A SIMPLIFIED SYSTEM OF BACTERIAL CLASSIFICATION

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INTRODUCTION

Among the contemporary systems of classification of bacteria the best known and most complete are those of the Bergey's Manual (1948), of Krassilnikov (1949) and of Prévot (1948). Each has its advantages and disadvantages. Each was prepared by specialists--microbiologists with special training and interests in single branches of microbiology. We need biologists--microbiologists who are able to introduce better biologic concepts into the development of classification of bacteria (Cowan, 1955).

The first system, that of the Bergey's Manual (1948), is the most complete but it is also the most complicated. Certain of the specialized groups of bacteria are much split up, not on the basis of their genuine biological characteristics, but in the majority of cases on the basis of particular and unstable characters, such as the ability to produce disease in certain plant hosts. The basis of this system is an idealistic notion of species as a taxonomic concept, not the realities as found in nature. From this concept has come the recognition of a large number of "split" species, which do not in reality correspond to the biological species of microorganisms to be found in nature. The essential characteristics of this system is the recognition of discontinuities, of static states and the consequent creation of a series of "mechanical keys" for the practical determination of the specialized groups of bacteria. It would seem that this system cannot serve as the basis for making a contemporary system for classifying the bacteria.

The second system, that of Krassilnikov (1949) is quite different, even though it is concerned primarily with the non-pathogenic bacteria significant in general, agricultural, and technological bacteriology. This classification is based on the materialistic concept of a species as a reality in nature, as a definite stage in the development of living

matter, as a link in the chain of evolution of living things. These species are based on the complex of the more stable biological characteristics, and thus keep up the dynamics of development of organisms in nature. Since species in nature include varieties (subspecies), biotypes, ecotypes and strains, in this system each species of microorganism is described in accordance with the main characteristics with a range of biotypes and strains which may be differentiated. This corresponds best with the natural state of the organism, it is nearest to the natural evolutionary classification of microorganisms, and may well therefore serve as the basis for making a contemporary classification.

The third system, that of Prévot (1948) is based on the ideas of the creators of the first system, with adoption and special stressing of some of its negative characteristics. The criteria for separation of the several categories are fixed upon a still lower level, there is no justification for the separation on the basis of such trivial characters. Moreover, the nomenclature is even more complex and unjustified than in the system of the Bergey's Manual. It is not surprising, therefore, that one finds a family named Innominaceae with a genus Innominatus.

OUR SYSTEM

As a result, we have suggested (Tešić, 1956) a new and simpler classification of bacteria based in essentials upon the system of Krassilnikov with certain changes made primarily for didactic reasons. We accept fully the principles upon which this system is based by the Russian bacteriologist. We have attempted to apply it more literally in some places. We have endeavored to simplify and make more uniform the nomenclature, this for the didactic requirements in the teaching of general, agricultural and technical microbiology.

BACTERIOLOGICAL NOMENCLATURE
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Class SCHIZOMYCETES Nägeli, 1857--BACTERIA

Order I. EUBACTERIALES Buchanan, 1917--TRUE BACTERIA

Family I. COCCACEAE Zopf, 1889--SPHERICAL BACTERIA

- Genus I. Micrococcus Migula, 1900. Single, non-motile spherical bacteria
- Genus II. Planococcus Migula, 1900. Single, motile, spherical bacteria
- Genus III. Nitrosococcus Winogradsky, 1892. Spherical bacteria of nitrification
- Genus IV. Streptococcus Billroth, 1874. Spherical bacteria in chains
- Genus V. Sarcina Goodsir, 1842. Spherical, non-motile bacteria in packets
- Genus VI. Planosarcina Migula, 1900. Spherical, motile bacteria in packets

Family II. MYCOBACTERIACEAE Chester, 1901--ROD-SHAPED, NON-MOTILE BACTERIA

- Genus I. Mycobacterium Lehmann et Neumann, 1896. Acid-fast bacteria
- Genus II. Corynebacterium Lehmann et Neumann, 1896. Gram positive bacteria
- Genus III. Aplanobacterium¹ Smith, 1905. Gram negative bacteria
- Genus IV. Propionibacterium Orla-Jensen, 1909. Propionic bacteria
- Genus V. Lactobacterium Beijerinck, 1900. Lactic bacteria

Family III. PSEUDOMONADACEAE Winslow et al., 1917--ROD-SHAPED, MOTILE (POLAR FLAGELLA) BACTERIA

- Genus I. Pseudomonas Migula, 1900. Nonpigmented and fluorescent bacteria
- Genus II. Chromopseudomonas Tešić, 1956. Pigmented, polar-flagellated bacteria
- Genus III. Rhodopseudomonas Kluyver et van Niel, 1937. Purple polar-flagellated bacteria

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¹Editorial Note. The generic name proposed by Smith was Aplanobacter, not Aplanobacterium. The latter is a nomen novum.

- Genus IV. Rhizomonas Orla-Jensen, 1909. Root nodule bacteria
- Genus V. Nitrosomonas Winogradsky, 1892. Polar-flagellated bacteria producing nitrate
- Genus VI. Acetomonas Orla-Jensen, 1909. Vinegar-producing bacteria
- Family IV. BACTERIACEAE Cohn, 1872--ROD-SHAPED, MOTILE (PERITRICHOUS) BACTERIA
- Genus I. Bacterium¹ Ehrenberg, 1828. Colorless, rod-shaped, peritrichous bacteria
- Genus II. Chromobacterium Bergonzini, 1881. Pigmented, rod-shaped, peritrichous bacteria
- Genus III. Chlorobacterium Lauterborn, 1913. Green bacteria
- Genus IV. Photobacterium Beijerinck, 1889. Luminous bacteria
- Genus V. Azotobacterium² Beijerinck, 1901. Asymbiotic nitrogen-fixing bacteria
- Genus VI. Thiobacterium Lehmann et Neumann, 1927. Sulfur-oxidizing bacteria
- Genus VII. Nitrobacterium³ Winogradsky, 1892. Nitrite-oxidizing bacteria
- Family V. SPIRILLACEAE Migula, 1894--SPIRAL-SHAPED BACTERIA
- Genus I. Vibrio Müller, 1773. Rods, curved, bacteria
- Genus II. Cellvibrio Winogradsky, 1927. Rods, curved, cellulolytic bacteria
- Genus III. Spirillum Ehrenberg, 1830. Spiral, colorless bacteria
- Genus IV. Rhodospirillum Molisch, 1907. Spiral purple bacteria

¹Editorial Note. The generic name Bacterium was made a nomen rejiciendum by action of the Rome Microbiological Congress (1953).

²Editorial Note. The generic name proposed by Beijerinck was Azotobacter and not Azotobacterium. The latter is a nomen novum.

³Editorial Note. The generic name proposed by Winogradsky was Nitrobacter, not Nitrobacterium. The latter is a nomen novum.

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Family VI. BACILLACEAE Fischer, 1895--ROD-SHAPED
SPOROGENIC BACTERIA

- Genus I. Bacillus Cohn, 1872. Spores central and cells cylindrical
- Genus II. Clostridium Prazmowski, 1880. Spores central and cells swollen
- Genus III. Plectridium Fischer, 1895. Spores terminal and cells cylindrical

Order II. ACTINOMYCETALES Buchanan, 1917--ACTINOMYCETES

Family I. ACTINOMYCETACEAE Buchanan, 1918--ACTINOMYCETES WITH CHAINS OF CONIDIA

- Genus I. Actinomyces Harz, 1877. Typical or true actinomycetes
- Genus II. Proactinomyces Jensen, 1934. Primitive actinomycetes

Family II. MICROMONOSPORACEAE Krassilnikov, 1941--
ACTINOMYCETES WITH SINGLE CONIDIA

- Genus I. Micromonospora Oerskov, 1923. Actinomycetes with single conidia

Order III. MYXOBACTERIALES Jahn, 1911--SLIME BACTERIA

Family I. PROMYXOBACTERIACEAE Imshenetzki, 1945--
PRIMITIVE SLIME BACTERIA

- Genus I. Promyxobacterium Imshenetzki, 1945. Slime bacteria with rounded ends
- Genus II. Cytophaga Winogradsky, 1929. Slime bacteria with pointed ends
- Genus III. Sporocytophaga Stanier, 1940. Sporogenic slime bacteria with pointed ends

Family II. MYXOBACTERIACEAE Thaxter, 1892--ROD-SHAPED
SLIME BACTERIA

- Genus I. Polyangium Link, 1809. Slime bacteria with many cysts
- Genus II. Sorangium Jahn, 1924. Slime bacteria with acervate cysts
- Genus III. Chondromyces Berkeley et Curtis, 1857. Slime bacteria with cystophores

Family III. MYXOCOCCACEAE Jahn, 1924--SPHERICAL SLIME BACTERIA

- Genus I. Angiococcus Jahn, 1924. Slime bacteria with spherical cysts
- Genus II. Myxococcus Thaxter, 1892. Slime bacteria with ovoid spores
- Genus III. Chondrococcus Jahn, 1924. Slime bacteria with slime spores

Order IV. FERRIBACTERIALES Krassilnikov, 1949--IRON BACTERIA

Family I. FERRIBACTERIACEAE Krassilnikov, 1949--TRUE IRON BACTERIA

- Genus I. Gallionella Ehrenberg, 1838. Kidney-shaped iron bacteria
- Genus II. Siderococcus Dorff, 1934. Spherical iron bacteria
- Genus III. Sideromonas Cholodny, 1922. Oviform iron bacteria
- Genus IV. Siderobacterium¹ Naumann, 1921. Rod-shaped iron bacteria

Family II. FERRITRICHACEAE Tešić, 1956--FILAMENTOUS IRON BACTERIA

- Genus I. Sphaerotilus Kützing, 1833. Heterotrophic iron bacteria
- Genus II. Leptothrix Kützing, 1833. Iron bacteria with motile gonidia
- Genus III. Crenothrix Cohn, 1870. Iron bacteria with non-motile gonidia

Order V. THIOBACTERIALES Buchanan, 1917--SULFUR BACTERIA

Family I. THIOBACTERIACEAE Buchanan, 1917--TRUE SULFUR BACTERIA

- Genus I. Achromatium Schewiakoff, 1893. Colorless sulfur bacteria
- Genus II. Chromatium Perty, 1852. Colored sulfur bacteria

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¹Editorial Note. The generic name proposed by Naumann was Siderobacter, not Siderobacterium. The latter is a nomen novum.

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Genus III. Rhabdomonas Cohn, 1875. Purple sulfur
bacteria

Genus IV. Thiospirillum Winogradsky, 1888. Spiral
sulfur bacteria

Family II. THIOTRICHACEAE Pringsheim, 1949--FILAMENTOUS
SULFUR BACTERIA

Genus I. Beggiatoa Trevisan, 1842. Filaments not in
bundles

Genus II. Thioploca Lauterborn, 1907. Filaments in
bundles

Genus III. Thiothrix Winogradsky, 1888. Filaments
attached

Order VI. SPIROCHAETALES Buchanan, 1918--SPIROCHETES

Family I. SPIROCHAETACEAE Swellengrebel, 1907--
SPIROCHETES

Genus I. Spirochaeta Ehrenberg, 1838. Saprophytic
spirochetes

DISCUSSION

The first differences between the classification of Krassilnikov and that of ours lies in the fact that we regard the bacteria as constituting a class, in conformity with the ideas of the majority of microbiologists in the world. The Soviet author has introduced higher categories of taxa. We have omitted his special classes of these microorganisms, retaining the orders, families and genera. Further we have disagreed with the Soviet author who places all non-motile bacteria in the class of Actinomycetes, and have retained them in the order of the true bacteria, as have many other microbiologists. Further, we have omitted some of the members of the sulfur bacteria as of minor significance, but here also we have proposed a new system of classification, even though it is recognized as being of an "artificial" character. Finally, with the names of certain genera within a family, we have endeavored to get them nearer to the name of the type genus, hence we have chosen to use the names of genera

already known, recognizing that these are usually the genera based upon "physiological" characters. We justify this on the basis of didactic utility.

In certain families we have made some important changes. We have restored the genus Corynebacterium to the family Mycobacteriaceae in contrast to Krassilnikov. In place of his name Pseudobacterium we have restored the older well known name Aplanobacterium. In the family Pseudomonadaceae we introduced the new name Chromopseudomonas for a genus to include all pigmented bacteria with polar flagella, in order to do away with a multiplicity of names (such as Xanthomonas etc.). We have also recognized the name Rhizomonas even though it is a homonym of a genus of Flagellata, for this there is other precedent in contemporary microbiology. On account of the didactic reasons already mentioned we have transmuted certain generic names in order to facilitate grammatical usage (e.g. Azotobacter--Azotobacterium; Aplanobacter--Aplanobacterium; Nitrobacter--Nitrobacterium; Lactobacter--Lactobacterium; Siderobacter--Siderobacterium). In the family of Bacillaceae we have again introduced the genus Plectridium, which was discarded by Krassilnikov. In the iron bacteria we have proposed a new name of the family Ferritrichaceae.

Finally, the author is aware that in this system of the classification of bacteria, he has also included several names for genera and families, which are not fully consistent with the rules of the Code of International Bacteriological Nomenclature. Thus he has retained the family Bacteriaceae and the genus Bacterium, in spite of the decision of the Congress at Rome that these names become nomina rejicienda, because, like so many other microbiologists in Europe and Russia, he holds a divergent opinion. In order to avoid misunderstanding about the grammatical gender, with the names of genera ending in -bacter, the author has used everywhere the names of genera ending in -bacterium, which is much simpler and more definite. The new name of genus Chromopseudomonas is given after the pattern of the name Chromobacterium Bergonzini, 1881, but in the sense of Topley and Wilson, 1936, so that bacteria of all shades of pigments could be included. The new name of the family Ferritrichaceae also does not have its corresponding genus, but this is not the only exception of this kind in modern classification of bacteria (e.g. Bergey's

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Manual, 1957). And again, with the trend of making the names uniform, according to the type genus in the family, some later synonyms have been taken, which would in any case, according to the above mentioned rules, be the "later illegitimate synonyms".

Hence, the author trusts that the suggested system of classification, together with the nomenclature used, should usefully serve in teaching general, agricultural and technological bacteriology.

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