UDC Biology revision project: reports on stages 3-6

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Abstract: This report is an update on the progress of the revision of biological systematics in UDC. The first stage of the project, carried out in 2010, included the taxonomy of vertebrates, which was published in E&C 32 (2010). The second stage, finished in 2011, affected most of class 582 - Botany, and the results were published as a revised table in E&C 33 (2011). The third, fourth, fifth and sixth stages have been completed and appear in *Extensions and Corrections to the UDC* 36-27 (2014-2015) either as proposals or revised schedules. The revised schedules include 582.28 Fungi, 582.3 Red and green algae, Bryophyta, Pteridophyta and 592/595 Invertebrates. Proposals are presented for 578.8 Viruses, 579.8 Bacteria, 582.24 Protista and 582.25 Chromista, with further input and consideration being invited for these schedules. The report provides a general overview of the content organization and presentation in the new schedules as well as specific information on the revision process where these may be considered relevant.

1. Introduction

The UDC Biology Revision Project started in 2010. Its first stage included changes in classes 597/599 Vertebrata, and related subdivisions in class 56 Palaeontology. The revised tables were published in *Extensions and Corrections to the UDC* 32 (2010) together with a detailed introduction to the revision rationale and procedure (Civallero, 2010). These changes were included in the MRF 10 release.

Following the same procedure, the second stage of the project included the revision of class 582 Botany (specifically 582.4/.9, Monocotyledons and Dicotyledons) alongside the cancellation and redirection of parallel entries in class 56 Palaeontology. The tables were published in *Extensions and Corrections to the UDC* 33 (2011), with an article summarizing the details of the process (Civallero, 2011). These changes were included and distributed with the UDC MRF 11.

The third stage concerns classes 595/595 Invertebrates, 596.2 Urochordata, 596.4 Cephalochordata and 596.6 Mixini. The fourth stage contains revision of classes 582.26/.27 Algae, 582.28 Fungi and 582.3 Red and green algae, Bryophyta, Pteridophyta. These two stages are published as revised schedules in this double issue of the E&C, 36-37 (2014-2015) and are included in the UDC MRF 12. The fifth stage covers most microorganisms (Bacteria and Protista groups, classes 579.8, 579.9, 582.23, 582.24 and 593.1) and Chromista group (class 582.25). Finally, the sixth part concerns classification and systematics of viruses (classes 578.8 and 578.9). These two last stages are presented in this issue of the E&C as proposals. Proposals concern the areas where scientific findings are still being disputed or are further apart from the traditional and common knowledge supported by the literary warrant an require more effort to be correctly presented in the schedules. In addition, some areas such as systematics of viruses and bacteria that are more associated with other UDC classes may benefit from further checks and input from the UDC users.

As explained in the previous updates of the biology revision project (Civallero, 2010, 2011), both living and extinct organisms are now presented in a single sequence in classes 58 Botany and 59 Zoology. Previous parallel entries for fossil organisms have been removed from class 56 Palaeontology, and are now presented by colon combination, e.g. 56:593.4 Fossil sponges. As mentioned in earlier reports and is equally relevant for these stages of the revision - the UDC schedules have to provide solutions for both popular and scientific terminology. Thus, some outdated and 'folk' taxons have to be preserved in the schedules and described in a way that makes their scientific status evident.

In this report, a general overview of the content organization and presentation of the new schedules is provided, as well as specific information on the revision process. The work on revised classes is described in more detail and proposals are presented only with a basic summary information. Revised schedules referred to in this paper are available in their correct sequence in the section Revised UDC Tables and proposed schedules in the section Proposals of this issue of the *Extensions and Corrections* (36-37).

2. General structure and presentation style of the revised schedules

Regarding the textual presentation and naming style, Latin scientific names are preferred for all taxa, while common names, when existent, are indicated in parentheses. Whenever relevant, explanations in the form of qualifiers are also added, e.g.:

593.632	Tabulata (extinct)
593.633	Actiniaria (sea anemones)
593.634	Scleractinia (stony corals)
593.635	Antipatharia (black corals)

In class captions, formal Latin names may be followed by one of the three 'qualifiers': '(extinct)', '(scientifically outdated)' and '(genus)'. Taxa belonging to fossils and extinct entities are marked as such and taxa that are no longer scientifically acceptable, but need to be preserved because of the strong literary warrant are followed by a note '(scientifically outdated)'. Tables are composed in such a way that although based on modern taxonomy (referred to shortly as Linnaean taxonomy), they also include some groups from phylogenetic systematics or cladistics (Civallero, 2010: 10). Thus, Latin names appearing in captions may represent taxonomic levels (kingdom, phyla, class, order etc.) and/or clades. Since some Latin names work for both, the use of qualifiers to denote the precise taxonomic level is not considered practical. On a more specific level of the hierarchy, tables list well known genera and species that are required in other areas of the UDC tables (e.g. agriculture, medicine and industries). In such cases, formal Latin names are provided for the genera followed by a qualifier '(genus)', and vernacular names in English are added in parentheses.

Including notes have a very important role in the revised schedules in this area. They are used as a way of expanding the list of entities that may be too specific to form classes of their own. Including may contain: a) subfamilies whose names may be sought after but which do not appear in the subdivision; these are always presented with their Latin names and the English variants if these happen to exist; b) a selection of genera and species most representative or known to belong to the respective taxa, listed using their common English names. Following the release of the UDC MRF 11, it was drawn to our attention that the formal Latin binomial nomenclature would be very useful if added to all species, to help with the translation of the vernacular names or to be used on their own in translation when vernacular names do not exist. This approach is planned to be implemented throughout the revised schedules.

Scope notes are most often used to provide instruction about the new location of concepts that in the past used to be and are no longer classed in the respective class. Scope notes in biology are also used to fulfil another role. Because of the constraint of decimal notation there are numerous situations where shorter notations have to be left empty in order to obtain wider base when there are more than ten coordinated classes. Given that UDC is often used in the form of abridged schedules for smaller collections or in situations where there is no need for greater specificity, the availability of shorter notations is very important. For this reason it was decided to use empty shorter notations above, not to denote a class in its proper sense which would not be possible, but rather as a grouping mechanism for coordinated classes that follow on the level below. Whenever this is the case, a scope note contains the following statement: "This class is provided for the convenience of grouping, when more specific classification is not required or is not possible".

Information notes are used very frequently in the revision of biology systematics in order to provide further clarifications. These notes usually contain additional information about naming or about ongoing disputes and ambiguities in relation to classification e.g.:

!	582.28	F**ungi** Including: True fungi (Eumycota / Eumycetes), moulds and yeasts **SN:** *Class here fungi in general. Class here mycology. Alternatively denote mycology as a branch of study by colon combination with 001* IN: *Fungi is a kingdom on its own, independent of kingdom Plantae, at least since 1969 (Whittaker). Previously it was included inside Plants and traditionally associated with Botany, an association that still prevails*

In addition to the notes published in *Extensions and Corrections*, the UDC MRF database contain fields for cancellation comments and revision comments as well as notation and concept history, where more information about changes are recorded. These will be eventually included in the UDC Online schedules for the convenience of UDC users. For instance:

+	582.25	Chromista IN: *Chromista were also known as Chromophyta, Chromobiota and Chromobionta* **Concept History:** Chromista were before at 582.24
+	582.255	Bacillariophyta (diatoms) **Concept History:** Diatoms were before at 582.261.1
!	592	Placozoa SN: *Class invertebrates at 592/595* **Revision comment:** The scope of this class is narrowed: the previous description was "Invertebrata"

3. Revised schedules: Invertebrates (revision stage 3)

3.1. General issues

Unlike some other classes of plants and animals that underwent revision between 1996-1999, the class of Invertebrates remained unchanged since the creation of the UDC MRF in 1991. This means that these schedules have not been revised since 1980s and possibly even earlier and therefore contained many inconsistencies, deprecated terminology, incorrect hierarchies and outdated relationships between concepts. The revision involved a complete reorganization of the hierarchy which resulted in many classes being cancelled and relocated, many new classes added and remaining classes having their scope narrowed or broadened, and captions and notes significantly changed. Information about change in scope, naming, meaning or ongoing scientific disputes were provided in notes throughout the schedules.

Care was taken to reduce the disturbances these changes might cause to users as much as possible. Consequently, a number of deprecated classes have been preserved alongside scientifically correct classification, and references to outdated terminology have been provided in notes for the convenience of indexing, e.g.:

+	593.5/.8	Radiata / Coelenterata IN: *Radiata and Coelenterata are outdated classes, preserved in UDC for the convenience of indexing*

An attempt was made to place all new classes to inavailable empty notations. In the process of corrections, sometimes it was necessary to change significantly the meaning behind an existing

notation. Whenever this was the case, the care was taken that this is always limited to the broadening or narrowing of the previous meaning. Any such change is indicated in the administrative notes stored in the UDC MRF database as explained above.

3.2. Notes on specific changes and issues

Invertebrates (previously class 592 and now 592/595) is a popular, common concept rather than a scientific taxon; this fact has been noted in the scope note as is the case with all such classes. Given that taxa placed between 593 and 595 are also invertebrates, a span class 592/595 had to be created to encompass all entities considered to be invertebrates. Notation 592 now represents a significantly narrower class i.e. a minor taxon, Placozoa; it was decided not to discard this notation which is a beginning of span class 592/599 Systematic Zoology and needs to remain valid UDC number.

Outdated taxon Coelenterata at 593.3 used to include Cnidaria and Ctenophora, which in UDC are listed between 593.5 and 593.8. Therefore, the notation 593.3 has been cancelled and a new span class 593.5/.8 has been created for Coelenterata in order accommodate the true scope of the class; the name has been kept, since it is still very popular and present in literature.

Taxon Porifera at 593.4 has been updated. Sponge systematics is currently an area of ongoing research and is expected to undergo further changes; therefore, care has been taken to record current information into UDC schedules accurately. Among the most important changes: Homoscleromorpha has become independent of Demospongiae. Several folk names (e.g. slime sponges) have been clarified, and the names of several classes, such as 593.45 and 593.46, have been corrected. References used in updating this area were Morrow & Cárdenas (2015) and Hooper & Van Soest (2002), while Van Soest et al. (2016) was used as a source for supplementary information.

Cnidaria at 593.5 underwent major changes. Since cnidarians are mostly presented between 593.6 and 593.7, a new span class 593.5/.7 has been created for them, and notation 593.5 now represents a narrower concept: Scyphozoa.

Among cnidarians, taxa Hydrozoa at 593.7 and Scyphoza at 593.73 are actually at the same level in the systematic hierarchy and UDC schedule misrepresented this fact by subsuming Schyphoza to Hydrozoa. Therefore, Scyphoza has been moved to a proper location in the scheme (notation 593.5, freed by moving Cnidaria to the span class). The same hierarchy problem existed with taxa Staurozoa and Cubozoa, previously listed inside Scyphozoa. They have been added to Cnidaria as independent classes, though in an Including note at the new span class for 593.5/.7. The hierarchy of taxa Actiniaria at 593.65 and Madreporaria at 593.66 was also incorrect: they actually belong under Hexacorallia at 593.63, thus they had to be cancelled and placed at their correct hierarchical position.

There were further changes within cnidarians. For instance, an important but currently missing taxon Ceriantharia was listed in the including note of Anthozoa. Worth mentioning is that Hydrozoa created a number of problems since there are, nowadays, several classifications proposed for this taxon. The solution consisted of selecting the basic subdivisions which were in common to the most important of the existing Hydrozoa classifications and noting alternative names where appropriate. The final result is a general organization of Hydrozoa in two broader classes, Leptolinae and Trachylinae. However even if these two classes were not taken into account, the further subdivision of hydrozoans remains correct. Schuhert (2016) has been taken as the main source in revising this section.

Echinodermata at 593.9 and Hemichordata at 593.99, the only deuterostomes inside invertebrates, have been moved from their original positions, since they do not have any direct relation with Porifera and Radiata; in fact, from an evolutionary point of view, they are at the opposite end of the range. Also, there was a hierarchy problem with Hemichordata previously wrongly placed within Echinodermata when these classes actually belong to the same level.

Mollusca at 594 is another of the classes that underwent a major revision. Deprecated Lamellibranchia at 594.1 has been changed to Bivalvia. The old subdivision seemed to be organized according to Thiele (1935), which introduced the term Anisomyaria (used at 594.11). A number of structural problems were identified, including a missing class 594.12, and the existence of span classes 594.14/.17 and 594.18/.19 when classes 594.14, 594.17, 594.18 and 594.19 were missing. Among other actions that were taken, Bivalvia has been reduced to a set of taxa that appears both in old and new classifications; all alternate names have been kept in notes. All of them have been organized within the higher category levels according to the most recent taxonomic proposals; these broader classes had to be represented with span notations. This approach ensures that if a change in the higher re-organization would need to be accommodated in the future, this would not affect the basic subdivisions.

The classification of Gastropoda at 594.3 also underwent significant changes in relation to the previous structure introduced half a century ago. For the organization of this subdivision, the Linnaean classical scheme and the traditional classification by Thiele were respected, while the updates were taken from Ponder & Lindberg (1997) and Bouchet et al. (2005). The work has been done following the procedure described for Bivalvia.

In Cephalopoda at 594.5, the old class Decapoda as it was defined under at 549.58 has long been deprecated. The term 'decapods' is nowadays used for a subgroup of Crustacea comprising crayfish, crabs, lobsters, prawns and shrimp. The former class is currently known as Decapodiformes (subdivision of Cephalopoda; cf. SIRIS, 2001), and since the taxon encompasses several UDC classes, it has been moved to a new span class 594.58/.59.

Finally, there was a problem with taxa Bryozoa at 594.7 and Brachiopoda at 594.8, which were wrongly included in Mollusca. Therefore, these classes were cancelled and concepts were moved to their correct hierarchical place inside class 595.

Class 595 Articulata presented a challenge. The Articulata hypothesis, which grouped Annelida and Arthropoda, has been proved wrong by modern DNA analysis and the concept 'articulata' can only be used to represent a small subset of its previous meaning. Therefore the caption of class 595 had to be changed to represent a group of unrelated taxa and Articulata has become a subclass of 595.8 Echinodermata (i.e. under Crinoidea). The same happened with new class 595.19, which needed to include most Lophotrochozoa (except Annelida, which were already placed at 595.14).

For Platyhelminthes at 595.12, an agreement between the old, deprecated (but still popular) classification and the new, phylogenetic one (based on Ehlers, 1985), has been implemented. The same happened with Annelida: the main traditional division has been preserved and thoroughly updated. Aschelminthes, although an outdated class, has been added to the schedule as a span class 595.15/.17 within which many small taxa have been accommodated.

Arthropoda, previously placed at 595.2, in reality encompasses all classes from 595.3 to 595.7. Therefore, a new span class 595.2/.7 has been created to represent this taxon correctly. Notation 595.2 was preserved but its scope was changed to represent a narrower class, the fossil Arthropoda. As it is the case with many other invertebrates, the classification of arthropods has been disputed, therefore, a compromise between traditional and modern positions had to be be implemented in the organization of the schedules.

When it comes to Crustacea, the problems found are very similar to those reported for other classes: many subdivisions included in this taxon did not actually belong to Crustacea, and others taxa needed a span class to describe correctly their contents (e.g. Malacostraca, previously at 595.36, that has been moved to new 595.36/.38). For the organization of Crustacea at 595.3, Martin & Davis (2011) has been used as the main source.

The revision of Decapoda, previously at 595.38, resulted in putting in place the correct structure of all Eumalacostraca under 595.38, with decapods being placed at 595.384. The old outdated taxon Macrura at 595.384.1 was removed. The main source for this part of the revision was De Grave et al. (2009).

Tracheata at 595.4/.7 contained incorrect hierarchy: Chelicerata (classes 595.4 and 595.5) did not belong to this division. Instead of moving Chelicerata outside 595.4/.7, the caption at 595.4/.7 has been updated to reflect the correct content of the subdivision: Chelicerata. Myriapoda. Hexapoda, and a new span class 595.6/.7 has been created for Tracheata.

Arachnida at 595.4, within Chelicerata, was restructured to include a number of new subclasses. The revision is based on Sharma et al. (2014). Old class 595.7 Insecta (Hexapoda) has been corrected, since Hexapoda and Insecta are no longer understood as synonyms: Hexapoda is currently considered to include Insecta and Entognatha. Insecta has been moved to a new span class 595.71/.79.

The caption of class 595.71 has been updated from Apterygogenea to Apterygota, and mistakes in hierarchy were corrected (e.g. Collembola is no longer considered part of Apterygota). Within Orthoptera at 595.72, a number of classes have been cancelled; most of them because of mistakes in hierarchical placement. These classes did not belong to Orthoptera, but were parallel taxa (e.g. Dermaptera or Mantoidea). Archiptera at 595.73 was outdated and, therefore, the notation was changed to represent a group of classes containing numerous taxa; that enabled a number of important species, from crickets to termites, to be placed in more correct positions.

Hemiptera at 595.75 has been corrected and updated according to Song et al. (2012). For the time being, Diptera at 595.77 kept its traditional subdivision into Nematocera and Brachycera. In the future a different organization, based on span classes, may be considered following further research. In Lepidoptera at 595.78, the artificial traditional grouping of moth families into Microlepidoptera / Macrolepidoptera at 595.782 has been removed and the class caption was replaced with a list of scientific taxa of moths: Tineoidea, Gracillarioidea, Gelechioidea. Yponomeutoidea.

Within Hymenoptera at 595.79, class Parasitica (parasitoidal wasps) is placed at 595.792; however, in the future, following further research, this subdivision may need to be enlarged and it may encompass 595.791 to 595.793. Aculeata presented a hierarchy problem and has been moved to a new span class 595.794/.799 in order to include all the taxa belonging to it

Due to the existing configuration of the schedules and in order to minimise changes, many groups that are phylogenetically related had to be placed in distant positions, e.g. Lepidoptera at 595.78 and Trichoptera at 595.748, or Diptera at 595.77 and Neuroptera at 595.741.

Finally, Echinodermata at 595.8 and Hemichordata at 595.9 were placed at the end of the schedule, in a more appropriate place regarding their phylogenetic relationships, and inside a newly created span class Deuterostomia at 595.8/599.

4. Revised schedules: Algae, Fungi, Bryophyta, Pteridophyta (revision stage 4)

4.1. General issues

The fourth stage of the biology revision deals with classes that, strictly speaking, do not belong and should not be subsumed to 58 Botany. The disciplinary or perspective organization of knowledge in UDC places phenomena under their field of study. Thus taxonomies of living organism and their respective kingdoms are placed within the following poorly defined subdisciplines: Virology, Microbiology, Botany and Zoology. This fact, coupled with the reality that existing classes occupy almost all available notational space, puts many constraints in re-organization of the living organisms

into groups that are more up to date with modern science. This is a particular problem when it comes to e.g. Fungi or Algae, which are subsumed to Botany although they belong to a different kingdom from Plantae. Other examples include, for instance, Protista (placed under Zoology) and some unicellular algae included in the kingdom Bacteria.

One should note that even if possible to implement, new updated classification of biological kingdoms may not be an approach UDC should pursue. The fact is that the scope of these kingdoms has varied greatly throughout the 20th century and these categories do not provide the stability necessary for library classifications. Not until a completely new systematization is achieved based on the genetic data, will it be possible to hope for a "definitive" systematics of living organisms. Therefore, there is no option but to work around the old traditional divisions adding necessary adjustments that would bring up to date the most outdated parts of the scheme and give provisions for the majority of important taxa.

The last, partial revision of the 582.2 subdivision took place in 1997 (published in the *Extensions and Corrections to UDC*, 19). Thus, the subdivision in question still exhibits inconsistencies, deprecated terminology, incorrect hierarchies and outdated relationships between concepts. Needless to say, revision of this part of the schedules resulted in many cancellations, relocations and many new classes being added.

4.2 Notes on specific changes and issues

Algae

A folk taxon at 582.261/.279, Algae have been moved to a new class at 582.27 to be used for general classification of Algae. However, all particular groups of algae have been placed in their respective kingdoms. Algae includes taxa belonging to at least two different kingdoms (Chromista and Plantae). These taxa have been removed from their old position and placed in a new, correct one: Chlorophyta (green algae), for example, has been moved to Plantae, while Phaeophyceae (brown algae) has been placed inside Chromista.

Chlorophyta at 582.303/.305 were organized according to Leliaert et al. (2012); Rhodophyta at 582.301, according to Lee (2008); Glaucophyta at 582.302 and Charophyta at 582.308, according to Maddison & Schulz (2007). All taxa were checked against Guiry & Guiry (2016). All these groups were moved to Plantae, but they were kept outside the newly created span class Embriophyta at 582.32/.9.3

Chrysophyceae at 582.261.2 and Dinoflagellata at 593.162 are awaiting the revision completion to be moved to Chromista (currently only a proposal). All of them are proposed to be organized according to Guiry & Guiry (2016); for Xanthophyceae, Adl et al. (2012) was used as an extra source of information, and for Dinoflagellates, Gómez (2012) was consulted.

Fungi

Although traditionally studied by Botany, Fungi are closest to kingdom Animalia and, therefore, to Zoology; as a matter of fact, both groups are modernly classed as 'opisthokonts'. At least since 1969, Fungi is considered to be a kingdom on its own. In UDC, in line with the prevailing traditional views, Fungi were placed in Botany at 582.28. Not having an option for the correct placement outside kingdoms of plants or animals, the class was revised and left in its existing place at 582.28. Fungi underwent substantial corrections and was extended with new subdivisions and species.

Fungi, as a taxon, does not have an accepted system for taxonomic classification; there are frequent name changes above the species level, and many species have several scientific names depending of the stage of its life cycle. In 2007, some agreement was reached through a collaborative effort; the

schemes derived from this agreement (McLaughlin & Spatafora, 2014; Esser, 2015; Silar, 2016) have been used here. ITIS (2016) was used as a supplementary source of information.

The basic, existing structure for Fungi in UDC has been respected, with the exception of a couple of classes (namely 582.282.11 and 582.282.31) which needed to be cancelled in order not to interfere with the general structure. Most classes were expanded, updated and enriched with more terminology. In cases were a main taxon has just one subdivision (e.g. class/order), they were included in the same caption in order to reduce the number of subdivisions in the scheme.

Special care was taken with fungi that are lichenized, i.e. that serve as the supportive structure for lichens. Whenever it was possible, these fungi were marked; this way, when classifying lichens at 582.29, the task of identifying the fungal partner would be easier.

Plantae

Plantae, previously at 582.32/.998 (and to 2009 at 582.3/.99) have been moved to a new span class 582.3/.9, which now includes green and red algae at 582.31, Bryophyta at 582.32, fossil Tracheophyta at 582.36 and Pteridophyta at 582.39. Both Bryophyta and Tracheophyta have been enlarged. The old spans 582.32/.998 and 582.361/.99 had a problem in notation, i.e. one of the notations forming the span class was not a valid UDC number.

The most important advantage of the change is that the new notation for Plantae's provided room for a correct placement of green and red algae. Also, Embriophyta at 582.32/.9 has been added. For the organization of Plantae, the scheme by Kenrick & Crane (1997) was followed.

Bryophyta

Bryophyta is nowadays considered a folk taxon, nevertheless it represents a convenient way of grouping non-vascular plants (mosses, hornworts and liverworts). Previous caption Bryophyta in general has been renamed Bryophyta in general at 582.32 to distinguish it from the Bryophyta in the strict sense at 582.323/.329, encompassing only the mosses.

Class Hepaticae (582.321) has been renamed Marchantiophyta. It has been classed according to Söderström [et al.] (2016), a work which takes advances from previous works and updates them. Hornworts (582.322) were also corrected and expanded.

Several classes within the subdivision of 582.323/.329 Bryophyta in the strict sense have been expanded (e.g. 582.323 and 582.324); old class Polytrichales at 582.325.1 has been redirected; class 582.325.3 Other bryophytes has been corrected; and subdivisions inside Bryales at 582.325.2, which were affected by a hierarchy problem, have been re-positioned.

Pteridophyta

Pteridophyta at 582.37/.39 have been moved to 582.39 and have been organized according to Smith et al. (2006); a number of conflicts within this class have been solved as well. Lycopodiophyta at 582.38 does not belong to Pteridophyta, but it is an equivalent taxon; with the new notation of the latter, the problem is solved. The class has been updated, according to Christenhusz & Byng (2016).

Psilotopsida has been moved from 582.391, and Ophioglossales (which belongs to it) has been placed in the subdivision. Outdated Filicopsida at 582.394 has been cancelled, and Mariattales at 582.394.5 has been relocated.

After these changes, span class 582.393/.399 Pteridopsida has been created to encompass most of the

main ferns (according to Christenhusz & Chase, 2014, and Christenhusz et al., 2016). These main ferns were misplaced in the hierarchy: all 13 classes were grouped under Dennstaedtiaceae at 582.394.7, while in fact they should be on the same subdivision level. This taxon is now moved in its proper place and re-organized.

5. Proposals for revision of Chromista, Bacteria and Protista (revision stage 5)

Chromista

Some authors consider Chromista a kingdom, or at least a high-level, independent taxon. Previously grouped with Protista at 582.24, following this revision Chromista was proposed to be placed on its own in a new class 582.25. The proposed class is structured according to Guiry & Guiry (2016) and Cavalier-Smith (2010). It includes a significant number of unicellular organisms, as well as most of algae (e.g. brown algae). Since the structure and the members of Chromista are still under discussion, only the main subdivisions, families and genera have been proposed to be included in the UDC schedules.

Class 579.8 Microorganisms

According to its caption, class 579.8 should represent a classification and systematics of microorganisms. The contents of the schedule, however, include bacteria only. The structure of 579.8 combined both a classification of bacteria according to diverse morphological and physiological criteria (e.g. shape, Gram staining, method of obtaining energy), and a classical Linnaean taxonomy. The first problem to observe is that the Linnaean systematics is outdated showing problems in hierarchy and naming. Furthermore, the morphological-physiological classification of bacteria is incomplete. And finally, the combination of two classifications in a single hierarchy (Linnaean taxonomy and morphological-physiological classification) creates problems that limit expansion and affect logic and accuracy in each of the systems in question. A single genus can include members with different shapes and methods of obtaining energy (and even a wide array of combinations of these two factors), making their organization in a taxonomic structure of this nature difficult, to say the least.

After careful consideration, it appeared that it would be best to keep class 579.8 for morphological-physiological classification only, while a new class, 579.9, is proposed to be created to accommodate an updated systematic classification of bacteria. If necessary, in the future links between the two tables may be established through cross-references.

Class 579.81 included groups that were not related among them except for the fact that some of their main members were phototrophic organisms (i.e. had a common system of producing their energy). The same happened with class 579.82, which included gliding bacteria, i.e. groups of bacteria with some of their members sharing a common method of moving (gliding), but with no other relation whatsoever. In fact, class 579.82 Gliding bacteria contains diverse organisms such as Myxobacteriales at 579.821 and Cytophagales at 579.822, which are Deltaproteobacteria (phylum Proteobacteria) and Bacteroidetes (phylum FCB), respectively.

A different criterion was proposed in 579.83, which grouped bacteria with a common external structure (sheathed bacteria) and shape (budding bacteria, spiral and curved bacteria; all of them, assumed to be sheathed). This class includes, again, taxa as different among them as Spirochaetes at 579.96 (phylum Spirochaetes) and Spirillaceae at 579.835.1 (phylum Proteobacteria).

A combination of criteria was proposed in 579.841, which classed microorganisms which are at the same time Gram negative, aerobic and have a particular shape (Gram negative bacteria being at 579.84). Incidentally, not all Gram negative taxa are listed. Again, 579.841 brings together a heterogeneous collection of entities which may or may not be totally related by the morphological and physiological features used as criteria: Pseudomonadaceae at 579.841.2 and Rhizobiaceae at 579.841.3 (phylum

Proteobacteria) have little in common with most Halobacteriaceae at 579.841.5, which are not even Bacteria, but belong to domain and kingdom Archaea. Classes 579.842, 579.844 and 579.845 grouped together microorganisms belonging to different phyla, e.g. Vibrionaceae at 579.843 (phylum Proteobacteria), Bacteroidaceae at 579.844.1 (phylum FCB) and Veillonellaceae at 579.845.1 (phylum Firmicutes).

Class 579.85 contains several problems. Methane-producing bacteria are actually Archaea, not Bacteria. But the organisms listed under 579.852 were not even methane producers. They were organized according to a new criterion: form of reproduction. The fact that they are Gram positive bacteria is not noted in the caption of this class although this characteristic appears duly noted in the following class 579.86. And the genus Clostridium at 579.852.13 was incorrectly placed under the family Bacillaceae. In addition, genera were presented with a mixture of formal and common names, e.g. "Bacillus spp" at 579.852.11, but Clostridium and Mycoplasmas at 579.852.13 and 579.887, respectively.

Class 579.86 lacks a number of well known taxa and there were multiple criteria used in the subdivision for their inclusion (Gram staining, form of reproduction, shape). And again, it included members of different phyla, as Micrococcaceae at 579.861 (phylum Actinobacteria) and Streptococcaceae at 579.862 (phylum Firmicutes).

Class 579.87 Actinomycetes and related organisms appears to be the least problematic, although the classification itself needs an update. Finally, class 579.88 collocates three groups that do not have anything in common except the fact that they are all bacteria: Rickettsias at 579.881 (phylum Protobacteria), Chlamydias at 579.882 (phylum PVC) and Mycoplasmas at 579.887 (phylum Firmicutes).

As stated above, 579.8 is proposed to be used for the classification of bacteria according to non-systematics criteria; therefore, some of its subdivisions have not been cancelled. These subdivisions are part of a taxonomy used in clinical and medical environments, where systematics are not as important as a series of morphological and physiological features that are critical to identify particular bacteria. Therefore, clinical bacteriologists and physicians do not care if Streptococcus are members of phyllum Firmicutes and class Lactobacillales; they consider them to be Gram positive aerobic and/or facultative anaerobic cocci.

The criteria proposed for this "classification" is Gram staining, bacterial morphology (shape and structure) and energy and carbon source. The suggested categories are based in the volumes of the Bergey's Manual of Systematic Bacteriology (see below).

Class 579.9 Systematics of bacteria

In order to place the taxa organizing Bacteria in a systematic structure, new class 579.9 is proposed to be created. Several sources have been used to build the basic scheme of phyla, classes, orders and families, and to decide which genera were to be included: the main ones were Garrity et al. (2007) and the five volumes of Bergey's Manual of Systematic Bacteriology, published by Springer between 2001 and 2012 and edited by the most prominent bacteriologists in the world. They were complemented by the use of the LSPN (Parte, 2016).

The general subdivision based on Gram staining is suggested to be preserved here as span classes 579.91/.92 and 579.93/.96, because of its practical value in the scientific, medical and biological domains. Several instances of old terminology (such as Firmicutes or Mollicutes) have been retained in the schedules because of their popularity.

The main division between Bacteria and Archaea (Archaeobacteria) has been reflected in the proposal. Regarding this division and the main scheme for the organization of bacteria in phyla, the work of Woese (1987, 1990) has been taken into account, as well as all the recent developments included in the sources quoted above and in the relevant academic bibliography.

All the subdivisions at phylum level have been provided with a five-digit notation, although a number of minor phyla have been reunited in a single class (e.g. FCB group and PVC group at 579.94). Six-digit notations have been reserved for taxa between phylum and family level, i.e. classes, subclasses, orders, suborders and superfamilies. Finally, seven-digit notations include families, which contain an "Including" note listing their main genera. The reason behind this organization is that the taxa between phylum and family are prone to be changed and reorganized again in the near future, since the taxonomy of Bacteria is under continuous scientific scrutiny. However, families representing the most important species are well established nowadays, and any future changes that can be anticipated are not likely to lead to a substantial modification of the current scheme.

Whenever a class had a unique order which, in turn, had a unique family, all taxa were included in the same caption, as in 579.991.1 Thermoplasmata. Thermoplasmatales. Thermoplasmataceae.

Regarding the genera listed in the proposed schedule, the most important species were taken into account, their importance being considered from the role they play in relation to humans. Therefore, most species with a medical or economical significance has been included, alongside several organisms repeatedly quoted in academic publications because of their particular biological characteristics.

Class 582.23 Bacteria as plants

Class 582.23 included bacteria "as plants", i.e. what is to be understood as bacteria that perform photosynthesis. The fact of classifying bacteria not for being such organisms, but according to their system of production of energy is troublesome. There are many different ways of producing energy among bacteria, besides photosynthesis, and many of them use more than one (see above). However, the criteria to define a bacterium are very clear, and those are to be used in UDC. For this reason class 582.23 has been proposed to be cancelled and moved to class 579.9.

Class 582.231 included Schizophyta (and alternate names), a group created by Cohn in 1875 which has long been deprecated. The members of this old taxon have been moved to Bacteria. The same thing happened with class 582.232, which included blue-green algae (Cyanobacteria and alternate names).

In the case of Archaea at 582.233, they are not bacteria, but should be placed in their own division among other microorganisms. That division has been created at 579.99.

Class 582.24 Protista

Class 582.24, Protista (Protoctista). Chromista. Protozoa was a duplicated concept also included in Zoology (class 593.1) as Protozoa.

Protozoa and Protista are understood to be synonyms, and they were meant to be in a single place in the UDC scheme. Since most protozoans have been studied by Zoology, they have been placed at 593.1, and everything else is proposed to be cancelled and moved to this location.

Several classes, such as 582.243 Hyphochytriomycota and 582.244 Oomycota, are proposed to be cancelled and placed under 582.25.

Class 593.1 Protista

The old class 593.1, Protozoa, has been proposed to be renamed to Protista. This group, often considered to be a kingdom, has been kept in Zoology (though UDC had a section in Botany devoted to them, too, at 582.24).

Class Rhizopoda at 593.11 and Amoebae at 593.12 are synonyms; therefore, 593.11 is proposed to be changed to include basic Opistokhonta, while 593.12 can be reserved for amoebae. The latter class

(renamed Amoebozoa) is proposed to be reorganized and expanded, in order to better describe these organisms, using Cavalier-Smith (2015) as a source.

Class Heliozoa at 593.13 is an obsolete group; its members are nowadays distributed among several taxa. Therefore, it has been cancelled and redirected to its broader class.

Old class Radiolaria at 593.14 is proposed to be changed to Rhizaria, its scope being widened. Radiolaria and other members of Radiolaria (like Foraminifera and Cercozoa) are also proposed to be placed here. In the case of the Cercozoa, its main subdivision (Plasmodiophoromycota) is suggested to be placed earlier in the schedules within Botany at 582.245. For Rhizaria, Moreira [et al.] (2007) were used as reference.

Old class Flagellata / Mastigophora at 593.16 is an outdated folk taxon, its scope being quite inexact: there are many flagellates organisms outside this class. Also, the fact of having a particular morphological trait (like a flagellum, in this case) is no longer considered to be a criterion for systematic classification, therefore this concept is proposed to be removed. The notation 593.16 is proposed to be used to represent a broader class of Excavata.

Some classes are proposed to be removed from Excavata because, despite being flagellates, they belong to different taxa. Chromomonadina at 593.161.4 and Volvocidae at 593.161.52 are in fact algae, and Dinoflagellata (and one of its subdivisions, Noctilucea) are Protista, but they are included in a different group, Alveolata. On the other hand, taxon Euglenozoa (old Euflagellata at 593.161) is proposed to be expanded (especially with the addition of class 593.161.1, Kinetoplastida, describing a very important group of human parasites known as Trypanosomatidae), and Percolozoa at 593.164 and Metamonada at 593.165 are proposed to be added.

Taxon Alveolata, which does not exist in UDC, is proposed to be added as a span class with notation 593.17/.19, including a number of important Protista groups. For Alveolata, Ruggiero et al. (2015) and Silar (2016) were used as sources of information.

Because it is a class still under discussion, Ciliophora (ciliates, 593.17) is not proposed to be expanded at this stage. Names are proposed to be updated and some details have been added.

Dinoflagellata are divided in UDC between Botany at 582.276 and Zoology at 593.162, considered to be algae and flagellates. Now, they are proposed to be reunited in a single class at 593.18, with their structure corrected and significantly expanded.

Apicomplexa at 593.19 is proposed to be corrected and expanded with more details. Sarcosporidia at 593.193 belong to an old, outdated Kudo system, and is, therefore proposed to be cancelled and redirected. Myxosporidia at 593.194 is an obsolete folk taxon that does not have an equivalent in modern taxonomy and is therefore proposed to be redirected to its broader class, while Microsporidia is proposed to be redirected to Fungi at 582.289.

6. Proposal for classification of Viruses (revision stage 6)

According to its caption, class 578.8 was used in UDC for the classification and systematics of viruses, which parallels the structure of 579.8 Classification and systematics of microorganisms. The structure of 578.8 combined both a classification of viruses according to their hosts (bacterial, plant, invertebrate and vertebrate hosts) and a classical Linnaean taxonomy. As with Bacteria, three problems can be observed here. Firstly, the Linnaean systematics was seriously outdated. In relation and in addition to this, schedules also contained many issues at a terminology and taxonomy level. Secondly, the host-based classification of viruses was incomplete and some important hosts were omitted. Thirdly, the

combination of two classification systems within a single hierarchy, Linnaean taxonomy and host-based classification, even if used in the past, is quite ineffective and presents obstacles to correct representation of either of the systems.

It was proposed that 578.8 remains as host-based classification only, while a new class, 578.9, has been created to include an updated systematic classification of viruses. For this classification, a combination of the two more used systems nowadays (Baltimore and International Committee on Taxonomy of Viruses - ICTV classifications) has been used. The table includes a number of main genera with their own, independent notation; more genera may be added in the future by subdividing existing classes.

7. Conclusion

The revised schedules completed in the last stages of the revision project (Invertebrates followed by Algae, Fungi, Bryophyta and Pteridophyta) are included and released with the UDC MRF 12. The proposed schedules for Protista, Chromista, Bacteria and Viruses, published in this issue of the *Extensions and Corrections*, will undergo further checks and once completed will be published as revised schedules in the next double issue 38-39 (2016-2017), planned to be digital only. Comments and suggestions are now invited from UDC users in relation to these proposals.

Currently in progress is the revision of biology-related areas in class 6, in particular agriculture, but also textile, food and other industries where plants or animals appear linked to products and materials. Unnecessary duplication of entities will be removed and colon combination suggested where appropriate. All revised schedules will further be improved by adding Latin binomial names to the existing vernacular names in English. These changes in schedules will appear in this and subsequent issue of the *Extensions and Corrections to the UDC*. Further improvement and more semantically relevant data will be added to the UDC MRF database to enable easer tracing of the concept movement and re-use of notation.

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