NOTE

Misunderstanding the Bacteriological Code

B. J. Tindall

Tel: +49 531 2616 224. Fax: +49 531 2616 418.
e-mail: bti@dsmz.de

DSMZ–Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, Mascheroder Weg 1b, D-38124 Braunschweig, Germany

The Bacteriological Code contains Principles and Rules governing the naming of prokaryotic taxa. However, interpretation of the Code is not always easy, nor is the dynamic link between the names of taxa and a particular taxonomic opinion always fully appreciated.

Keywords: Bacteriological Code, taxonomy, nomenclature

During the course of reviewing taxonomic work for various journals and reading published work on the taxonomy of prokaryotes it is clear that a number of simple mistakes arise when interpreting the Bacteriological Code (Lapage *et al.*, 1992). The first surprise to many scientists not familiar with taxonomy is that the Bacteriological Code does not attempt to regulate either which methods are to be used, or which taxonomic interpretation of a given problem is correct (i.e. there is no regulated 'official' taxonomy). The Bacteriological Code deals solely with the way in which names are assigned to organisms, and which of these are to be used. Simple though this may appear, the Bacteriological Code is often misunderstood. It is because the Bacteriological Code is not correctly understood that names are used wrongly, or mistakes appear in the literature which can be misleading.

One of the most interesting aspects of the Bacteriological Code is the fact that, as laid down in Principle 8 of the Bacteriological Code, 'each order or taxon of a lower rank with a given circumscription, position, and rank can bear only one correct name'. This often appears to be interpreted as meaning that a particular nomenclatural type can only be assigned one name, and the name to be used is that which has most recently be validly published. Such a system would, in fact mean that an 'official' taxonomy has been introduced, since only the most recent taxonomic treatment in which names are published in the *International Journal of Systematic Bacteriology* (IJSB) are to be used. This is not the intention of Principle 8 (in combination with General Consideration 4), which is probably more subtle, but indirectly supports the freedom of taxonomic thought and action; c.f. the Botanical Code (Greuter *et al.*, 1994) and the draft BioCode (Greuter *et al.*, 1996). The situation is best illustrated by examples Let us take the hypothetical organism {*Cowanella skermanii*} for which the designated type strain is HCC (Hypothetical Culture Collection) 70000. For the sake of the present example, the organism was included on the Approved Lists of Bacterial Names. During the course of later work the organism was shown to be similar to members of the genus *Pseudomonas* RNA group II. It was therefore proposed that this organism be transferred to {*Pseudomonas skermanii*} in 1985 (i.e. the organism falls within the circumscription of the genus *Pseudomonas*). During the course of work on members of this group it was shown that there was sufficient similarity between this strain HCC 70000 and all other members of *Pseudomonas* RNA group II for this organism to be included in the genus *Burkholderia* Yabuuchi *et al.*, 1993^{VP} (Yabuuchi *et al.*, 1993) as {*Burkholderia skermanii*} (the organism falls within the circumscription of the genus *Burkholderia*). During the course of the rearrangement of the genus *Burholderia* this organism was then shown to not fall within the circumscription of the genera *Burholderia* (Yabuuchi *et al.* 1993^{VP}) emend. Yabuuchi *et al.* 1996^{VP} (Yabuuchi *et al.*, 1996) or *Ralstonia* and must be placed in another genus, for which case the genus {*Cowanella*} has priority, i.e. organism must be named {*Cowanella skermanii*}. Should this interpretation of the scientific facts prove to be disputable one may find that one group of taxonomists holds that this group of organisms (*Pseudomonas* RNA group II) should be divided into three genera, *Burkholderia*, *Ralstonia* and {*Cowanella*}, then HCC 70000 must bear the name {*Cowanella skermanii*} should it be placed in a separate genus (rank), whereas another group of scientists consider that all three genera should be unified in the genus *Burkholderia*, in which case HCC 70000 must bear the name {*Burkholderia skermanii*} if it is considered to fall within the circumscription of the genus *Burkholderia*.

In order to avoid confusion, hypothetical taxonomic names have been created and are designated {.....}. These names (e.g. {*Cowanella skermanii*}, {*Pseudomonas skermanii*}, {*Burkholderia skermanii*}, {*Skermanella cowanii*}, etc.) are not to be considered to have been effectively or validly published in the sense of the Bacteriological Code.

It is possible for two correct names to remain in use along side one another, since the Bacteriological Code only determines the correctness of a name, not whether the taxonomic interpretation is correct. It is at the discretion of the authors (or other scientists) to decide which correct name they choose to use, provided it is consistent with the circumscription they are using. Thus, if HCC 70000 is considered by a scientist to fall within the circumscription of the genus *Burkholderia*, then an author should not use the names {*Cowanella skermanii*} or {*Pseudomonas skermanii*}, and {*Burkholderia skermanii*} is the only correct name. Despite the fact that the casual reader may gain the impression that there is no regulation of which names are to be used, the most important aspect of all the combinations listed above is that the taxonomist must make a choice not between the various combinations, but must choose between the circumscriptions of the different genera in which the species has been placed. In fact, rather than simply selecting the last combination published, the taxonomist is confronted with scientifically evaluating the characterization and classification of the organism in question, an aspect far more important than the name of the organism alone.

A second problem relating to the use of correct names is the misunderstanding that all names published in the IJSB are correct. This is an over-interpretation of the use of the IJSB as a central vehicle for communicating to the scientific community which names are candidates for being correct names. The mechanism for determining which name is correct is based on legitimacy, valid publication and priority of publication (Principle 6). Priority of publication is determined by Section 5 of the Bacteriological Code and should not cause problems. In order to be legitimate a name must be in accordance with the Rules (Rule 23a). Only those names which have appeared on the Approved Lists of Bacterial Names, by original publication in the IJSB since 1 January 1980, or by notification in the Validation Lists, can be considered to be validly published. The general misunderstanding is that validation is equivalent to a name being correct, and this is not the case. This may also be illustrated by using the hypothetical strain HCC 70000 as an example. If two authors study HCC 70000 and independently publish a new species description in the IJSB in the year 2000, but one group calls the organism {*Cowanella skermanii*}, while the other calls the organism {*Skermanella cowanii*}, then only one of these names is correct, and that is the one which is published first. Both may be legitimate and validly published, but only one can have priority by definition. However, there are cases where the name which appears first in the IJSB may not have priority, nor is it the correct name. If one of the authors publishes the name {*Cowanella skermanii*} based on a study of HCC 70000, HCC 70001 and HCC 70002, but fails to designate a type strain or give a formal description of the species, then this is not in accordance with the rules and is illegitimate (Rule 23a). The subsequent formal proposal that HCC 70000 be the type strain of {*Skermanella cowanii*} in a later issue of the IJSB is, therefore, the correct name of the organism, because it is both legitimate and validly published. The Bacteriological Code also states under Rule 23b that only legitimate names and epithets are taken into consideration for the purposes of priority. Thus it is possible that names are validly published in the IJSB, are none-the-less not correct (may be illegitimate or do not have priority) and should, therefore not be used. This problem does not occur very often, but there are a number of instances where validly published proposals appearing in the IJSB are certainly not correct names.

The third problem relates to the simple fact that names, once validly published remain validly published. There are a number of articles where authors have expressed the opinion that once an organism is transferred to a another taxon the other name becomes 'invalid', should be removed from the lists, or that a species name which was validly published, but subsequently transferred to another genus should appear as 'nom.rev.' because it has been transferred back to the original genus. In fact this has interesting consequences because the Bacteriological Code only governs the valid publication of a new name or a new combination, it does not cater for the notification of an organism being transferred between validly published species names. Using the first example of {*Cowanella skermanii*}, {*Pseudomonas skermanii*} and {*Burkholderia skermanii*} the problem may be quite easily illustrated. If one assumes that the original description of {*Cowanella skermanii*} provided a good circumscription of the genus {*Cowanella*}, but only subsequent DNA–RNA hybridization indicated its transfer to the genus *Pseudomonas*, and that the subsequent transfer to the genus *Burkholderia* was suggested by additional 16S rDNA sequence work, all such new combinations must be validly published. However, as long as a name is correct (i.e. validly published, legitimate, and has priority within the rank in which it was published) the name may be reused without notification in the IJSB. Thus, it would be possible for an author to submit an article to any journal other than the IJSB simply stating that 'based on previously published data the organism currently placed in the genus *Burkholderia* as {*Burkholderia skermanii*} clearly represents a distinct genus for which it is proposed that the previously validly published name {*Cowanella skermanii*} is appropriate. A description of the genus and species has been given previously and serves to distinguish this organism from the genus *Burkholderia* Yabuuchi *et al.* 1993^{VP} (emend.Yabuuchi *et al.*, 1996^{VP}).' There is no need to either revive the name (it was validly published), nor is there any need to makes changes in the designation of type species, type strain or the circumscription of the genus, since this was done in the original publication of the species {*Cowanella skermanii*}. Such a return to a previous nomenclature may go unnoticed since no notification was made in

the IJSB (although this is not required by the Bacteriological Code), and the most recent taxonomic opinion not taken up because this change to the previous combination was not published in the IJSB. An appropriate solution to making the scientific community aware of changes in taxonomic opinion (i.e. taxonomic re-evaluation of taxa previously validly published names or emended descriptions of taxa which have been published outside the IJSB) which would not normally appear in the 'Validation List' would be to create a 'List notifying changes in taxonomic opinion'.

In order to properly represent such difficulties in official lists one should avoid implying which taxonomic treatment is suitable, unless one is clearly expressing a taxonomic opinion. Thus, it is common practice to write {*Cowanella skermanii*} → {*Pseudomonas skermanii*} → {*Burkholderia skermanii*}, whereas objective synonyms may be more appropriately represented by {*Cowanella skermanii*} ≡ {*Pseudomonas skermanii*} ≡ {*Burkholderia skermanii*}, and subjective synonyms by {*Cowanella skermanii*} = {*Pseudomonas skermanii*}. The terms objective and subjective synonyms are used in the sense used in the Bacteriological Code. Subjective synonyms refer to a type with which more than one name is associated. Objective synonyms refer to different types with which different names are associated, but which the scientist concerned considers to be the same taxon. It would be suitable to make the following entries in -a database:

1) In the case of the objective synonyms {*Cowanella skermanii*} ≡ {*Pseudomonas skermanii*} ≡ {*Burkholderia skermanii*}

Taxonomic name:	{*Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Described as being an objective synonym of {*Pseudomonas skermanii*} ≡ {*Burkholderia skermanii*}
Taxonomic name:	{*Pseudomonas skermanii*} {Basonym: *Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Described as being an objective synonym of {*Cowanella skermanii*} ≡ {*Burkholderia skermanii*}
Taxonomic name:	{*Burkholderia skermanii*} {Basonym: *Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Described as being an objective synonym of {*Cowanella skermanii*} ≡ {*Pseudomonas skermanii*}

2) In the case of the subjective synonyms {*Cowanella skermanii*} = {*Skermanella cowanii*}

Taxonomic name:	{*Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Described as being a subjective synonym of {*Skermanella cowanii*}
Taxonomic name:	{*Skermanella cowanii*}
Status:	Validly published, legitimate, priority = correct
Comments	{*Cowanella skermanii*} has been described as being a subjective synonym

3) In the case of two validly published, legitimate names, one (the first named) of which has priority over the other: {*Cowanella skermanii*} – {*Skermanella cowanii*}

Taxonomic name:	{*Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Has priority over the name {*Skermanella cowanii*}
Taxonomic name:	{*Skermanella cowanii*}
Status:	Validly published, legitimate, does not have priority = not correct
Comments	{*Cowanella skermanii*} has priority over this name

4) In the case of two validly published names, one (the first named) of which is illegitimate: {*Cowanella skermanii*} – {*Skermanella cowanii*}

Taxonomic name:	{*Cowanella skermanii*}
Status:	Validly published, legitimate, priority = correct
Comments	Has priority over the illegitimate name {*Skermanella cowanii*}
Taxonomic name:	{*Skermanella cowanii*}
Status:	Validly published, illegitimate, does not have priority = not correct
Comments	The correct name of the taxon is {*Cowanella skermanii*}

The Bacteriological Code operates on a number of simple principles. However, sometimes an inappropriate interpretation of the Principles and Rules causes confusion. In particular the principle of the 'freedom of taxonomic thought and action' is not fully appreciated and the scientist is required to make an evaluation of the data presented before making a taxonomic judgement, rather than just opening an appropriate reference book and slavishly following what has been published before.

Acknowledgements

I would like to thank Professor P. H. A. Sneath (University of Leicester, UK) for reading an initial draft, Professor E. Stackebrandt (DSMZ, Braunschweig, Germany) for constructive criticism, and Professor J. McNeill (Royal Ontario

Museum, Canada) for providing the incentive to write the present article.

References

Greuter, W., Barrie, F. R., Burdet, H. M., Chaloner, W. G., Demoulin, V., Hawksworth, D. L., Jørgensen, P. M., Nicolson, D. H., Silva, P. C., Trehane, P. & McNeill, J. (editors) (1994). *International Code of Botanical Nomenclature* (*Tokyo Code*) (*Regnum Vegetabile* series, volume 131). Königstein: Koeltz Scientific Books.

Greuter, W., Hawksworth, D. L., McNeill, J., Mayo, M. A., Minelli, A., Sneath, P. H. A., Tindall, B. J., Trehane, P. & Tubbs, P. (1996). Draft Biocode: the prospective international rules for the scientific names of organisms. *Taxon* **45**, 349–372.

Lapage, S. P., Sneath, P. H. A., Lessel, E. F., Skerman, V. B. D., Seeliger, H. P. R. & Clark, W. A. (editors) (1992). *International Code of Nomenclature of Bacteria* (*1990 Revision*). *Bacteriological Code*. Washington, DC: American Society for Microbiology.

Yabuuchi, E., Kosako, Y., Oyaizu, Y., Yano, I., Hotta, H., Hashimoto, Y., Ezaki, T. & Arakawa, M. (1993). Validation of the publication of new names and combinations previously effectively published outside the *IJSB*. List No. 45. *Int J Syst Bacteriol* **43**, 398–399.

Yabuuchi, E., Kosako, Y., Yano, I., Hotta, H. & Nishiuchi, Y. (1996). Validation of the publication of new names and combinations previously effectively published outside the *IJSB*. List No. 57. *Int J Syst Bacteriol* **46**, 625–626.