In 1753, the Swedish naturalist Carl Linnaeus (1707–1778) published his major botanical work, *Species Plantarum*, which was the starting point for the modern nomenclature of living beings. This nomenclature uses Latin or Latinized words and is universal: scientists from all countries can recognize a given organism by its Latin name. This Latin name consists of two parts: a noun (substantive) in the nominative case, which corresponds to the ‘genus’, followed by an epithet (adjective) that indicates the ‘species’ in that genus. This binomial system is applied both to plants and animals. For example, the scientific name of the common cat is *Felis catus*, and that of the wild rose is *Rosa canina*. In his book *Linnaeus only named plants known in his time.

In the 1670s, the Dutch draper Antonie van Leeuwenhoek (1632–1723) was the first to see bacteria through a primitive microscope. One century later, the microbial world was still hardly known. In 1774, Linnaeus proposed the term *Chaos* as a generic name for the whole microscopic life. In 1786, the Danish naturalist Otto Friedrich Müller (1730–1784) described several species of bacteria and attempted the first bacterial classification.

**Prokaryotes: Bacteria and Archaea**

Prokaryotes are microorganisms whose cells lack a nucleus separated from the cytoplasm by a membrane. Prokaryotes were classified as bacteria until 1990, and currently prokaryotes are divided into two large groups: *Bacteria* and *Archaea*. The application of names to living beings is based on a type-specimen approach that relates the scientific name of every taxon to one particular specimen or group of specimens (taxon is any unit used in biological classification, which usually comprises other taxa of lower rank). Types are usually physical specimens kept in museums or special collections. In special cases, when it is not possible to have a physical specimen, an image can be designated as a type. In the case of prokaryotes, the type should be a culture maintained in one or several microbiology laboratories that act as repositories. Many prokaryotic species cannot be cultured and there are species that have not even been visualized but are known because genetic sequences of their genomes have been identified.

**Nomenclature of bacteria**

*Bacteria* and *Archaea* species have been traditionally named according to the rules and recommendations of the International Code of Botanical Nomenclature, because originally they were considered to be plants. *Archaea* as a taxonomical category was established by Carl Woese in 1990 before which all prokaryotes were considered to be bacteria. In this chapter, we will use the term ‘bacteria’ comprising both *Bacteria* and *Archaea*, following common practices.

Bacteriologists participating in the International Botanical Congress held in Ithaca, New York, in 1926 recommended that any bacterial name that had been published since 1753 (the year of publication of Linnaeus’ *Species Plantarum*) and was still recognizable should be accepted. Under the Botanical Code, living cultures were not allowed as type material. With bacteria, however, there was a conflict because living cultures were of utmost importance for bacterial taxonomy. A compromise was reached at the First International Congress of Microbiology, held in Paris in 1930, where it was decided that an international committee would be set up to handle all aspects of bacterial nomenclature and to prepare an independent code. The *Bacteriological Code* was finally approved in 1947, at the Fourth International Congress for Microbiology, held in Copenhagen.

Nevertheless, it was not until the 1980s that taxonomists working on bacteria established rules specific to these organisms and decided that the only names with standing nomenclature would be those included in the *Approved List of Bacterial Names* and in validation lists that would be published in the *International Journal of Systematic Bacteriology*, now the *International Journal of Systematic and Evolutionary Microbiology* (IJSEM).

The new starting date for bacterial names was set as January 1980, and the Approved List comprised all the scientific bacterial names that had retained their nomenclatural validity from the past. Of the around 40,000 names that were found in the scientific literature published over the last hundred years, only around 2000 names were included in the 1980 Approved List. According to the Bacteriological Code, the main purpose of giving a name to a taxon is ‘to supply a means of referring to it.’ Note that the rules of the Bacteriological Code do not cover taxonomic categories above the rank of Class.

Currently, official lists of names can be consulted at several websites, including the List of Prokaryotic names with Standing in Nomenclature (LPSN), by J.P. Euzéby (www.bacterio.cict.fr); the Taxonomic Outline of Bacteria and Archaea (TOBA), by G.M. Garrity (www.taxonomicoutline.org/index.php/toba) and the Bacterial Nomenclature Up-to-Date database, compiled...
2.3: Bacteriological nomenclature

Consists of a set of rules that are designed to be used to name microorganisms. These rules are based on several criteria that have been adopted in recent years, including genotypic, and sequence-based phylogenetic data, as well as on several other criteria that have been adopted in recent years. The major criteria used to distinguish bacterial species, such as the family and the genus, are the nucleotide sequences of 16S rRNA. 16S rRNA is used as a molecular constant because it occurs in all organisms, and its structure is conserved and variable regions (the former differing by less than 20% and the latter by 100%) of the 15S rRNA. Its base sequence also provides significant evolutionary information. In its 2007 version, the TOBA included the corresponding identifiers of the Ribosomal Database Project (RDP) and GenBank, as well as the name of the species, genus, family, and order. The class of the species is a Latinized binomen consisting of the name of the genus to which the species belongs in the singular form, with a capital letter. The names of higher categories are Roman numerals. The name of the species is a singular word without a plural ending or a word 'serotype' or its abbreviation 'ser.' Example: Staphylococcus aureus. The names of the higher categories are Latinized nouns in the plural form, written in capital letters. Example: Pseudomonadae (a family).

A species may be divided into two or more subspecies. The name of a subspecies is the name of the species followed by the abbreviation 'subsp.' – in roman type – and a specific epithet, which is an adjective. For the subspecies that includes the type strain of the species, the specific epithet is the same as the specific epithet. Example: Staphylococcus aureus subsp. aureus. The other subspecies have individual type strains.

There are still other ranks below subspecies such as biotype, serovar, phagovar, and pathovar. The suffix 'var' comes from the Latin word 'variant,' and it replaced the former types of taxonomic ranks, such as type, biotype, serotype, etc. They are used to gather strains that can be distinguished by some special characteristics including biochemical properties, antigenic makeup, reactions to bacteriophages, and pathogenicity. They do not have official standing in nomenclature, but they can be very practical.

In the case of Salmonella, a genus of pathogenic bacteria, the species is divided into two subspecies: S. enterica, the type species, and S. bongori, formerly subspecies V. A third species, S. subterranea was described in 2004. Salmonella enterica consists of six subspecies, which are referred to by a roman numeral and a name. Example: S. enterica subsp. indica (VI). As for serotypes, in the case of S. enterica subsp. enterica (I), they are referred to by a name which is not italicized and has the first letter capitalized, to make it clear that it is not a species. The first time such serotypes appear in a text, the word 'serotype' or its abbreviation 'ser.' should be included between the genus name and the word that indicates the serotype. Example: Salmonella serovar Typhimurium or Salmonella enteritidis.

Nomenclature of cyano bacteria presents another problem due to the fact that they were considered to be unicellular algae (cyanophyta or 'blue-green algae'). Thus, their nomenclature was governed by the International Code of Botanical Nomenclature, and the species name was followed by the epithet – in italic – genus abbreviated (I), they are written in full the first time it appears in a publication, and after that, it can be abbreviated for the other species. If there are several generic names used for the same cyano bacterial species, then it can be abbreviated without the indication of cyano bacteria. Example: staphylococcus/staphylococci in English, and estafilococo in Spanish; salmonella/salmonellae in English, and salmonel/salmonelles in Catalan. Strains in culture collections usually have a number preceded by an abbreviation of the name of the culture collection. Type strains are indicated by a superscript capital T. Example: NCT 1185T is the type strain for Arcobacter cryaerophilus in the National Collection of Type Cultures in London.

A new prokaryotic category, Candidatus, was discussed at the 1994 meeting of the International Committee of Systematics and Classification (ICST). In 1997, the ICST added Candidatus as a new prokaryotic category. Candidatus would be a useful category to name uncultured prokaryotes whose relatedness with other prokaryotes has been determined and its authenticity has been verified. Example: Candidatus Magnetoglobus multicellularis (note that the whole name is written within single quotation marks).

Citation practice

Latin bacterial names are printed in italics to distinguish them from the rest of the text. The name of a genus should be written in full the first time it appears in a publication, after which it can be abbreviated to the capital letter in the rest of the text. Recommended exceptions are: (a) when the generic name starts a sentence, (b) the first time it appears in a citation of a species name in a figure or a table, and (c) in the legend of a figure. In a list or series of species that belong to the same genus, the name of the genus is usually spelled out first for the species and listed and abbreviated for the other names. If there are several genera that belong to the same initial letter, the names should be used in each type they appear in the text. If a publication deals with species of different genera that have the same initial letter, using the one-letter abbreviation could lead to confusion, on the other hand, using unabbreviated generic names would increase the length of the article or chapter. In such a case, it is recommended to use three-letter abbreviations. If a name that is not valid is used, it should be cited with quotation marks. Example: Escherichia coli, which is a name formerly used for what are now several species. When current synonyms exist, some authors like to combine them using the alternative generic name within parentheses (e.g., Escherichia coli (Truper) Stackebrandt and Euzéby). Common (vernacular) bacterial names coined from the generic names are written in roman type without initial capital letter, the plural ending may be Latin or English (or capitol after the word in the text). Examples: staphylococcus/ staphylococci in English, and estafilococo in Spanish; salmonella/salmonellae in English, and salmonel/salmonelles in Catalan. Strains in culture collections usually have a number preceded by an abbreviation of the name of the culture collection. Type strains are indicated by a superscript capital T. Example: NCT 1185T is the type strain for Arcobacter cryaerophilus in the National Collection of Type Cultures in London.

The scientific Latin names assigned to a species should be pronounced according to Latin rules. Like Italian, Spanish, Portuguese, and German, Latin belongs to the Romance languages and to phonetics, and Latin words should be pronounced close to their spelling. Native speakers of languages pronounced differently from their spelling such as French and especially English, have developed their own rules of their own languages. They should try to pronounce at least the vowels as they are pronounced in Italian, Spanish, and Portuguese.6 For example, many English speaking microbiologists refer to Escherichia coli with the genus abbreviated (E. coli), uttering something like ‘ecoli’ (English pronunciation, [ɛkəlɪ] in phonetic spelling), which can be difficult to understand for non-native English speakers, at least for its non-native English speakers. This is exacerbated by the common practice of placing the emphasis on the first syllable which adds to the confusion.

Citing new bacterial names

If a new genus or species is described for the first time, the authors must propose a new name, and the title of the article in which it is described must indicate it. The name is validated if it is published in a book or a journal. New names are published in a book or a journal. The name will have a status of ‘effectively published’ but not validated. To have a status of ‘effectively published’ a name must have been submitted for validation to the IJSEM. It must be included on a Validation List in the IJSEM. Sending a name for inclusion in the Validation List is an author’s responsibility. Authors must also take into account that the Bacteriological Code now requires that new names be typified with living cultures maintained in two registered culture collections.6,13 Practical advice to form generic names and specific epithets can be found in Truper6 and Triper and Euzéby,13 as well as in the instructions to authors of the IJSEM (http://ijis.
Editors must be very careful with articles that deal with taxonomic issues, including descriptions of new species and proposals of new names. In such cases, it is strongly recommended that a systematist reviews the manuscript.

Acknowledgement

The authors recognize the equivalent chapter by Jan B. Ursing published in the first edition of the EASE Science Editors’ Handbook (June 1995, reissued June 2003). Prof. Ursing, who died in February 2000, was Associate Editor of the International Journal of Systematic Bacteriology (now the International Journal of Systematic and Evolutionary Microbiology).

References