamental differences in the bacterial cell wall structure. Typical Gram-negative bacteria, Gram-positive bacteria, and mycoplasmas (bacteria lacking a cell wall) differ in many characteristics (**Tab. 01**).

Table 01: Some characteristic differences between Gram-negative, Gram-positive bacteria and mycolpasmas.

Property	**Gram-negative bacteria**	**Gram-positive bacteria**	**Mycoplasmas**
Cell wall	Gram-negative type wall with inner 2–7 nm peptidoglycan layer and outer membrane (7–8 nm thick) of lipid, protein, and lipopolysaccharide. (There may be a third outermost layer of protein.)	Gram-positive type wall with a homogeneous, thick cell wall (20–80 nm) composed mainly of peptidoglycan. Other polysaccharides and teichoic acids may be present.	Lack a cell wall and peptidoglycan precursors; enclosed by a plasma membrane
Cell shape	Spheres, ovals, straight or curved rods, helices or filaments; some have sheaths or capsules.	Spheres, rods, or filaments; may show true branching.	Pleomorphic in shape; may be filamentous, can form branches.
Reproduction	Binary fission, sometimes budding	Binary fission, filamentous forms grow by tip extension	Budding, fragmentation, and/or binary fission
Metabolism	Phototrophic, chemolithoautotrophic, or chemoorganoheterotrophic	Usually chemoorganoheterotrophic, a few phototrophic	Chemoorganoheterotrophic; most require cholesterol and long-chain fatty acids for growth.
Motility	Motile or nonmotile. Flagella placement can be varied—polar, lophotrichous, peritrichous. Motility may also result from the use of axial filaments (spirochetes) or gliding motility.	Most often nonmotile; have peritrichous flagella when motile	Usually nonmotile
Appendages	Can produce several types of appendages—pili and fimbriae, prosthecae, stalks	Usually lack appendages (may have spores on hyphae)	Lack appendages
Endospores	Cannot form endospores	Some groups	Cannot form endospores

2. Second edition

After 1984, the year of publication of first edition of *Bergey's Manual of Systematic Bacteriology,* much work has done on sequencing of rRNA, DNA and proteins which has made

the phylogenetic analysis of prokaryote feasible. As a consequence, the second edition of Bergey's manual is largely phylogenetic rather than phenetic and it is published in five volumes, the first volume was published in 2001 and the second in 2005. Three additional volumes are due in 2007. Although gram-staining properties are generally considered phenetic characteristics, they also play a role in the phylogenetic classification of microbes (T**ab. 01**).

It has more ecological information about individual taxa. The second edition does not group all the clinically important prokaryotes together as the first edition, instead, pathogenic species will be placed phylogenetically and thus scattered throughout the following five volumes (**Tab. 02**).

- Volume 01: The Archaea, and the deeply branching and phototrophic bacteria.
- Volume 02: The Proteobacteria
- Volume 03: The low G + C gram positive bacteria
- Volume 04: The high G + C gram + positive bacteria
- Volume 05: The Planctomycetes, Spirochaetes, Fibrobacteres, Bacteroidetes, Fusobacteria, *Chlamydiae, Acidobacteria, Verrumicrobia,* and *Dictyoglomus* (Volume 5 also will contain a section that updates descriptions and phylogenetic arrangements that have been revised since publication of volume 1.).

Table 02: Organization of *Bergey's Manual of Systematic Bacteriology*.

Taxonomic rank	**Representative genera**
Volume 1. *The Archaea and the Deeply Branching and Phototrophic Bacteria*	
Domain *Archaea*	
Phylum *Crenarchaeota*	
Class I. *Thermoprotei*	*Thermoproteus, Pyrodictium, Sulfolobus*
Phylum *Euryarchaeota*	
Class I. *Methanobacteria*	*Methanobacterium*
Class II. *Methanococci*	*Methanococcus*
Class III. *Methanomicrobia*	*Methanomicrobium*
Class IV. *Halobacteria*	*Halobacterium, Halococcus*
Class V. *Thermoplasmata*	*Thermoplasma, Picrophilus, Ferroplasma*
Class VI. *Thermococci*	*Thermococcus, Pyrococcus*
Class VII. *Archaeoglobi*	*Archaeoglobus*
Class VIII. *Methanopyri*	*Methanopyrus*
Domain *Bacteria*	
Phylum *Aquificae*	*Aquifex, Hydrogenobacter*
Phylum *Thermotogae*	*Thermotoga, Geotoga*
Phylum *Thermodesulfobacteria*	*Thermodesulfobacterium*

Phylum *Deinococcus-Thermus*	*Deinococcus, Thermus*
Phylum *Chrysiogenetes*	*Chrysogenes*
Phylum *Chloroflexi*	*Chloroflexus, Herpetosiphon*
Phylum *Thermomicrobia*	*Thermomicrobium*
Phylum *Nitrospira*	*Nitrospira*
Phylum *Deferribacteres*	*Geovibrio*
Phylum *Cyanobacteria*	*Prochloron, Synechococcus, Pleurocapsa, Oscillatoria, Anabaena, Nostoc, Stigonema*
Phylum *Chlorobi*	*Chlorobium, Pelodictyon*

Volume 2. *The Proteobacteria*

Phylum *Proteobacteria*	
Class I. *Alphaproteobacteria*	*Rhodospirillum, Rickettsia, Caulobacter, Rhizobium, Brucella, Nitrobacter, Methylobacterium, Beijerinckia, Hyphomicrobium*
Class II. *Betaproteobacteria*	*Neisseria, Burkholderia, Alcaligenes, Comamonas, Nitrosomonas, Methylophilus, Thiobacillus.*
Class III. *Gammaproteobacteria*	*Chromatium, Leucothrix, Legionella, Pseudomonas, Azotobacter, Vibrio, Escherichia, Klebsiella, Proteus, Salmonella, Shigella, Yersinia, Haemophilus.*
Class IV. *Deltaproteobacteria*	*Desulfovibrio, Bdellovibrio, Myxococcus, Polyangium*
Class V. *Epsilonproteobacteria*	*Campylobacter, Helicobacter*

Volume 3. *The Low G* 1 *C Gram-Positive Bacteria*

Phylum *Firmicutes*	
Class I. *Clostridia*	*Clostridium, Peptostreptococcus, Eubacterium, Desulfotomaculum, Heliobacterium, Veillonella.*
Class II. *Mollicutes*	*Mycoplasma, Ureaplasma, Spiroplasma, Acholeplasma*
Class III. *Bacilli Bacillus,*	*Bacillus, Caryophanon, Paenibacillus, Thermoactinomyces, Lactobacillus, Streptococcus, Enterococcus, Listeria, Leuconostoc, Staphylococcus.*

Volume 4. *The High G* 1 *C Gram-Positive Bacteria*

Phylum *Actinobacteria*	
Class *Actinobacteria*	*Actinomyces, Micrococcus, Arthrobacter, Corynebacterium, Mycobacterium, Nocardia, Actinoplanes, Propionibacterium, Streptomyces, Thermomonospora, Frankia, Actinomadura, Bifidobacterium*

Volume 5. ***The Planctomycetes, Spirochaetes, Fibrobacteres, Bacteriodetes, and Fusobacteria***	
Phylum *Planctomycetes*	*Planctomyces, Gemmata*
Phylum *Chlamydiae*	*Chlamydia*
Phylum *Spirochaetes*	*Spirochaeta, Borrelia, Treponema, Leptospira*
Phylum *Fibrobacteres*	*Fibrobacter*
Phylum *Acidobacteria*	*Acidobacterium*
Phylum *Bacteroidetes*	*Bacteroides, Porphyromonas, Prevotella, Flavobacterium, Sphingobacterium, Flexibacter, Cytophaga.*
Phylum *Fusobacteria*	*Fusobacterium, Streptobacillus*
Phylum *Verrucomicrobia*	*Verrucomicrobium*
Phylum *Dictyoglomi*	*Dictyoglomus*
Phylum *Gemmatimonadetes*	*Gemmatimonas*