



**E- CONTENT
ON
MICROBIAL TAXONOMY
by**

**DR. ABHAY B. SOLUNKE
DEPARTMENT OF MICROBIOLOGY
SHRI GOVINDRAO MUNGHALE
ARTS & SCIENCE COLLEGE,
KURKEHDA. 441209.**

www.sgmunghatecollege.in/www.abhaysolunke.info



MICROBIAL TAXONOMY

Introduction

The classification of microbes underwent a series of classification systems. The first attempt was in 1773. The first report of the Committee on Characterization and Classification of Bacterial Types was published in the Journal of Bacteriology in September, 1917,

A committee of the Society of American Bacteriologists (Berger, Breed, Hammer, Harrison and Huntoon) have recently (1923) prepared a Manual of Determinative Bacteriology. In general, the classification suggested by Winslow et al. has been followed. In some groups genera have been added, and several new families created. In the treatment of the Bacteriaceae they have followed Castellani and Chalmers and in orders other than Euacteriales they have followed Buchanan.

SUGGESTIONS AND RECOMMENDATIONS OF THE SOCIETY OF AMERICAN BACTERIOLOGISTS

The preliminary report of the Committee of the Society of American Bacteriologists on Characterization and Classification of Bacterial Types (Winslow, Broadhurst, Buchanan, Krumwiede, Rogers and Smith 1917) suggested the following to the Society:

We recommend to the Society of American Bacteriologists:

- a. That the International Rules for Botanical Nomenclature be accepted by the Society as governing bacterial terminology, with the exception that French, English or German may be substituted for Latin in the diagnosis.
- b. That the date of publication of the third edition of Zopf's Spaltpilze be considered as the date for the beginning of bacteriological nomenclature for the purpose of determining priority, with the exception of a list of genera to be adopted by the Society at its 1918 meeting.
- c. That the Society take steps to present these recommendations to the next International Botanical Congress, and if possible to secure favourable action thereon by that body.

Codes of Nomenclature in Microbial Taxonomy

A guiding principle that for each kind of organism there should be one valid name, and that there should be some criterion as to the correctness or validity of any name, it is evident that there must be developed and recognized some code of rules or laws. Such so-called "Codes of Nomenclature".

- The author who names the genus places his name after the name given. We speak of *Bacillus* Cohn, and mean the genus *Bacillus* as Cohn established it; of *Vibrio* Ehrenberg emend. Loeffler, and mean the genus *Vibrio* as established by Ehrenberg and afterward more accurately described by Loeffler.
- Whoever discovers a new species or names one not previously named gives it a genus and a species name, and places his own name after the latter.
- Families (*familiae*) are designated by the name of one of their genera or ancient generic names with the ending *-aceae*.
- The preferable designation for the orders of microorganisms would have the ending *-ales*.



- Genera receive names, substantives (or adjectives used as substantives) in the singular number and written with a capital letter, which maybe compared with our own family names, e.g. bacterial genera are *Bacillus*, *Actinomycetes* and *Vibrio*.
- When the name of a genus, subgenus or section is taken from the name of a person, it is formed in the following manner:
 - a. When the name ends in a vowel, the letter *a* is added (for example *Glazioua Gtaziou*; *Bureua* after *Bureau*), except when the name already ends in *a*, inwhich case *ea* is added (e.g., *Collaea* after *Colla*).
 - b. When the name ends in a consonant, the letters *ia* are added (thus *Magnusia* after *Magnus*; *Ramondia* after *Ramond*), except when the name ends in *er*, in which case *a* is added (e.g., *Kernera* after *Kerner*).
 - c. The spelling of the syllables unaffected by these finals is retained, even with the consonants *k* and *w* or with groupings of vowels which were not used in classic Latin. Letters which are unknown to botanical Latin must be transcribed, diacritic signs are suppressed. The German *a, li*, become *ae, oe, ue*, the French, *e* and *e* become generally *e*.
 - d. Names may be accompanied by a prefix, or a suffix, or modified by an agramor abbreviation. In these cases they count as different words from the original name. E.g., *Durvillea* and *Urvillea*, *Lapeyroxisea* and *Peyrousea*, *Englera*, *Englerastrum* and *Englerella*, *Bouchea* and *Ubochea*, *Gerardia* and *Graderia*, *Martia* and *Martiusia*.
- Comments. Among the generic names of bacteria which have been derived from patronymics are *Pasteurella*, *Salmonella*, *Klebsiella*, *Detoniella*, *Zopfiella*, *Mantegazzaea*, *Erwinia*, *Pacinia*, *Cornelia*, *Newskia*, *Pollendera*, *Macintoshillus*, *Metchnikovillus*, *ZopfiuSi* It will be noted that authors have frequently given generic names among the bacteria by adding *-ella* in accordance with above. The custom is so well established for opposing it that there would seem to be little good reason at the present time

THE RULES OF BACTERIAL NOMENCLATURE ACCORDING TO LEHMANN AND NEUMANN

Following the precedent of Linnaeus, every plant or animal, therefore, every microorganism must have two Latin names: the first designating the genus to which the organism in question belongs, this name being a substantive; the second indicating the species, which name is an adjective (not two) or the genitive of a substantive, or rarely a substantive in the nominative case.

Genera must only be founded upon important morphologic characteristics; so called "biologic genera," such as *Photobacterium* for all light-emitting bacteria,

Bory de St. Vincent's Classification

Bory de St. Vincent (1824) created the genus *Melanella* to include all non-flexible organisms of the group of *Vibrionides* whether straightor spiral. To this genus he transferred four of Mueller's species of *Vibrio*. {*V. lineola*, *V. rugula*, *V. bacillus* and *V. spirillum*}.

Bory de Saint-Vincent in 1824 gave the classification of infusoria and two different families given were, *Monadaires* and *Vibrionides*. He introduced many of the terms still in use at the present day, e.g. *Bacillus*, *Proteus*, *Spirillum*, and *Vibrio*

Bory de St. Vincent in 1826, prepared a "Tableau des Ordes, des Families et des Genres de Microscopiques. " This was a dichotomous key to genera. A translation of the key carried out to include only the forms now listed with the bacteria is as follows:



Bory de St. Vincent's Classification (1826)

- a. Without Testa.
- b. Perfectly smooth, without cilia or other vibratile organsOrder *Gymnode*
- c. Without appendages.
- d. Never linear or wormlike. (5 families.)
- dd. Linear or wormlikeFamily *Vibrionides*
- e. Body opaque.
- f. Coiled in a discoid spiral.....*Spirilina*
- ff. Not coiled in a discoid spiral.....*Melanella*
- ee. Body transparent (diaphanous),
- f. Attenuate at both tips.....*Vibrio*
- ff. Obtuse.
- g. With one end enlarged.....*Lacrimatoria*
- gg. Not enlarged at one end.....*Pupella*

Buchanan

Buchanan, in his classification system (1917), gave six orders instead of four, by giving ordinal rank to the *Spirochaetes* and *Actinomycetes*.

Chons classification

Ferdinand Cohn (1854) described as a genus the slimy bacterial growth which develops in certain solutions, giving it the name *Zoogloea*. Later (1872) he abandoned this term recognizing this to be simply a growth stage in the developmental cycle. Cohn's most important conclusion at this time was to the effect that the bacteria (*Vibrionien*) belong in the plant kingdom rather than with the true Infusoria.

Chon in 1872 classified microbes in four groups depending upon their shapes.

Group I: cocci or rounded bacteria or *Sphaerobacteria* or globular:

Group II: cylinder shaped or short rods or *Microbacteria*;

Group III: longer rods or thread-like organism or vibrio or comma shaped or Filamentous or *Desmobacteria*;

Group IV: screw-shaped or spiral bacteria or *Spirobacteria*.

Conn (1909) suggested the following classification

Spherical Bacteria:

Dividing in one plane, so as to form chains. *Streptococcus*.

Dividing in two planes, and not forming chains. *Micrococcus*.

Dividing in three planes, and forming cubical masses, *Sarcina*.

Rod Shaped Bacteria: With flagella, and consequently motile, *Bacillus*.

Without flagella and consequently non-motile, *Bacterium*.

With a single flagellum, *Pseudomonas*.

Spiral Bacteria: *Spirillum*.

Higher Bacteria: {*Cladothrix*, *Leptothrix*, *Streptothrix*, *Actinomyces*}

The genus *Bacillus* is further divided as follows:

Bacilli with one flagellum are named Monotrichic *Bacilli* or *Pseudomonas*.

Bacilli with one flagellum at each end, *Microsporon*.

Bacilli with a tuft of flagella at one end are called Lophotrichic *Bacilli*.

Bacilli with flagella over the whole body are called Peritrichic *Bacilli*.



Dujardin

Dujardin used the family designation *Vibrionia* to include "Animaux sans organes locomoteurs visibles, se mouvent par l'effect de leur contractibilité générale."

Dujardin in 1841 classified the microbes (*Vibrionia*) in:

1. *Bacterium*: Organisms with filaments that are rigid with movements. Cells straight, non-flexuous, more or less definitely jointed, with slow wave-like motility.
2. *Vibrio*: Organisms with flexible filament and undulatory movements. Cells straight or bent, more or less definitely jointed, flexuous
3. *Spirillum*: Spiral filaments with rotatory movements. Filamentous forms spiral or screw shaped, never straight, and revolving rapidly on the axis Spirillum.

Dujardin (1841) united the two genera *Spirillum* and *Spirochete* of Ehrenberg.

Ehrenberg

The first considerable contributions to bacteria and their classifications, following Mueller, were those of Ehrenberg (from 1828-1838). Certain of his genera of the Infusoria were made up almost entirely of organisms now included with bacteria. The following key will indicate the principal groups of the Infusoria and the position of the "bacterial" genera in the system.

Ehrenberg's Classification of the Infusoria (1838)

- a. Forms which ingest solid particles, as carmine..... *Polygastrica*
- aa. Forms which never ingest particles.
- b. Family *Monadina*. Genus *Monas*, of which *Monas crepusculum* was probably a bacterium.
- bb. Family *Vibrionia*. Forms which tend to form filaments as a result of incomplete fission.
- c. Cells not flattened.
- d. Cells not flexuous.
- e. Forming straight rods . . . *Bacterium*
- ee. Forming spiral rods..... *Spirillum*
- dd. Cells flexuous.
- e. Straight rods..... *Vibrio*
- ee. Spiral rods..... *Spirochaeta*
- cc. Cells in form of a flattened spiral..... *Spirodiscus*

Davaine Classification

The classification of Davaine (1808) provides for the motionless, filamentous bacteria, but does not include the micrococci. He first insisted that the *Vibrioniens* of Ehrenberg are truly vegetable organisms, allied to the algae. He makes four genera, as follows:

Filaments straight or bent, but not in a spiral

Moving spontaneously,

Motionless

Rigid Bacterium Flexible Vibrio Bacteridium

Filaments spiral..... *Spirillum*

Hoffman

Hoffman in 1869 included in his classification the spherical bacteria, and pointed out the fact that motility could not be taken as a generic character, as it was not constant in the same species and depended to some extent upon temperature conditions, etc.



Jensen

Jensen divided bacterial kingdom into two orders: (1) *Cephalotrichinae* and (2) *Peritrichinae*.

Otto Friedrich Miiller

Otto Friedrich Miiller in 1773 classify the microbes in two genera the *Monas* and *Vibrio*. Mueller in his *Vermium terrestrium et fluviatilem* (1773), gave the following key, that describes the main groupings and the genera of the group in which the bacteria fall.

Mueller's Classification of Vermes (1773)

- a. Tentaculi destituti.
- b. Vagantes..... Infusoria
- c. Organis externis nullis
- d. Teretes.
 - 1. Corpus punctiforme..... Monas
 - 2. Corpus sphaericina..... Volvox
 - 3. Corpus cylindraceum Enchelis
 - 4. Corpus elongatum..... Vibrio
 - 5. Corpus cavum..... Bursaria

Luerssen's Classification of Bacteria

Luerssen (1879) in the first volume of his Botanik discusses the genera of bacteria.

Maggi's Classification of Bacteria

Maggi (1887) in his "Acque potabili" outlined a bacterial classification as follows:

- A. Order I. *Spirobacteria* Cohn
- I. Genus 1. *Spirochaeta* Ehr.
- II. Genus 2. *Spirillum* Ehr.
- III. Genus 3. *Vibrio* Auct. emend.
- B. Order II. *Desmobacteria* Cohn
- I. Genus 1. *Cladothrix* Cohn
- II. Genus 2. *Crenothrix* Cohn
- III. Genus 3. *Beggiatoa* Trevisan
- IV. Genus 4. *Leptothrix* Kiitzing
- V. Genus 5. *Bacillus* Cohn
- C. Order III. *Microbacteria* Cohn
- I. Genus 1. *Bacterium* Dujardin emend.
- II. Genus 2. *Zygobacterium* Maggi.
- D. Order IV. *Sphaerobacteria* Cohn
- I. Genus 1. *Micrococcus*.

Perty

Perty(1852) in his "Zur Kenntniss kleinster Lebensformen " divided the Infusoria into *Ciliata* and *Phytozoidia*, the latter in turn hdivided into three sections, the third of which he termed *Lampozoidea*.The family *Vibrionida* is included under this. The subfamilies andgenera of the *Vibrionida* may be differentiated as follows:

Perty's Classification of the Vibrionida (1852)

- a. Chains or filaments spirally wound.
- Subfamily 1. *Spirillina*
- 1. Cells not flexuous..... *Spirillum*



- 2. Cells flexuous..... *Spirochaeta*
 - aa. Filaments flexuous or straight. Subfamily 2. *Bacterina*
 - 1. Cells flexuous..... *Vibrio*
 - 2. Cells not flexuous, cells isolated..... *Bacterium*
 - 3. Cells not flexuous, in filaments..... *Metallacter*
 - 4. Cells not flexuous, filaments..... *Sporonema*

Three species of *Spirillum*, one of *Spirochaeta*, three of *Vibrio*, one of *Bacterium*, one of *Metallacter* and one of *Sporonema* were described.

Baumgarten

The classification of Baumgarten(1890) divides the bacteria into two principal groups, as follows:

Group I. Species relatively monomorphous.

Group II. Species pleomorphous.

The first group includes the micrococci, the bacilli, and the spirilla; the second group the spirulina of Hueppe, leptotrichace (Zopf), and cladotrichace.

The pleomorphous species described by Hauser under the generic name *Proteus* are included in the second group among the spirulina.

The Coccii, in the classification of Baumgarten, constitute a single genus with the following subgenera: 1, *Diplococcus*; 2, *Streptococcus*; 3, Merismopedia (Zopf)—"Merista" (Hueppe); 4, Sarcina(Goodsir) ; 5, *Micrococcus* ("*Staphylococci*").

Simple morphological classification of the monomorphous group of Baumgarten corresponds with the nomenclature now generally in use.

Von Baer (1827) proposed to establish a genus *Lineola* to include all of the extremely minute Infusoria.

Zopf's classification

Zopf, who insists upon the polymorphism of these low organisms, divides the bacteria into four groups:

- 1.Coccoceae.—Up to the present time, only known in the form of cocci.
- 2.Bacteriaceae.—Have for the most part spherical, rod-like, and filamentous forms; the first (coccii)
- 3.Leptotrichaceae.— Spherical, rod-shaped, and filamentous forms.
- 4.Cladotrichaceae.—Spherical, rod-shaped, filamentous, and spiral forms; the filamentous form presents pseudo-branches.

Zopf's classification rests on the doctrine of pleomorphism, which cannot be accepted as in any way proved except in the case of a few well-known non-pathogenic forms; but his classification may be accepted as a basis from which to work in bringing proof or disproof of the theory of pleomorphism.

Classification of bacteria on the basis of cell wall: -

Depending upon the staining reactions by Gram stain bacteria can be classified into two types, those are: -

i)**Gram positive**: -this type of bacteria retains the crystal fire lit or gram stain which appear violaceous. Example: – *Streptococcus*.

ii)**Gram negative**:-they do not retain the gram stain, but they take up the red colour of the counter stain. Example:–Saffranin (*Escherichia coli*).

Classification of bacteria on the basis of nutrition: -

On the basis of nutrition bacteria are classified as following:



1) **Autotrophic bacteria**:—these bacteria are non-pathogenic, free living, self-sustaining in nature, which prepares their own food by utilisation of solar energy and inorganic components like carbon dioxide, nitrogen etc. They are of two types:

i) **Photoautotrophs**:—these bacteria contain bacterio-chlorophyll and bacterioviridin and can prepare their own food by fixing carbon dioxide the nature by the utilisation of solar energy.

ii) **Chemoautotrophs**:—these are the bacteria which prepare they are food by deriving the energy from oxidation of inorganic substances like nitrogen dioxide, carbon dioxide etc. and they can also fix carbon dioxide and water for their nutrition.

2) **Heterotrophic bacteria**:—this type of bacteria cannot fix inorganic carbon but rather depend on external organic carbon for their nourishment. They also can be classified on the basis of presence and absence of flight and on the basis of the media on which the bacteria are growing.

Classification on the basis of temperature dependence/response : –

Bacteria can be classified into three major types on the basis of their temperatures response as indicated below: –

◆ **Thermophilic** (thermo+phyllic=temperature loving); Thermophilic bacteria are those which can survive at high temperature of 45 to 60°C temperatures

◆ **Mesothermic** (medium+thermic= medium temperature) can survive at 25 to 45°C

◆ **Hypothermic** (hypo = low) these bacteria survive at low temperatures like 8°C or even less.

In common most bacteria survive in between 25 to 45°C, i.e. they are mesotherms.

CLASSIFICATION BASED ON OXYGEN REQUIREMENT

Not all bacteria require oxygen to survive. Some can survive without oxygen. These are the microbes considered to be immortals due to cell division. But this feature adds even more weight to it.

Bacteria are classified based on the oxygen requirement as

Aerobic: Which require oxygen to survive.

Anaerobic bacteria: These bacteria do not require oxygen for survival. They are further as two types

Obligate anaerobes: They survive in absence of oxygen. But when exposed to oxygen they die.

Facultative anaerobes: These also survive in environments without oxygen but when exposed to oxygen they can survive.

Questions:

1. Define Taxonomy.
2. Give the suggestions and recommendations of the society of American Bacteriologists on classification of microorganisms.
3. Write a note on the rules of bacterial nomenclature of Lehmann and Neumann.
4. Describe Code of Nomenclature in Microbial Taxonomy.
5. Define Pleomorphism.
6. Define Genera.
7. Define Autoroph, Chemotroph, & Heterotroph.
8. Describe the bacterial cell wall.
9. Define the flagella.
10. Describe classification of microbes according to Baumgarten.



11. Describe the Zopfs classification system.
12. Describe the Davaine Classification system.
13. Describe the Ehrenberg's classification of the Infusoria.
14. Describe the Bory de St. Vincent's classification.
15. Describe the Maggi's classification of bacteria.
16. describe the types of flagellar arrangements in bacteria.

References:

1. A.B.Solunke, V.S.Hamde, R.S.Awasthi, P.R.Thorat(2013).History of Microbiology & Microbiological Methods. Athrava Publications, Jalgaon.
- 2.A.B.Solunke, V.S.Hamde, P.S.Wakte, R.S.Awasthi(2015).Manual of Methods of Pure culture studies. NPI Publishers New Delhi.
3. W. Bulloch, The History of Bacteriology(1938).Dover Publications, New York.
4. G.C. Ainsworth,(1976).Introduction to the history of mycology. Cambridge University Press.
5. J.D. Bernal, Science in history (1965) Hawthorn Books, New York.
6. D.J. Boorstin, The discoverers (1986). Penguin Books, Harmondsworth.
7. A.B.Solunke.(2016).The Book of Citric Acid. NPI Publishers, New Delhi.