

RESEARCH ARTICLE

A Higher Level Classification of All Living Organisms

Michael A. Ruggiero^{1*}, Dennis P. Gordon², Thomas M. Orrell¹, Nicolas Bailly³, Thierry Bourgoïn⁴, Richard C. Brusca⁵, Thomas Cavalier-Smith⁶, Michael D. Guiry⁷, Paul M. Kirk⁸

1 Integrated Taxonomic Information System, National Museum of Natural History, Smithsonian Institution, Washington, District of Columbia, United States of America, **2** National Institute of Water & Atmospheric Research, Wellington, New Zealand, **3** WorldFish—FIN, Los Baños, Philippines, **4** Institut Systématique, Evolution, Biodiversité (ISYEB), UMR 7205 MNHN-CNRS-UPMC-EPHE, Sorbonne Universités, Museum National d'Histoire Naturelle, 57, rue Cuvier, CP 50, F-75005, Paris, France, **5** Department of Ecology & Evolutionary Biology, University of Arizona, Tucson, Arizona, United States of America, **6** Department of Zoology, University of Oxford, Oxford, United Kingdom, **7** The AlgaeBase Foundation & Irish Seaweed Research Group, Ryan Institute, National University of Ireland, Galway, Ireland, **8** Mycology Section, Royal Botanic Gardens, Kew, London, United Kingdom

* ruggierm@si.edu



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Abstract

We present a consensus classification of life to embrace the more than 1.6 million species already provided by more than 3,000 taxonomists' expert opinions in a unified and coherent, hierarchically ranked system known as the Catalogue of Life (CoL). The intent of this collaborative effort is to provide a hierarchical classification serving not only the needs of the CoL's database providers but also the diverse public-domain user community, most of whom are familiar with the Linnaean conceptual system of ordering taxon relationships. This classification is neither phylogenetic nor evolutionary but instead represents a consensus view that accommodates taxonomic choices and practical compromises among diverse expert opinions, public usages, and conflicting evidence about the boundaries between taxa and the ranks of major taxa, including kingdoms. Certain key issues, some not fully resolved, are addressed in particular. Beyond its immediate use as a management tool for the CoL and ITIS (Integrated Taxonomic Information System), it is immediately valuable as a reference for taxonomic and biodiversity research, as a tool for societal communication, and as a classificatory "backbone" for biodiversity databases, museum collections, libraries, and textbooks. Such a modern comprehensive hierarchy has not previously existed at this level of specificity.

Introduction

Biological classification (taxonomy) aims to simplify and order the immense diversity of life into coherent units called taxa that have widely accepted names and whose members share important properties. It synthesizes information concerning a great variety of characters (e.g.,

morphological; molecular: genes, metagenome, and metabolome; etho-ecological). There is currently no consensus among the world's taxonomists concerning which classification scheme to use for the overall hierarchy of life, in part because of the confusion resulting from Hennig's [1] redefinition of previous terminology of classification, which has not been universally accepted; the separate goals of cladification and classification [2]; and conflicting or unresolved evidence for phylogenetic relationships. The continuing advances in the use of specialized analytical tools from many different fields and their resulting conclusions and assumptions require regular updates as advances in knowledge are made.

Biological classification can integrate diverse, character-based data in a phylogenetic framework, which allows a broad user community to utilize the disparate knowledge of shared biological properties of taxa. Phylogeny is, therefore, the basis for these biological classifications but there is still strong debate over their accounting for evolutionary divergence or information content other than the branching pattern [3]. Accordingly, classifications have often been labeled either phylogenetic or evolutionary, depending mainly upon whether or not they reject paraphyletic groups [3, 4].

While the type of classification to be used to support further exploration and analysis of any biological scenario may be important, it is not the subject of this paper. The proposed classification does not address detailed phylogenetic questions and, while hierarchical and reflective of phylogeny, is not itself a phylogenetic tree. The aim of this classification is to be a pragmatic means of managing the ever-increasing knowledge of the diversity of life, its relationships, characteristics, and properties. Indeed, the past two decades have witnessed an explosion in biodiversity research and informatics, emphasizing the need for a quality list of accepted scientific names of the more than 1.9 million described living species [5] and for greater consensus on how to classify them at higher taxonomic ranks. Since 2001, Species 2000 and the Integrated Taxonomic Information System (ITIS) have worked with their respective contributors to complete a comprehensive species list, called the Catalogue of Life (CoL). The CoL Annual Checklist (<http://www.catalogueoflife.org/annual-checklist/2014/>) already contains more than 1.6 million valid or accepted species names provided by more than 140 taxonomic databases involving more than 3,000 taxonomists [6]. More than 82% of the global species databases are provided at the rank of class or below (includes 1.3 million species), and more than 63% are provided at the rank of order or below (includes 1.0 million species). Owing to the heterogeneity in higher level classification among the contributed databases, the CoL managers sought a practical and coherent hierarchical classification that could serve as a framework for data integration. Here we explain the rationale behind the consensus higher level classification that we propose for CoL use.

Our goal, therefore, is to provide a hierarchical classification for the CoL and its contributors that (a) is ranked to encompass ordinal-level taxa to facilitate a seamless import of contributing databases; (b) serves the needs of the diverse public-domain user community, most of whom are familiar with the Linnaean conceptual system of ordering taxon relationships; and (c) is likely to be more or less stable for the next five years. Such a modern comprehensive hierarchy did not previously exist at this level of specificity. In this sense it summarizes overarching aspects of the tree of life, including both paraphyletic and monophyletic groups, both being important in facilitating meaningful communication among scientists and between the scientific community and society.

The most recent higher level classification to this level was published more than 30 years ago, before the advent of modern molecular analysis [7]. Beyond the immediate use for CoL, the hierarchy is valuable as a reference for taxonomic and biodiversity research, as a tool for societal communication, and as a stable classificatory "backbone" for biodiversity databases, museum collections, libraries, and textbooks, to name a few applications.

Approach

When Linnaeus introduced his novel “system of nature” in the mid-18th century, he recognized three kingdoms of nature: *Regnum Vegetabile* (plants), *Regnum Animale* (animals), and *Regnum Lapideum* (minerals) that has long since been abandoned. However, as is evident from the title of his work, he introduced lower level taxonomic categories (named class, order, genus, and species), each successively nested within higher ranked categories. Linnaeus' system has proven to be robust for more than 250 years (see the comprehensive discussion and suggestions for dealing with potential conflicts in Vences *et al.* [8]). In modern-day classifications, the starting point for botanical names is Linnaeus' *Species Plantarum* [9] and for zoological names it is the tenth edition of the *Systema Naturae* [10]. Since Linnaeus, the expansion of knowledge and the increase in the number of described species has required an expansion of the number of hierarchical levels (ranks) within the system. The categories of family and phylum (or division) were introduced in the early 19th century and many intermediate categories have been added since. There is currently little agreement about the general names for categories above that of kingdom; here we use superkingdom rather than empire or domain. In addition, there are three separate codes that govern the assignment and use of scientific names, each with different requirements and terminology and consequences for their classifications. For algae, fungi, and plants (ICN: *International Code of Nomenclature for algae, fungi, and plants*), the principle of priority does not apply above rank of family; for animals (ICZN: *International Code of Zoological Nomenclature*), priority does not apply above the family-group ranks; and for prokaryotes other than Cyanobacteria (ICNB: *International Code of Nomenclature of Bacteria*), only the categories ranked as class and below are covered by the code. A recent paper by the International Committee on Bionomenclature compares terminology among six current nomenclatural codes and makes recommendations for their use in improving communication [11].

In 2005, on behalf of the International Society of Protistologists, Adl *et al.* [12] presented a nested eukaryote-only cladification that used the names of six supergroups—Amoebozoa, Opisthokonta, Rhizaria, Excavata, Chromalveolata, and Archaeplastida (= Plantae) [13–17]—as the highest ranked eukaryote groups. Their schema was updated in 2012 [18], with Rhizaria and Chromalveolata replaced by SAR plus four small hacrobian groups. Although these taxa are nested, and ranked by a “bulleted” system, Adl *et al.* avoided the use of Linnaean higher category names (phylum, class, order, family) that would have more usefully denoted rank. Insofar as the nested groups comprise a mix of taxon names based on priority (i.e., according to the year of introduction of the name), many individual genera as well as traditional taxon names (family through class) end up having the same rank in the Adl *et al.* hierarchy, while at the same time having different suffixes or none at all. The ranks assigned therein often seem to reflect our present partial ignorance of relationships more than careful assessment of relative phenotypic disparity as in Linnaean taxonomy. This is very confusing when these “group names” (genus to kingdom) are used in isolation without regard to phylogenetic relativity. Two of the great benefits of Linnaean-ranked categories and their standardized suffixes are that they instantly relativize taxa that are otherwise unknown to the non-specialist and also indicate the relative degree of phenotypic distinctiveness amongst groups. The overarching higher level classification used by the CoL, therefore, uses the standard formal categories, as it is intended to be simultaneously pragmatic and informative of both evolutionary relatedness and relative phylogenetic subordination. A classification should be biologically well-grounded and widely useful. In its simplicity, it provides less detail about relationships than a complete phylogeny but is still congruent with it [19]. Our classification is not intended to compete with a cladification such as Adl *et al.*'s—both are valid ways of ordering the living

world—but we would argue that their's is less comprehensible to many in the public-domain user communities.

These actual complexities of phylogenetic history emphasize that classification is a practical human enterprise where compromises must be made [20]. We have therefore named only groups generally considered to have had a monophyletic origin, even though some of them may be paraphyletic (i.e., do not include all descendants of their last common ancestor) and others, e.g., Euglenozoa, Rhizaria, Cercozoa, include subgroups (such as Euglenophyceae, Chlorarachnea, and *Paulinella*) that evolved by the symbiogenetic merger of two fundamentally different lineages [21], while others have had infusions of genes from elsewhere [22] and therefore do not conform to any purely formal definition of monophyly. We have not adopted the view that one should never accept paraphyletic groups in a classification but rather have evaluated each case of parphyly on its practicability and usage. In some cases (e.g., classical bryophytes) we accepted the splitting of paraphyletic taxa into holophyletic groups (groups with a monophyletic origin that also include all descendants of their last common ancestor, i.e., clades). In others we retained ancestral (paraphyletic) taxa when it seemed beneficial to do so (e.g., Prokaryota, Protozoa, Crustacea, Sarcopterygii, Reptilia). For practical purposes we treat Proteobacteria and Cyanobacteria as holophyletic phyla even though both exclude their mitochondrial and chloroplast descendants, neither of which is now a bacterium but an evolutionarily chimaeric cell organelle. We have conservatively retained several groups where evidence for parphyly or holophyly is contradictory, such as Archaea (Archaeobacteria).

A panel of experts representing the major taxonomic disciplines was convened to review, revise, and update the existing incomplete CoL hierarchy. These authors consulted more than 200 sources (see [S1 Appendix](#)), most of which were from recent taxonomic publications and websites. The product is a current and practical classification that meets the panel's established goal. In achieving a consensus, the panel was required to make some compromises that may require future revision as the related issues are resolved. While all of these individuals made contributions to the hierarchy, not all necessarily endorse every aspect of it. The CoL classification will undergo review and revision at five-year intervals to consider changes as necessary.

Results and Discussion

We are proposing a two-superkingdom (Prokaryota and Eukaryota), seven-kingdom classification that is a practical extension of Cavalier-Smith's six-kingdom schema [19]; the latter has been used, for example, in the compendious checklist of marine biota of Chinese seas [23] and in the first comprehensive national inventory of biodiversity for New Zealand [24–26]. For each of these kingdoms we had to exercise our taxonomic judgment and reach a practical compromise among diverse opinions and usages and conflicting evidence about certain phylogenetic questions important for defining the boundaries between and ranks of major taxa, including kingdoms. Our schema includes: the prokaryotic kingdoms Archaea (Archaeobacteria) and Bacteria (Eubacteria), and the eukaryotic kingdoms Protozoa, Chromista, Fungi, Plantae, and Animalia. We have retained 14 ranks from superkingdom to order ([Table 1](#)). Several key taxonomic issues, some not fully resolved, are discussed below.

Prokaryota

The higher classification of prokaryotes is still somewhat unsettled. Woese and Fox [27] treated Archaeobacteria (Archaea) and Eubacteria (Bacteria) as separate kingdoms. Margulis and Schwartz [28] recognized the superkingdom Prokarya, containing one kingdom Bacteria that

Table 1. List of ranks used in the hierarchy with the number of taxa per rank.

Rank	Number of Taxa
Superkingdom	2
Kingdom	7
Subkingdom	11
Infrakingdom	8
Superphylum	6
Phylum	96
Subphylum	60
Infraphylum	4
Superclass	12
Class	351
Subclass	145
Infraclass	23
Superorder	52
Order	1,467

Main ranks are in bold type; unnamed taxa are not counted.

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included a subkingdom Archaea; Cavalier-Smith also treated Archaeobacteria and Eubacteria as prokaryote subkingdoms [19, 29]. Commonly used sources of prokaryote names, such as the List of Prokaryotic Names with Standing in Nomenclature (LPSN) [30] and the Taxonomic Outline of Bacteria and Archaea (TOBA) [31] treat Bacteria and Archaea as separate domains but are silent about the category of kingdom. While these sources list the names of phyla in common use as a service to the user, they are not validly published under the ICNB. We have not placed phylum names in quotation marks as they have but we have so designated a few prokaryote names at lower ranks that are in common use but not (or not yet) valid. As no prokaryote names above the ranks of class are covered by ICNB rules, there is no official higher classification of prokaryotes [32] and any attempt at such is necessarily difficult. We have chosen to adopt the classification in current use by the Catalogue of Life. It is derived from the TOBA and recognizes Bacteria and Archaea as equivalent in rank to the eukaryote kingdoms. We treat them as *de facto* kingdoms until there is a better resolution of their status. The number of negibacterial “phyla” currently recognized [30] is probably excessive compared with eukaryotes and mainly reflects uncertainty about the true relationships of many small phyla, probably exaggerating the significance of their biological disparity. Greater use of multigene trees rather than over reliance on rRNA gene trees alone may eventually allow further simplification by grouping them into fewer phyla, possibly only about half the present number [28].

Protozoa and Chromista

Unicellular eukaryotes, usually called protists, comprise a polyphyletic group of eukaryotes that do not undergo tissue formation through the process of embryological layering. They include ancestrally unicellular eukaryotes directly descended from bacteria by the origin of the nucleus, endomembrane, cytoskeleton, and mitochondria. Assigning them to separate kingdoms was historically difficult when only light microscopy was available but is now

considerably facilitated because of advances in electron microscopy and gene sequencing. Formerly, the unicellular amoeboid group Myxozoa with multicellular spores was included in Protozoa but these protists are now firmly within the animal kingdom, having been proven to be greatly simplified parasitic animals. Yeasts are unicellular fungi that evolved polyphyletically from multicellular filamentous ancestors and are assigned to one of three higher fungal phyla. Microsporidia are highly reduced intracellular parasites traditionally considered to be Protozoa, but they have been known for two decades to be related to Fungi. At one time it was thought microsporidia had evolved from Fungi and therefore were placed in that kingdom [19, 33]. For several years multigene trees were contradictory about whether microsporidia branched within or diverged from Fungi. The latest evidence is that they are most closely related to rozellids [34], which also have been treated either as Fungi or Protozoa. If this recent phylogeny [34] is correct, both should be in the same kingdom. Here we take the view that the best demarcation between Protozoa and Fungi lies immediately before the origin of the chitinous wall around vegetative fungal cells and associated loss of phagotrophy [33]. We therefore include microsporidia and rozellids in Protozoa (vegetatively wall-less, typically phagotrophs) not Fungi (vegetatively walled osmotrophs).

For decades, taxonomists have debated the boundary between Protozoa and Plantae. We accept the view that it should be placed just prior to the evolutionary origin of chloroplasts and that Plantae should comprise all eukaryotes with plastids directly descending from the initially enslaved cyanobacterium, i.e., Viridiplantae (green plants), Rhodophyta (red algae), and Glaucophyta (glaucophyte algae), but exclude those like chromists that got their chloroplasts from plants secondarily by subsequent eukaryote-to-eukaryote lateral transfers. Therefore, all green algae are included in Viridiplantae and Plantae and are excluded from Protozoa. The only photosynthetic Protozoa are Euglenophyceae, which obtained their chloroplasts subsequently from an enslaved green alga [21].

The boundary between Protozoa and Chromista has been more controversial. Chromista was established to include all chromophyte algae (those with chlorophyll *c*, not *b*) considered to have evolved by symbiogenetic enslavement of another eukaryote (a red alga) as well as all heterotrophic protists descended from them by loss of photosynthesis or entire plastids [35]. With phylogenetic advances it has become clearer that alveolates (once considered Protozoa) are related to chromistan heterokont algae (and related heterotrophic heterokonts) and more distantly to Rhizaria, the three together forming the major group Harosa (equivalent to SAR). Consequently, Chromista has been greatly expanded to include all Harosa as well as other former protozoa that turned out to be related to haptophytes or cryptophytes. Chromista now includes many groups once treated as Protozoa [19], an expansion followed here. In multigene trees, this expansion is the most difficult part of the entire eukaryote tree to resolve. They sometimes show one or both of Plantae and Chromista as a clade but often their major subgroups are intermingled in contradictory ways [36, 37]. This may be a consequence of the eukaryote-eukaryote chimaeric history of chromists that acquired some genes from red algae or of the very rapid basal radiation of the robust corticate clade (i.e. Plantae plus Chromista). Because of this, some question whether Chromista represents a clade, yet trees are still too poorly resolved to eliminate the likelihood from cell evolutionary considerations that Chromista and Plantae are genuinely distinct sister clades. Evidence that Harosa is a clade is very strong. Evidence that Haptista plus Cryptista are a clade Hacrobia is strong on some trees but questioned by others [37].

Protozoa, like Prokaryota, is certainly a paraphyletic taxon [38]; Animalia, Fungi, Plantae, and Chromista all evolved from it. In our hierarchy Protozoa comprises seven phyla, of which

four are probably clades and three paraphyletic. We do not consider it useful in a general classification to subdivide the paraphyletic phyla into numerous smaller ones, often with only a handful of species that most have never heard of, even though a few specialists might favor that despite their constituent subgroups not differing radically in cell structure. For both Protozoa and Chromista we have favored large groups with shared body plans, analogous to extremely diverse animal phyla like Chordata and Arthropoda. The higher proportion of ancestral (paraphyletic) phyla in Protozoa compared with terminal groups like animals and plants is unsurprising because they were the first eukaryotes and they diverged early on but with many fewer associated major changes in body plan than occurred during the much later radiation of bilateral animals. Distinct early diverging protozoan clades can be remarkably similar morphologically and biologically [39].

Fungi

As stated earlier, we take the view that the best demarcation between Protozoa and Fungi lies immediately before the origin of the chitinous wall around vegetative fungal cells and associated loss of phagotrophy. We use an updated version of the higher classification presented in the 10th Edition of the *Dictionary of Fungi* [40]. The evolutionarily convergent Oomycetes such as the serious pest *Phytophthora*, formerly treated as Fungi, belong instead in phylum Pseudofungi of the heterokont Chromista.

Plantae

As with the other kingdoms, Plantae is classified in a variety of ways. Margulis and Schwartz [28] restricted Plantae to land plants (embryophytes or higher plants) and popularized the use of kingdom Protocista to include lower plants (green, red, and glaucophyte algae) and lower Fungi as well as chromists with classical protozoa. Many now consider such a kingdom too broad and heterogeneous and the associated separation of lower and higher plants in different kingdoms to be undesirable. Now taxonomists almost universally classify lower and higher plants together in the single kingdom Plantae and lower and higher fungi within the single kingdom Fungi. We have adopted this delimitation of Plantae here [19, 35] (for which Archaeplastida [12, 18] is a less familiar recent synonym). The structure of plastid genomes and the derived chloroplast protein-import machinery support a single origin of glaucophytes, red algae, green algae, and embryophytes (land plants). The ancestral embryophyte is thought to have originated from relatives of the Charales (stoneworts) or Coleochaetales (Charophyta). Jeffrey [41] first grouped charophytes and embryophytes as a clade Streptophyta, which was later validated as a superphylum [42] and reduced to phylum by Bremer [43].

Chase and Reveal [44] published a phylogenetic classification of land plants, reasoning that “If the major clades of green algae are recognized as classes, then all land plants, the embryophytes, should be included in a single class, here recognized as Equisetopsida.” This argument, however, overemphasizes cladistic level compared with phenotypic disparity, and is contrary to traditional assignment of phylum (or division) status to the main bryophyte, “pteridophyte” and seed-plant subgroups. This latter treatment was exemplified in the 2008 Annual Checklist of the CoL, which listed three bryophyte phyla, four pteridophyte phyla, and five seed-plant phyla, reflecting the arrangement found in many university textbooks of the late 20th century and in Margulis and Schwartz’s *Five Kingdoms* [28]. Here we recognize four embryophyte phyla—three of bryophytes (liverworts, hornworts, and mosses) and a single phylum Tracheophyta for vascular plants—with all species characterized by a diploid phase having xylem and phloem. Bryophyte specialists tend to treat each of the three major bryophyte groups as phyla—Marchantiophyta, Anthocerotophyta, Bryophyta [45, 46]. We have chosen a

conservative approach to the higher classification of plants, largely consistent with Mabberley [47] for the embryophyte ranks above class, while using Chase and Reveal [44] and Stevens [48] for the lower ranks.

Animalia (Metazoa)

The numbers of phyla and classes with extant species in kingdom Animalia differ according to molecular and morphological partitioning in phylogenies [49–59] as well as the preferred treatments of specialists of particular traditional phyla and where to “draw the line” between related taxa and how to rank them—the ranking of phylum versus subphylum is sometimes rather subjective. Based on the contributions of taxonomic experts to an outline of higher level classification and survey of taxonomic richness [60, 61], as many as 39 animal phyla might be recognized (more, if Porifera were abandoned as a phylum and constituent major clades given higher rank [62]). Below we discuss some issues encountered in arriving at decisions for our proposed classification, which accepts 34 animal phyla.

(1) Porifera—one phylum or three? Nielsen [62] argued that ‘The three apparently monophyletic sponge groups Silicea, Calcarea, and Homoscleromorpha do not constitute a monophyletic group, and the “phylum Porifera” thus has to be abandoned.’ More recent studies alternatively support paraphyly [63] or holophyly [58, 64] of sponges. Until the issue is resolved, we will follow the Porifera community [65–67] in retaining one phylum Porifera with four classes.

(2) Status of Myxozoa. Recent work on the vermiform myxozoan *Buddenbrockia* has demonstrated conclusively that myxozoans are extremely simplified Cnidaria, possibly Medusozoa [68, 69]. We classify Myxozoa as a subphylum of Phylum Cnidaria.

(3) Flatworms—monophyletic or not? In 1995, Nielsen [70] wrote “The delimitation of the phylum [Platyhelminthes] is not much in question,” but recent molecular analyses, combined with a careful reconsideration of morphology and anatomy, have confused the classification of Platyhelminthes, affecting particularly Acoela, *Xenoturbella*, and Nemertodermatida. Egger *et al.* [71] reviewed the evidence, noting the contrast between morphological and phylogenomic data. Whereas the stem-cell system and the mode of replacing epidermal cells unite both Acoela and Rhabditophora and are not found in any other bilaterian lineage, phylogenomic data support a separation of these two groups, a conclusion reached by Philippe *et al.* [72] based on mitochondrial genes, a phylogenomic data set of 38,330 amino-acid positions, and miRNA complements. We follow Philippe *et al.* [72] and Tyler and Schilling [73] in uniting Acoela, *Xenoturbella*, and Nemertodermatida as the deuterostome phylum Xenacoelomorpha. The remaining internal classification of Platyhelminthes is also somewhat problematic. We propose a classification that is based in part on Riutort *et al.* [74] and Tyler [75].

(4) Phylum Gnathifera or phyla Acanthocephala, Gnathostomulida, Micrognathozoa, and Rotifera? Until recently, all four of these groups were commonly treated as separate phyla [28, 61, 76–80]. However, numerous recent molecular and morphological analyses nest Acanthocephala within Rotifera [81–86]. A syncytial epidermis links rotifers, *Seison* and Acanthocephala; Ahlrichs [87, 88] proposed Syndermata for this clade. As revealed by transmission electron microscopy [89] and scanning electron microscopy [90], the jaw apparatus of gnathostomulids and rotifers is remarkably similar. That of *Seison* is less obviously homologous [91] and the *Seison*idea may have diverged from rotifers at an early stage of their evolution. On the other hand, *Seison* has similar sperm to acanthocephalans and the epidermis of both groups contains bundles of filaments. *Limnognathia maerski*, representing a new category of organism (Micrognathozoa) from cold fresh waters in Greenland and the Crozet Islands [92, 93], has a remarkable jaw apparatus (the most complicated known among invertebrates) with

clear homologies, in both the jaw elements and musculature, with the trophi in Rotifera and the jaws in Gnathostomulida. The jaw apparatus and musculature, as well as molecular analyses, unite these taxa as a clade known as Gnathifera (see [86, 92]). In the analysis by Giribet *et al.* [94], the issue remained unresolved, as Micrognathozoa appeared independent of Gnathostomulida and Rotifera, with unclear affiliation. Edgecombe *et al.* [59] and Nielsen [95] retain phylum status for Gnathostomulida, Micrognathozoa, and Rotifera but not Acanthocephala. We treat each of the major gnathiferan groups as a phylum, including Acanthocephala, following Monks and Richardson [79], though some of us think that the number of gnathiferan phyla ought to be substantially reduced when their phylogeny, including ingroup relationships of Rotifera *sensu lato*, is more firmly established.

(5) The scalidophoran phyla Adrianov and Malakhov [96] erected phylum Cephalorhyncha for Kinorhyncha, Loricifera, Priapula, and Nematomorpha. The first three of these phyla have in common an eversible snout (introvert) with scolid spines and inner and outer retractor muscles, a similar excretory filter (protonephridium), and similar sense organs, providing strong justification for uniting them in a single clade, the Scalidophora [97]. There is also molecular support, though not unanimity, for a clade of Kinorhyncha, Loricifera, and Priapula, known as Scalidophora. On the other hand, Kinorhyncha has internal and external body segmentation lacking in the other groups. Neuhaus and Higgins [98] noted that conflicting evidence exists for every one of the possible sister-group relationships among these phyla and prefer to keep them separate in a superphylum Scalidophora (which is preferred over Cephalorhyncha, the latter name originally including the Nematomorpha). We recommend separate scalidophoran phyla, though the number might be greatly reduced when the phylogeny becomes clearer.

(6) The chordate subphyla Cephalochordata and Urochordata Some sequence analyses have questioned the monophyly of Chordata [99, 100]. Nielsen [95] maintains Urochordata (or Tunicata) and Cephalochordata as separate phyla, whereas the group Urochordata is closer to Vertebrata (craniates), in a clade Olfactores, than Cephalochordata. We retain all three groups as traditional chordate subphyla.

Many users of classifications would prefer a stable, unchanging system. Yet classifications are syntheses of biological knowledge, particularly contemporary phylogenetic understanding of taxa, that must be regularly updated in accord with new scientific discoveries. Taxonomy must therefore navigate between the dual perils of ignoring important advances and making premature or unnecessary changes. We seek stability in nomenclature at the species level but at higher levels the concepts and compositions of major taxa, and therefore the scope of well-known names, must inevitably shift as new organisms are discovered and evolutionary affinities are better understood. The fact that we have been able to agree on a practical unified classification shows that taxonomists can broadly agree, despite the diverse experiences, viewpoints, and to some extent, differing philosophies of classification represented on our panel. The present classification (as, indeed, all classifications) should be regarded as interim, and it will inevitably change in certain respects, some hinted at above. However, we suspect that the recent torrent of radical re-evaluations (resulting especially from the application of DNA sequencing and other new techniques) may lessen as time passes. We hope that this unusually comprehensive classification will be widely useful and provide a sound basis for further improvement. A complete proposed classification from superkingdom to order is provided in Table 2 and is available for download at <<http://www.catalogueoflife.org/col/>>. Below the rank of infra-kingdom, we have followed the convention used in the Catalogue of Life and listed taxon names alphabetically. This allows easier searching by those not familiar with the phylogenies of

Table 2. Proposed hierarchical classification from superkingdom to order.

SUPERKINGDOM PROKARYOTA		
KINGDOM ARCHAEA [= ARCHAEBACTERIA]		
Phylum Crenarchaeota		
	Class "Aigarchaeota"	Order N.N. ("Ca. <i>Caldiarchaeum</i> ")
	Class "Korarchaeota"	Order N.N. ("Ca. <i>Korarchaeum</i> ")
	Class "Thaumarchaeota"	Order Cenarchaeales
	Class Thermoprotei [= Crenarchaeota]	Order Acidilobales
		Order Desulfurococcales
		Order Fervidicoccales
		Order Sulfolobales
		Order Thermoproteales
Phylum Euryarchaeota		
	Class Archaeoglobi	Order Archaeoglobales
	Class Halobacteria	Order Halobacteriales
	Class Methanobacteria	Order Methanobacteriales
	Class Methanococci	Order Methanococcales
	Class "Methanomicrobia"	Order N.N. (<i>Methanocalculus</i>)
		Order Methanocellales
		Order Methanomicrobiales
		Order Methanosarcinales
	Class Methanopyri	Order Methanopyrales
	Class "Nanohaloarchaea"	Order N.N. (e.g., " <i>Ca. Nanosalinarum</i> ")
	Class Thermococci	Order Thermococcales
	Class Thermoplasmata	Order Thermoplasmatales
KINGDOM BACTERIA [= EUBACTERIA]		
SUBKINGDOM NEGIBACTERIA		
Phylum Acidobacteria		
	Class N.N. (<i>Bryobacter</i>)	
	Class Acidobacteria	Order Acidobacteriales
	Class Holophagae	Order Acanthopleuribacterales
		Order Holophagales
Phylum Aquificae		
	Class Aquificae	Order Aquificales
Phylum Armatimonadetes		

(Continued)

Table 2. (Continued)

	Class Armatimonadia	Order Armatimonadales
	Class Chthonomonadetes	Order Chthonomonadales
	Class Fimbriimonadia	Order Fimbriimonadales
Phylum Bacteroidetes	Class Bacteroidia	Order Bacteroidales
	Class Cytophagia	Order Cytophagales
	Class Flavobacteria	Order Flavobacteriales
	Class Sphingobacteria	Order Sphingobacteriales
Phylum Caldiserica	Class Caldiserica	Order Caldisericales
Phylum Chlamydiae	Class Chlamydiae	Order Chlamydiales
Phylum Chlorobi	Class Chlorobia	Order Chlorobiales
	Class Ignavibacteria	Order Ignavibacteriales
Phylum Chrysiogenetes	Class Chrysiogenetes	Order Chrysiogenales
Phylum Cyanobacteria [= Cyanophyta]	Class Cyanophyceae [= Phycobacteria]	Order Chroococcales
		Order Nostocales
		Order Oscillatoriales
		Order Pseudoanabaeniales
		Order Synechococcales
	Class Gloeobacteria [= Gloeobacterophyceae]	Order Gloeobacterales
Phylum Deferribacteres	Class Deferribacteres	Order Deferribacterales
Phylum Deinococcus-Thermus [= Hadobacteria]	Class Deinococci	Order Deinococcales
		Order Thermales
Phylum Dictyoglomi	Class Dictyoglomia	Order Dictyoglomales
Phylum Elusimicrobia	Class Elusimicrobia	

(Continued)

Table 2. (Continued)

		Order Elusimicrobiales
Phylum Fibrobacteres	Class Fibrobacteria	Order Fibrobacterales
Phylum Fusobacteria	Class Fusobacteriia	Order Fusobacteriales
Phylum Gemmatimonadetes	Class Gemmatimonadetes	Order Gemmatimonadales
Phylum Lentisphaerae	Class Lentisphaeria	Order Lentisphaerales
		Order Victivallales
		Order Oligosphaerales
Phylum Nitrospira	Class "Nitrospira"	Order "Nitrospirales"
Phylum Planctomycetes	Class Phycisphaerae	Order Phycisphaerales
	Class Planctomycea	Order Planctomycetales
Phylum Proteobacteria	Class Alphaproteobacteria	Order N.N. (e.g., <i>Breoghania</i>)
		Order Caulobacterales
		Order Kiloniellales
		Order Kordiimonadales
		Order Magnetococcales
		Order "Parvularculales"
		Order Rhizobiales
		Order Rhodobacterales
		Order Rhodospirillales
		Order Rickettsiales
		Order Sneathiellales
		Order Sphingomonadales
	Class Betaproteobacteria	Order N.N. (<i>Chitinivorax</i>)
		Order Burkholderiales
		Order Hydrogenophilales
		Order Methylophilales
		Order Neisseriales
		Order Nitrosomonadales
		Order "Procabacteriales"
		Order Rhodocyclales
	Class Deltaproteobacteria	Order N.N. (e.g., <i>Deferrisoma</i>)
		Order Bdellovibrionales

(Continued)

Table 2. (Continued)

		Order Desulfarculales
		Order Desulfobacterales
		Order Desulfovibrionales
		Order Desulfurellales
		Order Desulfuromonadales
		Order Myxococcales
		Order Syntrophobacterales
	Class Epsilonproteobacteria	
		Order Campylobacterales
		Order Nautiliales
	Class Gammaproteobacteria	
		Order N.N. (e.g., <i>Alkalimonas</i>)
		Order Acidithiobacillales
		Order Aeromonadales
		Order Alteromonadales
		Order Cardiobacterales
		Order Chromatiales
		Order "Enterobacterales"
		Order Legionellales
		Order Methylococcales
		Order Oceanospirillales
		Order Orbales
		Order Pasteurellales
		Order Pseudomonadales
		Order "Salinisphaerales"
		Order Thiotrichales
		Order "Vibrionales"
		Order Xanthomonadales
	Class Zetaproteobacteria	
		Order Mariprofundales
Phylum Spirochaetae		
	Class "Spirochaetes"	
		Order Spirochaetales
Phylum Synergistetes		
	Class Synergistia	
		Order Synergistales
Phylum Thermodesulfobacteria		
	Class Thermodesulfobacteria	
		Order Thermodesulfobacterales
Phylum Thermotogae		
	Class Thermotogae	
		Order Thermotogales
Phylum Verrucomicrobia		
	Class Opitutae	
		Order Opitiales
		Order Puniceicoccales
	Class Verrucomicrobiae	
		Order Verrucomicrobiales
SUBKINGDOM POSIBACTERIA		

(Continued)

Table 2. (Continued)

Phylum Actinobacteria	
Class Actinobacteria	Order Acidimicrobiales
	Order Actinomycetales
	Order Bifidobacteriales
	Order Coriobacteriales
	Order Euzebyales
	Order Gaiellales
	Order Nitriliruptorales
	Order Rubrobacteriales
	Order Solirubrobacteriales
	Order Thermoleophilales
Phylum Chloroflexi [= Chlorobacteria]	
Class Anaerolineae	Order Anaerolineales
Class Caldilineae	Order Caldilineales
Class Chloroflexia	Order Chloroflexales
	Order Herpetosiphonales
Class Dehalococcoidia	Order Dehalococcoidales
Class Ktedonobacteria	Order Ktedonobacteriales
	Order Thermogemmatisporales
Class Thermomicrobia	Order Sphaerobacteriales
	Order Thermomicrobiales
Phylum Firmicutes	
Class Bacilli	Order Bacillales
	Order Lactobacillales
Class Clostridia	Order Clostridiales
	Order Halanaerobiales
	Order Natranaerobiales
	Order Thermoanaerobacteriales
Class Erysipelotrichia	Order Erysipelotrichales
Class Negativicutes	Order Selenomonadales
Class Thermolithobacteria	Order Thermolithobacteriales
Phylum Tenericutes	
Class Mollicutes	Order Acholeplasmatales
	Order Anaeroplasmatales
	Order Entomoplasmatales
	Order Haloplasmatales
	Order Mycoplasmatales

(Continued)

Table 2. (Continued)

SUPERKINGDOM EUKARYOTA		
KINGDOM PROTOZOA		
SUBKINGDOM EOZOA		
INFRAKINGDOM EUGLENOZOA		
Phylum Euglenozoa		
Subphylum N.N.		
	Class Diplonemea	Order Diplonemida
	Class Kinetoplastea	Order Bodonida
		Order Prokinetoplastida
		Order Trypanosomatida
Subphylum Euglenoida		
	Class N.N.	Order Petalomonadida
		Order Ploeoitiida
	Class Euglenophyceae	Order Euglenida
		Order Eutreptiida
	Class Peranemea	Order Heteronemida
		Order Peranemida
		Order Rhabdomonadida
Subphylum Symbiontida		
	Class Postgaardea	Order Postgaardida
INFRAKINGDOM EXCAVATA		
Phylum Loukozoa		
Subphylum Eolouka		
	Class Jakobea	Order Jakobida
	Class Tsukubea	Order Tsukubamonadida
Subphylum Neolouka		
	Class Malawimonadea	Order Malawimonadida
Phylum Metamonada		
	Class Anaeromonadea	Order Oxymonadida
		Order Trimastigida
	Class Carpomonadea	Order Carpediemonadida
		Order Chilomastigida
		Order Dysnectida
	Class Eopharyngea	Order Diplomonadida
		Order Retortamonadida
	Class Trichomonadea	Order Cristamonadida
		Order Spirotrichonymphida

(Continued)

Table 2. (Continued)

	Order Trichomonadida
	Order Tritrichomonadida
Class Trichonymphea	
	Order Lophomonadida
	Order Trichonymphida
Phylum Percolozoa	
Subphylum Pharyngomonada	
Class Pharyngomonadea	
	Order Pharyngomonadida
Subphylum Tetramitida	
Class Heterolobosea	
	Order Acrasida
	Order Schizopyrenida
Class Lyromonadea	
	Order Lyromonadida
Class Percolatea	
	Order Percolomonadida
	Order Pseudociliatida
SUBKINGDOM SARCOMASTIGOTA	
Phylum Amoebozoa	
Subphylum Conosa	
Class Archamoebae	
	Order Mastigamoebida
	Order Pelobiontida
	Order Rhizomastigida
Class Dictyostelea	
	Order Dictyostelida
Class Myxogastrea [= Myxomycetes]	
Subclass Exosporeae	
	Order Ceratiomyxida
Subclass Myxogastria	
	Superorder Columelida
	Order Echinosteliida
	Order Fuscisporida
	Superorder Lucisporida
	Order Liceida
	Order Trichiida
Class Protostelea	
	Order Protostelida
Class Variosea	
	Order Artodiscida
	Order Holomastigida
	Order Phalansteriida
	Order Varipodida
Subphylum Lobosa	
Class Discosea	
Subclass Flabellinia	
	Order Dactylopodida
	Order Himatismenida
	Order Pellitida

(Continued)

Table 2. (Continued)

	Order Stygamoebida
	Order Trichosida
	Order Vanellida
Subclass Longamoebia	
	Order Dermamoebida
	Order Centramoebida
	Order Thecamoebida
Class Tubulinea [= Lobosea]	
	Order Arcellinida
	Order Echinamoebida
	Order Euamoebida
	Order Leptomyxida
	Order Nolandida
Phylum Choanozoa [with Microsporidia, Animalia, and Fungi constitutes "Supergroup Opisthokonta"]	
Subphylum Choanofila	
Class Choanoflagellata	
	Order Acanthoecida
	Order Craspedida
Class Corallochytra	
	Order Corallochytrida
Class Filasterea	
	Order Ministeriida
Class Ichthyosporea	
	Order Dermocystida
	Order Eccrinida
Subphylum Paramyria	
Class Aphelidea	
	Order Aphelidida
Class Cristidiscoidea	
	Order Fonticulida
	Order Nucleariida
Class Rozellidea	
	Order Rozellida
Phylum Microsporidia [with Choanozoa, Animalia, and Fungi constitutes "Supergroup Opisthokonta"]	
Class Disporea	
	Order N.N. (e.g., <i>Nosema</i>)
Class Metchnikovellea	
	Order Metchnikovellida
Class Minisporea [= Microsporea]	
	Order Minisporida [= Minisporea]
Class Pleistophorea	
	Order Pleistophorida
Phylum Sulcozoa	
Subphylum Apusozoa	
Class Breviatea	
	Order Breviatida
Class Thecomonadea	
	Order Apusomonadida
Subphylum Varisulca	
Class Diphyllatea	

(Continued)

Table 2. (Continued)

		Order Diphyllida
	Class Glissodiscea	
		Order Mantamonadida
		Order Planomonadida
	Class Hilomonadea	
		Order Rigifilida
KINGDOM CHROMISTA		
SUBKINGDOM HACROBIA		
	Phylum N.N.	
	Class Endohelea	
		Order Heliomonadida
		Order Microhelida
	Class Picomonadea	
		Order Picomonadida
	Class Telonemea	
		Order Telonemida
	Phylum Cryptista	
	Subphylum Palpitia	
	Class Palpitea	
	Subphylum Rollomonadia	
	Class Cryptophyceae	
		Order Cryptomonadales
		Order Pyrenomonadales
		Order Tetragonidiales
	Class Goniomonadea	
		Order Goniomonadida
	Class Leucocryptea	
		Order Katablepharida
		Order Palpitida
	Phylum Haptophyta	
	Class Coccolithophyceae [= Prymnesiophyceae]	
		Order Coccolithales
		Order Coccosphaerales
		Order Isochrysidales
		Order Phaeocystales
		Order Prymnesiales
		Order Syracosphaerales
		Order Zygodiscales
	Class Pavlovophyceae	
		Order Pavloales
	Phylum Heliozoa	
	Class Centrohelea	
		Order Acanthocystida
		Order Pterocystida
SUBKINGDOM HAROSA [= "Supergroup SAR"]		
INFRAKINGDOM HALVARIA		
	Superphylum Alveolata	
	Phylum Ciliophora	
	Subphylum Intramacronucleata	
	Class Armophorea	

(Continued)

Table 2. (Continued)

	Order Armophorida
	Order Clevelandellida
Class Colpodea	
	Order Bryometopida
	Order Bryophryida
	Order Bursariomorphida
	Order Colpodida
	Order Cyrtolophosidida
	Order Sorogenida
Class Litostomatea	
Subclass Haptoria	
	Order Cyclotrichiida
	Order Haptorida
	Order Pleurostomatida
Subclass Trichostomatia	
	Order Entodiniomorphida
	Order Macropodiniida
	Order Vestibuliferida
Class Spirotrichea	
Subclass Choreotrichia	
	Order Tintinnida
Subclass Hypotrichia	
	Order Euplotida
	Order Kiitrichida
Subclass Licnophoria	
	Order Licnophorida
Subclass Oligotrichia	
	Order Strombidiida
Subclass Protocruziida	
	Order Phacodiniida
	Order Protocruziida
Subclass Stichotrichia	
	Order Sporadotrichida
	Order Stichotrichida
	Order Urostylida
Class Nassophorea	
	Order Colpodidiida
	Order Microthoracida
	Order Nassulida
	Order Synhymeniida
Class Oligohymenophorea	
Subclass Apostomatia	
	Order Apostomatida
	Order Astomatophorida
	Order Pilisuctorida
Subclass Astomatia	
	Order Astomatida
Subclass Hymenostomatia	
	Order Ophyroglenida
	Order Tetrahymenida

(Continued)

Table 2. (Continued)

	Subclass Peniculia	
		Order Peniculida
		Order Urocentrida
	Subclass Peritrichia	
		Order Mobilida
		Order Sessilida
	Subclass Scuticociliatia	
		Order Philasterida
		Order Pleuronematida
		Order Thigmotrichida
	Class Phyllopharyngea	
	Subclass Chonotrichia	
		Order Cryptogemmida
		Order Exogemmiida
	Subclass Cyrtophoria	
		Order Chlamyodontida
		Order Dysteriida
	Subclass Rhynchodia	
		Order Hypocomatida
		Order Rhynchodida
	Subclass Suctoria	
		Order Endogenida
		Order Evaginogenida
		Order Exogenida
	Class Plagiopylea	
		Order Odontostomatida
		Order Plagiopylida
	Class Prostomatea	
		Order Prorodontida
		Order Prostomatida
	Subphylum Postciliodesmatophora	
	Class Heterotricha	
		Order Heterotrichida
	Class Karyorelictea	
		Order Loxodida
		Order Protoheterotrichida
		Order Protostomatida
	Phylum Miozoa	
	Subphylum Myxozoa	
	Infraphylum Apicomplexa	
	Superclass Apicomonada	
	Class Apicomonadea	
		Order Chromerida
		Order Colpodellida
		Order Voromonadida
	Superclass Sporozoa	
	Class N.N.	
		Order Blastogregarinida
	Class Coccidiomorpha	
	Subclass Coccidea	

(Continued)

Table 2. (Continued)

	Order Agamococcidida
	Order Eimerida
	Order Ixorheida
Subclass Coleotrophia	
	Order Coleotrophiida [= Protococciida]
Subclass Hematozoa	
	Superorder Aconoidia
	Order Nephromycida
	Order Piroplasmida
	Superorder Haemosporidia
	Order Hemosporida
Class Gregarinomorpha	
Subclass Cryptogregarina	
	Order Cryptogregarida (<i>Cryptosporidium</i>)
Subclass Histogregarina	
	Order Histogregarida
Subclass Orthogregarinia	
	Order Arthrogerida
	Order Vermigregarida
Class Paragregaria	
	Order Archigregarinida
	Order Stenophorida
	Order Velocida
Infraphylum Dinozoa	
Superclass Dinoflagellata	
Class Dinophyceae	
Subclass N.N.	
	Order Actiniscales
	Order Blastodinales
	Order Coccidinales
	Order Dinamoebales
	Order Lophodinales
	Order Pyrocystales
	Order Thoracosphaerales
Subclass Dinophysoidia	
	Order Dinophysidales
	Order Nannoceratopsales
Subclass Gonyaulacoidia	
	Order Gonyaulacales
	Order Gymnodiniales
Subclass Peridinoidea	
	Order Peridiniales
	Order Procentrales
Subclass Suessioidia	
	Order Suessiales
Class Ellobiopsea	
	Order Ellobiopsida
Class Noctilucea	
	Order Noctilucida
Class Oxyrrhea	

(Continued)

Table 2. (Continued)

	Order Acrocoelida
	Order Oxyrrhida
Class Syndinea	
	Order Rastrimonadida
	Order Syndinida
Superclass Perkinsozoa	
Class Myzomonadea	
	Order Algovorida
Class Perkinsea	
	Order Perkinsida
	Order Phagodinida
Subphylum Protalveolata	
Class Colponemea	
	Order Colponemida
Superphylum Heterokonta [= "Supergroup Stramenopiles"]	
Phylum Bigyra	
Class Bikosea	
	Order Anoecida
	Order Bicoecida
	Order Borokida
	Order Pseudodendromonadida
	Order Rictida
Class Blastocystea	
	Order Blastocystida
Class Nanomonadea	
	Order Uniciliatida
Class Opalineae	
	Order Opalinida
	Order Proteromonadida
Class Labyrinthulea	
	Order Labyrinthulida
	Order Thraustochytriida
Class Placididea [= Placidiophyceae]	
	Order Placidiida
Phylum Ochrophyta [= Heterokontophyta p.p.]	
Class Bacillariophyceae [= Diatomeae]	
Subclass Bacillariophycidae	
	Order Achnanthales
	Order Bacillariales
	Order Cymbellales
	Order Dictyoneidales
	Order Eunotiales
	Order Eupodiscales
	Order Lyrellales
	Order Mastogloiales
	Order Naviculales
	Order Rhopalodiales
	Order Surirellales
	Order Thalassiophysales
Subclass Coscinodiscophycidae	

(Continued)

Table 2. (Continued)

	Order Anaulales
	Order Arachnoidiscales
	Order Asterolamprales
	Order Aulacoseirales
	Order Biddulphiales
	Order Chaetocerotales
	Order Chrysanthemodiscales
	Order Corethrales
	Order Coscinodiscales
	Order Cymatosirales
	Order Ethmodiscales
	Order Hemiaulales
	Order Lithodesmiales
	Order Melosirales
	Order Orthoseirales
	Order Paraliales
	Order Rhizosoleniales
	Order Stictocyclales
	Order Stictodiscales
	Order Thalassiosirales
	Order Triceratiales
	Subclass Fragilariophycidae
	Order Ardissonales
	Order Climacospheniales
	Order Cycloporales
	Order Fragilariales
	Order Licmophorales
	Order Protoraphidales
	Order Rhabdonematales
	Order Rhapsoneidales
	Order Striatellales
	Order Tabellariales
	Order Thalassionematales
	Order Toxariales
	Class Bolidophyceae
	Order Parmales [= Bolidomonadales]
	Class Chrysomerothyceae
	Order Chrysomeridales
	Class Chrysophyceae
	Order Chloramoebales
	Order Chromulinales
	Order Chrysosphaerales
	Order Heterogloaeales
	Order Hibberdiales
	Order Hydrurales
	Order Ochromonadales
	Order Paraphysomonadida
	Order Synurales
	Order Thallochrysidales
	Class Eustigmatophyceae

(Continued)

Table 2. (Continued)

	Order Eustigmatales
Class Dictyochophyceae [= Hypogyristera]	
	Order Dictyochales
	Order Olisthodiscales
	Order Pedinellales
	Order Pelagomonadales
	Order Sarcinochrysidales
Class Phaeophyceae	
Subclass Dictyophycidae	
	Order Dictyotales
	Order Onslowiales
	Order Sphacelariales
	Order Syringodermatales
Subclass Discosporangiophycidae	
	Order Discosporangiales
Subclass Fucophycidae	
	Order Ascoseirales
	Order Asterocladales
	Order Desmarestiales
	Order Ectocarpales
	Order Fucales
	Order Laminariales
	Order Nemodermatales
	Order Phaeosiphoniellales
	Order Ralfsiales
	Order Scytothamiales
	Order Sporochnales
	Order Tilopteridales [= Cutleriales]
Subclass Ishigeophycidae	
	Order Ishigeales
Class Phaeothamniophyceae [= Aurophyceae]	
	Order Aurearenales
	Order Phaeothamniales
Class Picophagophyceae [= Picophagea]	
	Order Picophagales
	Order Synchronomales
Class Pinguiphyceae	
	Order Pinguiochrysidales
Class Raphidophyceae	
	Order Actinophryida
	Order Commatiida
	Order Raphidomonadales
Class Schizocladiphyceae	
	Order Schizocladiales
Class Xanthophyceae	
	Order Mischococcales
	Order Pleurochloridellales
	Order Tribonematales
	Order Vaucheriales
Phylum Pseudofungi [= Oomycota]	

(Continued)

Table 2. (Continued)

	Class Bigyromonadea	Order Developayellida
	Class Hyphochytrea	Order Hyphochytriida
		Order Pirsoniida
	Class Oomycetes	
	Subclass Eogamia	Order Anisopdiales
		Order Haptoglossales
		Order Lagenismatales
		Order Olpidiopsiales
		Order Rozellopsiales
	Subclass Peronosporidae	Order Peronosporales
		Order Pythiales
		Order Rhipidiales
	Subclass Saprolegniidae	Order Albuginales
		Order Leptomitales
		Order Sallagenidiales
		Order Saprolegniales
INFRAKINGDOM RHIZARIA		
	Phylum Cercozoa	
	Subphylum Endomyxa	
	Class Ascetosporea	Order Claustrosporida
		Order Haplosporida
		Order Paradinida
		Order Paramyxida
	Class Gromiidea	Order Gromiida
		Order Reticulosida
	Class Phytomyxea	Order Phagomyxida
		Order Plasmodiophorida
	Class Vampyrellidea	Order Vampyrellida
	Subphylum Monadofilosa	
	Class Imbricatea	
	Subclass Placonuda	Order Discocelida
		Order Discomonadida
		Order Euglyphida
		Order Marimonadida
		Order Variglissida
	Subclass Placoperla	Order Perlofilida
		Order Rotosphaerida
		Order Spongomonadida
		Order Thaumatomonadida

(Continued)

Table 2. (Continued)

		Order Zoelucasida
	Class Metromonadea	Order Metopiida
		Order Metromonadida
	Class Sarcomonadea	Order Cercomonadida
		Order Glissomonadida
		Order Pansomonadida
		Order Pseudosporida
		Order Sainouroida
	Class Thecofilosea	
	Subclass Eothechia	Order Cryomonadida
		Order Ebrida
		Order Matazida
		Order Ventricleftida
	Subclass Phaeodaria	Order Eodarida
		Order Opalococonchida
	Subclass Tectosia	Order Tectofilosida
	Subphylum Reticulofilosa	
	Class Chlorarachnea	Order Chlorarachnida
	Class Granofilosea	Order Cryptofilida
		Order Desmothoracida
		Order Leucodictyida
		Order Limnofilida
	Class Skiomonadea	Order Tremulida
	Phylum Retaria	
	Subphylum Foraminifera	
	Class Monothalamea	Order Allogromiida
		Order Astrorhizida
		Order Psamminida
		Order Stannomida
	Class Globothalamea	Order Carterinida
		Order Globeriginida
		Order Lagenida
		Order Lituolida
		Order Lofusiida
		Order Robertinida
		Order Rotaliida
		Order Testulariida
		Order Trochamminida
	Class Tubothalamea	Order Miliolida

(Continued)

Table 2. (Continued)

	Order Spirillinida
Subphylum Radiozoa	
Superclass Polycystinia	
Class Polycystinea	
	Order Collodarida
	Order Nassellaria
	Order Spumellaria
Superclass Spasmaria	
Class Acantharea	
	Order Arthracanthida
	Order Chaunacanthida
	Order Holacanthida
	Order Symphyacanthida
Class Sticholonchea	
	Order Taxopodida
KINGDOM FUNGI	
SUBKINGDOM DIKARYA [= NEOMYCOTA]	
Phylum Ascomycota	
Subphylum Pezizomycotina	
Class Archaeorhizomycetes	
	Order Archaeorhizomycetales
	Order Lahmiales
	Order Triblidiales
Class Arthoniomycetes	
	Order Arthoniales
Class Dothideomycetes	
Subclass N.N.	
	Order Acrospermales
	Order Botryosphaeriales
	Order Hysteriales
	Order Jahnuales
	Order Koralionastetales
	Order Patellariales
	Order Trypetheliales
Subclass Dothideomycetidae	
	Order Capnodiales
	Order Dothideales
	Order Microthyriales
	Order Myriangiales
Subclass Meliolomycetidae	
	Order Meliolales
Subclass Pleosporomycetidae	
	Order Mytilinidiales
	Order Pleosporales
Class Eurotiomycetes	
Subclass Chaetothyriomycetidae	
	Order Chaetothyriales
	Order Pyrenulales
	Order Verrucariales
Subclass Eurotiomycetidae	

(Continued)

Table 2. (Continued)

	Order Arachnomycetales
	Order Ascosphaerales
	Order Coryneliales
	Order Eurotiales
	Order Onygenales
	Subclass Mycocaliciomycetidae
	Order Mycocaliciales
Class Laboulbeniomyces	
	Order Laboulbeniales
	Order Pyxidiophorales
Class Lecanoromycetes	
Subclass N.N.	
	Order Candelariales
	Order Umbilicariales
	Subclass Acarosporomycetidae
	Order Acarosporales
	Subclass Lecanoromycetidae
	Order Lecanorales
	Order Lecideales
	Order Peltigerales
	Order Rhizocarpales
	Order Teloschistales
	Subclass Ostropomycetidae
	Order Agyriales
	Order Baeomycetales
	Order Ostropales
	Order Pertusariales
Class Leotiomycetes	
	Order Cytariales
	Order Erysiphales
	Order Geoglossales
	Order Helotiales
	Order Leotiales
	Order Medioloriales
	Order Rhytismatales
	Order Thelebolales
Class Lichinomycetes	
	Order Eremithallales
	Order Lichinales
Class Orbiliomycetes	
	Order Orbiliales
Class Pezizomycetes	
	Order Pezizales
Class Sordariomycetes	
Subclass N.N.	
	Order Phyllachorales
	Order Trichosphaeriales
	Subclass Hypocreomycetidae
	Order Coronophorales
	Order Hypocreales

(Continued)

Table 2. (Continued)

	Order Melanosporales
	Order Microascales
	Subclass Sordariomycetidae
	Order Boliniales
	Order Calosphaeriales
	Order Chaetosphaeriales
	Order Coniochaetales
	Order Diaporthales
	Order Ophiostomatales
	Order Sordariales
	Subclass Spathulosporomycetidae
	Order Lulworthiales
	Subclass Xylariomycetidae
	Order Xylariales
Subphylum Saccharomycotina	
Class Saccharomycetes	
	Order Saccharomycetales
Subphylum Taphrinomycotina	
Class Neoelectromycetes	
	Order Neoelectales
Class Pneumocystidomycetes	
	Order Pneumocystidales
Class Schizosaccharomycetes	
	Order Schizosaccharomycetales
Class Taphrinomycetes	
	Order Taphrinales
Phylum Basidiomycota	
Class Entorrhizomycetes	
	Order Entorrhizales
	Order Wallemiales
Subphylum Agaricomycotina	
Class Agaricomycetes	
Subclass N.N.	
	Order Auriculariales
	Order Cantharellales
	Order Corticiales
	Order Gloeophyllales
	Order Hymenochaetales
	Order Polyporales
	Order Russulales
	Order Sebaciniales
	Order Thelephorales
	Order Trechisporales
	Subclass Agaricomycetidae
	Order Agaricales
	Order Atheliales
	Order Boletales
	Subclass Phallomycetidae
	Order Geastrales
	Order Gomphales

(Continued)

Table 2. (Continued)

	Order Hysterangiales
	Order Phallales
Class Dacrymycetes	Order Dacrymycetales
Class Tremellomycetes	Order Cystofilobasidiales
	Order Filobasidiales
	Order Tremellales
Subphylum Pucciniomycotina	
Class Agaricostilbomycetes	Order Agaricostilbales
	Order Spiculogloeales
Class Atractiellomycetes	Order Atractiellales
Class Classiculomycetes	Order Classiculales
Class Cryptomycocolacomycetes	Order Cryptomycocolacales
Class Cystobasidiomycetes	Order Cystobasidiales
	Order Erythrobasidiales
	Order Naohideales
Class Microbotryomycetes	Order Hetrogastridiales
	Order Leucosporidiales
	Order Microbotryales
	Order Sporidiobolales
Class Mixiomycetes	Order Mixiales
Class Pucciniomycetes	Order Helicobasidiales
	Order Pachnocybales
	Order Platyglloeales
	Order Pucciniales
	Order Septobasidiales
Subphylum Ustilaginomycotina	
Class N.N.	Order Malasseziales
Class Exobasidiomycetes	Order Ceraceosorales
	Order Doassansiales
	Order Entylomatales
	Order Exobasidiales
	Order Georgefischeriales
	Order Microstromatales
	Order Tilletiales
Class Ustilaginomycetes	Order Urocystidales
	Order Ustilaginales
SUBKINGDOM EOMYCOTA	

(Continued)

Table 2. (Continued)

Phylum Chytridiomycota	
Class Blastocladiomycetes [= Allomycetes]	
	Order Blastocladiales
Class Chytridiomycetes	
	Order Chytridiales
	Order Lobulomycetales
	Order Neocallimastigales
	Order Olpidiales
	Order Rhizophlyctidales
	Order Rhizophydiales
	Order Spizellomycetales
Class Monoblepharidomycetes	
	Order Monoblepharidales
Phylum Glomeromycota	
Class Glomeromycetes [= Glomomycetes]	
	Order Archaeosporales
	Order Diversisporales
	Order Glomerales
	Order Paraglomerales
Phylum Zygomycota	
Subphylum N.N.	
Class N.N.	
	Order Basidiobolales
Subphylum Entomophthoromycotina	
Class N.N.	
	Order Entomophthorales
Subphylum Kickxellomycotina	
Class N.N.	
	Order Asellariales
	Order Dimargaritales
	Order Harpellales
	Order Kickxellales
Subphylum Mortierellomycotina	
Class N.N.	
	Order Mortierellales
Subphylum Mucoromycotina	
Class N.N.	
	Order Endogonales
	Order Mucorales
Subphylum Zoopagomycotina	
Class N.N.	
	Order Zoopagales
KINGDOM PLANTAE	
SUBKINGDOM BILIPHYTA	
Phylum Glaucophyta	
Class Glaucophyceae	
	Order Glaucocystales
Phylum Rhodophyta	
Subphylum Cyanidiophytina	
Class Cyanidiophyceae	

(Continued)

Table 2. (Continued)

	Order Cyanidiales
Subphylum Eurhodophytina	
Class Bangiophyceae	
	Order Bangiales
	Order Goniotrichales
Class Florideophyceae	
Subclass N.N.	
	Order Rhodachlyales
Subclass Ahnfeltiophycidae	
	Order Ahnfeltiales
	Order Pihelliales
Subclass Corallinophycidae	
	Order Corallinales
	Order Rhodogorgonales
	Order Sporolithales
Subclass Hildenbrandiophyceae	
	Order Hildenbrandiales
Subclass Nemaliophycidae	
	Order Acrochaetiales
	Order Balbianiales
	Order Balliales
	Order Batrachospermales
	Order Colaconematales
	Order Entwisleiales
	Order Nemaliales
	Order Palmariales
	Order Thoreales
Subclass Rhodymeniophycidae	
	Order Acrosymphytales
	Order Bonnemaisionales
	Order Ceramiales
	Order Gelidiales
	Order Gigartinales
	Order Gracilariales
	Order Halymeniales
	Order Nemastomatales
	Order Peyssonneliales
	Order Plocamiales
	Order Rhodymeniales
	Order Sebdeniales
Subphylum Metarhodophytina	
Class Compsopogonophyceae	
	Order Compsopogonales
	Order Erythropeltidales
	Order Rhodochaetales
Subphylum Rhodellophytina	
Class Porphyridiophyceae	
	Order Porphyridiales
Class Rhodellophyceae	
	Order Dixoniellales

(Continued)

Table 2. (Continued)

	Order Glaucosphaerales
	Order Rhodellales
Class Stylonematophyceae	Order Rufusiales
	Order Stylonematales
SUBKINGDOM VIRIDIPLANTAE	
INFRAKINGDOM CHLOROPHYTA	
Phylum Chlorophyta	
Subphylum Chlorophytina	
Class Chlorodendrophyceae	Order Chlorodendrales
Class Chlorophyceae	Order N.N. (e.g., Chlorangiopsidaceae)
	Order Chaetopeltidales
	Order Chaetophorales
	Order Chlamydomonadales [= Volvocales]
	Order Oedogoniales
	Order Sphaeropleales
Class Pedinophyceae	Order Marsupiomonadales
	Order Pedinomonadales
	Order Scourfieldiales
Class Trebouxiophyceae	Order Chlorellales
	Order Microthamniales
	Order Phyllisiphonales
	Order Prasiolales
	Order Trebouxiales
Class Ulvophyceae	Order Bryopsidales
	Order Cladophorales
	Order Dasycladales
	Order Oltmansiellopsidales
	Order Scotinosphaerales
	Order Trentepohliales
	Order Ulotrichales
	Order Ulvales
Subphylum Prasinophytina	
Class Mamiellophyceae	Order Dolichomastigales
	Order Mamiellales
	Order Monomastigales
Class Nephrophyceae [= Nephroselmidophyceae]	Order Nephroselmidales
Class Pyramimonadophyceae	Order Palmophyllales
	Order Prasinococcales
	Order Pseudoscourfieldiales
	Order Pyramimonadales
INFRAKINGDOM STREPTOPHYTA	

(Continued)

Table 2. (Continued)

Superphylum Charophyta	
Phylum Charophyta	
Class Charophyceae	Order Charales
Class Chlorokybophyceae	Order Chlorokybales
Class Coleochaetophyceae	Order Chaetosphaeriales
	Order Coleochaetales
Class Conjugatophyceae [= Zygnematophyceae]	Order Desmidiaceae
	Order Zygnematales
Class Klebsormidiophyceae	Order Klebsormidiales
Class Mesostigmatophyceae	Order Mesostigmatales
Superphylum Embryophyta	
Phylum Anthocerotophyta	
Class Anthocerotopsida	
Subclass Anthocerotidae	Order Anthocerotales
Subclass Dendrocerotidae	Order Dendrocerotales
	Order Phymatocerales
Subclass Notothylatidae	Order Notothyladales
Class Leiosporocerotopsida	Order Leiosporocerotales
Phylum Bryophyta	
Class Andreaeobryopsida	Order Andreaeobryales
Class Andreaeopsida	Order Andreaeales
Class Bryopsida	
Subclass Bryidae	Order Bartramiales
	Order Bryales
	Order Hedwigiales
	Order Hookeriales
	Order Hypnales
	Order Hypnodendrales
	Order Orthotrichales
	Order Ptychomniales
	Order Rhizogoniales
	Order Splachnales
Subclass Buxbaumiidae	Order Buxbaumiales
Subclass Dicranidae	Order Archidiales
	Order Bryoxiphiales

(Continued)

Table 2. (Continued)

	Order Dicranales
	Order Grimmeriales
	Order Pottiales
	Order Scouleriales
Subclass Diphysciidae	Order Diphysciales
Subclass Funariidae	Order Encalyptales
	Order Funariales
	Order Gigaspermales
Subclass Timmiidae	Order Timmiales
Class Oedipodiopsida	Order Oedipodiales
Class Polytrichopsida	Order Polytrichales
Class Sphagnopsida	Order Ambuchananiales
	Order Sphagnales
Class Takakiopsida	Order Takakiales
Class Tetraphidopsida	Order Tetraphidales
Phylum Marchantiophyta	
Class Haplomitriopsida	Order Calobryales
	Order Treubiales
Class Jungermanniopsida	
Subclass Jungermanniidae	Order Jungermanniales
	Order Porellales
	Order Ptilidiales
Subclass Metzgeriidae	Order Metzgeriales
	Order Pleuroziales
Subclass Pelliidae	Order Fossombroniales
	Order Pallaviciniales
	Order Pelliiales
Class Marchantiopsida	Order Blasiales
	Order Lunulariales
	Order Marchantiales
	Order Neohodgsoniales
	Order Sphaerocarpaceales
Phylum Tracheophyta	
Subphylum Lycopodiophytina	
Class Lycopodiopsida	Order Isoetales
	Order Lycopodiales

(Continued)

Table 2. (Continued)

	Order Selaginellales
Subphylum Polypodiophytina	
Class Polypodiopsida	
Subclass Equisetidae	Order Equisetales
Subclass Marattiidae	Order Marattiales
Subclass Ophioglossidae [= Psilotidae]	Order Ophioglossales
	Order Psilotales
Subclass Polypodiidae	Order Cyatheales
	Order Gleicheniales
	Order Hymenophyllales
	Order Osmundales
	Order Polypodiales
	Order Salviniiales
	Order Schizaeales
Subphylum Spermatophytina	
Superclass "Angiospermae"	
Class Magnoliopsida	
	Superorder N.N.
	Order N.N. (e.g., Icacinaceae)
	Superorder Amborellanae
	Order Amborellales
	Superorder Asteranae
	Order Apiales
	Order Aquifoliales
	Order Asterales
	Order Boraginales
	Order Bruniales
	Order Cornales
	Order Dipsacales
	Order Ericales
	Order Escalloniales
	Order Garryales
	Order Gentianales
	Order Lamiales
	Order Paracryphiales
	Order Solanales
	Superorder Austrobaileyanae
	Order Austrobaileyales
	Superorder Berberidopsidanae
	Order Berberidopsidales
	Superorder Buxanae
	Order Buxales
	Superorder Caryophyllanae
	Order Caryophyllales
	Superorder Ceratophyllanae
	Order Ceratophyllales

(Continued)

Table 2. (Continued)

Superorder Dillenianae
Order Dilleniales
Superorder Lilianae [= Monocotyledones]
Order Acorales
Order Alismatales
Order Arecales
Order Asparagales
Order Commelinales
Order Dasypogonales
Order Dioscoreales
Order Liliales
Order Pandanales
Order Petrosaviales
Order Poales
Order Zingiberales
Superorder Magnolianae
Order Canellales
Order Chloranthales
Order Laurales
Order Magnoliales
Order Piperales
Superorder Myrothamnanae
Order Gunnerales
Superorder Nymphaeanae
Order Nymphaeales
Superorder Proteanae
Order Proteales
Superorder Ranunculanae
Order Ranunculales
Superorder Rosanae
Order Brassicales
Order Celastrales
Order Crossosomatales
Order Cucurbitales
Order Fabales
Order Fagales
Order Geraniales
Order Huerteales
Order Malpighiales
Order Malvales
Order Myrtales
Order Oxalidales
Order Picramniales
Order Rosales
Order Sapindales
Order Vitales
Order Zygophyllales
Superorder Santalanae
Order Santalales
Superorder Saxifraganae

(Continued)

Table 2. (Continued)

	Order Saxifragales
	Superorder Trochodendranae
	Order Trochodendrales
	Superclass "Gymnospermae"
	Class Cycadopsida
	Subclass Cycadidae
	Order Cycadales
	Class Ginkgoopsida
	Subclass Ginkgooidae
	Order Ginkgoales
	Class Gnetopsida
	Subclass Gnetidae
	Order Gnetales
	Class Pinopsida
	Subclass Pinidae
	Order Pinales
KINGDOM ANIMALIA	
SUBKINGDOM N.N.	
Phylum Cnidaria	
Subphylum Anthozoa	
	Class Anthozoa
	Subclass Hexacorallia
	Order Actinaria
	Order Antipatharia
	Order Ceriantharia
	Order Corallimorpharia
	Order Scleractinia
	Order Zoantharia [= Zoanthidea]
	Subclass Octocorallia
	Order Alcyonacea
	Order Helioporacea
	Order Pennatulacea
Subphylum Medusozoa	
	Class Cubozoa
	Order Carybdeida
	Order Chirodropida
	Class Hydrozoa
	Subclass Hydroidolina
	Order Anthoathecata
	Order Gonoproxima
	Order Leptothecata
	Order Siphonophorae
	Subclass Trachylina
	Order Actinulida
	Order Limnomedusae
	Order Narcomedusae
	Order Trachymedusae
	Class Polypodiozoa
	Order Polypodiidea
	Class Scyphozoa

(Continued)

Table 2. (Continued)

		Order Coronatae
		Order Rhizostomeae
		Order Semaestomeae
	Class Staurozoa	
		Order Stauromedusae
	Subphylum Myxozoa	
	Class Malacosporea	
		Order Malacovalvulida
	Class Myxosporea	
		Order Bivalvulida
		Order Multivalvulida
	Phylum Ctenophora	
	Class Nuda	
		Order Beroida
	Class Tentaculata	
		Order Cambojiida
		Order Cestida
		Order Cryptobiferida
		Order Cydippida
		Order Ganeshida
		Order Lobata
		Order Platyctenida
		Order Thalassocalycida
	Phylum Placozoa	
	Class Placozoa (<i>Trichoplax</i>)	
	Phylum Porifera	
	Class Calcarea	
		Order Baerida
		Order Clathrinida
		Order Leucosolenida
		Order Lithonida
		Order Murrayonida
	Class Demospongiae	
		Order Agelasida
		Order Astrophorida
		Order Chondrosida
		Order Dendroceratida
		Order Dictyoceratida
		Order Hadromerida
		Order Halichondrida
		Order Haplosclerida
		Order Lithistida
		Order Poecilosclerida
		Order Spirophorida
		Order Verongida
	Class Hexactinellida	
		Order Amphidiscosida
		Order Aulocalycoida
		Order Fieldingida
		Order Hexactinosida

(Continued)

Table 2. (Continued)

	Order Lychniscosida
	Order Lyssacinosida
Class Homoscleromorpha	Order Homosclerophorida
SUBKINGDOM BILATERIA	
INFRAKINGDOM PROTOSTOMIA	
Superphylum N.N.	
Phylum Chaetognatha	Class Sagittoidea
	Order Aphragmophora
	Order Phragmophora
Phylum Orthonectida	Order Plasmodigenea
Phylum Rhombozoa	Order Dicyemida
	Order Heterocyemida
Superphylum Ecdysozoa	
Phylum Arthropoda	Subphylum Chelicerata
	Class Arachnida
	Superorder N.N.
	Order Amblypygi
	Order Araneae
	Order Opiliones
	Order Palpigradi
	Order Pseudoscorpiones
	Order Ricinulei
	Order Schizomida
	Order Scorpiones
	Order Solifugae
	Order Uropygi
	Superorder Acariformes
	Order Sarcoptiformes
	Order Trombidiformes
	Superorder Parasitiformes
	Order Holothyrida
	Order Ixodida
	Order Mesostigmata
	Order Opilioacarida
Class Merostomata	Order Xiphosura
Class Pycnogonida	Order Pantopoda
Subphylum Crustacea	Class Branchiopoda
	Order Anostraca
	Order Diplostraca
	Order Laevicaudata
	Order Notostraca
Class Cephalocarida	

(Continued)

Table 2. (Continued)

	Order Brachypoda
Class Malacostraca	
Subclass Eumalacostraca	
	Superorder Eucarida
	Order Amphionidacea
	Order Decapoda
	Order Euphausiacea
	Superorder Peracarida
	Order Amphipoda
	Order Bochusacea
	Order Cumacea
	Order Isopoda
	Order Lophogastrida
	Order Mictacea
	Order Mysida
	Order Spelaeogriphacea
	Order Tanaidacea
	Order Thermosbaenacea
	Superorder Syncarida
	Order Anaspidacea
	Order Bathynellacea
Subclass Hoplocarida	
	Order Stomatopoda
Subclass Phyllocarida	
	Order Leptostraca
Class Maxillopoda	
Subclass Branchiura	
	Order Arguloida
Subclass Copepoda	
	Infraclass Neocopepoda
	Superorder Gymnoplea
	Order Calanoida
	Superorder Podoplea
	Order Cyclopoida
	Order Gelyelloida
	Order Harpacticoida
	Order Misophrioida
	Order Monstrilloida
	Order Mormonilloida
	Order Siphonostomatoida
	Infraclass Progymnoplea
	Order Platycopioida
Subclass Mystacocarida	
	Order Mystacocaridida
Subclass Pentastomida	
	Order Cephalobaenida
	Order Porocephalida
Subclass Tantulocarida (e.g., Basipodellidae)	
Subclass Thecostraca	
	Infraclass Ascothoracida

(Continued)

Table 2. (Continued)

	Order Dendrogastrida
	Order Laurida
	Infraclass Cirripedia
	Superorder Acrothoracica
	Order Cryptophialida
	Order Lithoglyptida
	Superorder Rhizocephala
	Order Akentronida
	Order Kentronida
	Superorder Thoracica
	Order Ibliformes
	Order Lepadiformes
	Order Scalpelliformes
	Order Sessilia
	Infraclass Facetotecta (<i>Hansenocaris</i>)
	Class Ostracoda
	Order Halocyprida
	Order Myodocopida
	Order Paleocopida
	Order Platycopida
	Order Podocopida
	Class Remipedia
	Order Nectiopoda
	Subphylum Hexapoda
	Class Collembola
	Order Entomobryomorpha
	Order Neelipleona
	Order Poduromorpha
	Order Symphypleona
	Class Diplura
	Order N.N. (e.g., <i>Japygidae</i>)
	Class Insecta
	Subclass Archaeognatha
	Order Archaeognatha
	Subclass Dicondylia
	Order Zygentoma
	Subclass Pterygota
	Infraclass Neoptera
	Superorder Holometabola
	Order Coleoptera
	Order Diptera
	Order Hymenoptera
	Order Lepidoptera
	Order Mecoptera
	Order Siphonaptera
	Order Strepsiptera
	Order Trichoptera
	Superorder Neuropterida
	Order Megaloptera
	Order Neuroptera

(Continued)

Table 2. (Continued)

	Order Raphidioptera
	Superorder Paraneoptera
	Order Hemiptera
	Order Psocodea
	Order Thysanoptera
	Superorder Polyneoptera
	Order Blattodea
	Order Dermaptera
	Order Embioptera
	Order Grylloblattodea
	Order Mantodea
	Order Mantophasmatodea
	Order Orthoptera
	Order Phasmida
	Order Plecoptera
	Order Zoraptera
	Infraclass Palaeoptera
	Order Ephemeroptera
	Order Odonata
Class Protura	
	Order Acerentomata
	Order Eosentomata
	Order Sinentomata
Subphylum Myriapoda	
Class Chilopoda	
	Order Craterostigmomorpha
	Order Geophilomorpha
	Order Lithobiomorpha
	Order Scolopendromorpha
	Order Scutigermomorpha
Class Diplopoda	
Subclass Chilognatha	
Infraclass Helminthomorpha	
Superorder N.N.	
	Order Platydesmida
	Order Polyzoniida
	Order Siphonocryptida
	Order Siphonophorida
Superorder Juliformia	
	Order Julida
	Order Spirobolida
	Order Spirostreptida
Superorder Nematophora	
	Order Callipodida
	Order Chordeumatida
	Order Stemmiulida
	Order Siphoniulida
Superorder Merochaeta	
	Order Polydesmida
Infraclass Pentazonia	

(Continued)

Table 2. (Continued)

	Order Glomerida
	Order Glomeridesmida
	Order Sphaerotheriida
	Subclass Penicillata
	Order Polyxenida
	Class Pauropoda
	Order Hexamerocerata
	Order Tetramerocerata
	Class Symphyla (e.g., Scolopendrellidae)
Phylum Kinorhyncha	
	Order Cyclorhagida
	Order Homalorhagida
Phylum Loricifera	
	Order Nanaloricida
Phylum Nematoda	
	Class Chromadorea
	Subclass Chromadoria
	Order Chromadorida
	Order Desmodorida
	Order Desmoscolecida
	Order Selachinematida
	Subclass Plectia
	Superorder Monhysterica
	Order Monhysterida
	Superorder Plectica
	Order Benthimermithida
	Order Leptolaimida
	Order Plectida
	Superorder Rhabditica
	Order Diplogasterida
	Order Drilonematida
	Order Panagrolaimida
	Order Rhabditida
	Order Spirurida
	Superorder Teratocephalica
	Order Teratocephalida
	Class Dorylaimea
	Subclass Bathyodontia
	Order Bathyodontida
	Order Mermithida
	Order Mononchida
	Subclass Dorylaimia
	Order Dorylaimida
	Subclass Trichocephalia
	Order Diectophymatida
	Order Marimermithida
	Order Muspiceida
	Order Trichocephalida
	Class Enoplea
	Subclass Enoplia

(Continued)

Table 2. (Continued)

	Order Alaimida
	Order Enoplida
	Order Ironida
	Order Rhaptothyreida
	Order Trifusiida
	Order Tripyloidida
	Subclass Oncholaimia
	Order Oncholaimida
	Subclass Triplonchia
	Order Triplonchida
	Order Tripylida
Phylum Nematomorpha	
	Order Gordioidea
	Order Nectonematoidea
Phylum Onychophora	
	Class Udeonycophora
	Order Euonycophora
Phylum Priapula [= Priapulida]	
	Class N.N. (e.g., Priapulidae)
Phylum Tardigrada	
	Class Eutardigrada
	Order Apochela
	Order Parachela
	Class Heterotardigrada
	Order Arthrotardigrada
	Order Echiniscoidea
Superphylum Spiralia [= Lophotrochozoa]	
Phylum Acanthocephala	
	Class Archiacanthocephala
	Order Apororhynchida
	Order Gigantorhynchida
	Order Moniliformida
	Order Oligacanthorhynchida
	Class Eoacanthocephala
	Order Gyracanthocephala
	Order Neoechinorhynchida
	Class Palaeacanthocephala
	Order Echinorhynchida
	Order Heteramorphida
	Order Polymorphida
	Class Polyacanthocephala
	Order Polyacanthorhynchida
Phylum Annelida	
	Class N.N.
	Order Myzostomida
	Class Clitellata
	Subclass N.N.
	Order Apodadrilida
	Subclass Hirudinea
	Order Acanthobdellida

(Continued)

Table 2. (Continued)

	Order Arhynchobdellida
	Order Rhynchobdellida
	Subclass Oligochaeta
	Superorder N.N.
	Order N.N. (<i>Jennaria</i>)
	Order Branchiobdellida
	Order Capilloventrida
	Order Crassiclitellata
	Order Enchytraeida
	Order Haplotaxida
	Order Lumbriculida
	Order Tubificida
	Superorder Metagynaphora
	Order Moniligastrida
	Order Opisthophora
	Class Polychaeta
	Subclass N.N.
	Order N.N. (e.g., Nerillidae)
	Subclass Echiura
	Order Echiuroinea
	Order Heteromyota
	Order Xenopneusta
	Subclass Errantia
	Order Amphinomida
	Order Eunicida
	Order Phyllodocida
	Subclass Sedentaria
	Infraclass Canalipata
	Order Sabellida
	Order Spionida
	Order Terebellida
	Infraclass Scolecida (e.g., Arenicolidae)
Phylum Brachiopoda	
	Class Craniata
	Order Craniida
	Class Lingulata
	Order Lingulida
	Class Rhynchonellata
	Order Rhynchonellida
	Order Terebratulida
	Order Thecideida
Phylum Bryozoa	
	Class Gymnolaemata
	Order Cheilostomata
	Order Ctenostomata
	Class Phylactolaemata
	Order Plumatellida
	Class Stenolaemata
	Order Cyclostomata
Phylum Cyclophora	

(Continued)

Table 2. (Continued)

	Class Eucyclophora	
		Order Symbiida
Phylum Entoprocta		Order Coloniales
		Order Solitaria
Phylum Gastrotricha		Order Chaetonotida
		Order Macrodsasyida
Phylum Gnathostomulida		Order Bursovaginoidea
		Order Filospermoidea
Phylum Micrognathozoa	Class Micrognathozoa	
		Order Limnognathida
Phylum Mollusca	Class Bivalvia	
	Subclass Autobranchia	
		Superorder Heteroconchia
		Order Carditida
		Order Lucinida
		Order Myida
		Order Pholadomyida
		Order Trigoniida
		Order Unionida
		Order Veneroidea
		Superorder Pteriomorphia
		Order Arcida
		Order Limida
		Order Mytilida
		Order Ostreida
		Order Pectinida
		Order Pteriida
	Subclass Protobranchia	
		Order Nuculanida
		Order Nuculida
		Order Solemyoidea
	Class Caudofoveata	
		Order Chaetodermatida
	Class Cephalopoda	
	Subclass Coleoidea	
		Superorder Decabrachia
		Order Sepiida
		Order Sepiolida
		Order Spirulida
		Order Teuthida
		Superorder Octobrachia
		Order Octopoda
		Order Vampyromorphida
	Subclass Nautiloidea	
		Order Nautilida

(Continued)

Table 2. (Continued)

	Class Gastropoda	
	Subclass Caenogastropoda	
		Order Littorinimorpha
		Order Neogastropoda
	Subclass Cocculiniformia (e.g., Cocculinidae)	
	Subclass Heterobranchia	
		Order Acochlidioidea
		Order Anaspidea
		Order Cephalaspidea
		Order Gymnosomata
		Order Hygrophila
		Order Nudibranchia
		Order Pleurobranchomorpha
		Order Runcinacea
		Order Sacoglossa
		Order Stylommatophora
		Order Systellommatophora
		Order Thecosomata
		Order Umbraculida
	Subclass Neomphalina	
		Order N.N. (e.g., Neomphalidae)
	Subclass Neritimorpha	
		Order Cycloneritimorpha
	Subclass Patellogastropoda	
		Order N.N. (e.g., Patellidae)
	Subclass Vetigastropoda	
		Order N.N. (e.g., Ataphridae)
	Class Monoplacophora	
		Order Tryblidiida
	Class Polyplacophora	
		Order Chitonida
		Order Lepidopleurida
	Class Scaphopoda	
		Order Dentaliida
		Order Gadilida
	Class Solenogastres	
		Superorder Aplotegmentaria
		Order Cavibelonia
		Order Sterrofungia
		Superorder Pachytegmentaria
		Order Neomeniamorpha
		Order Pholidoskepia
Phylum Nemertea		
	Class Anopla	
		Order N.N. (e.g., Gorgonorhynchidae)
	Class Enopla	
		Order Monostilifera
		Order Polystilifera
	Class Paleonemertea (e.g., Carinomidae)	
Phylum Phoronida		

(Continued)

Table 2. (Continued)

	Class N.N. (e.g., <i>Phoronis</i>)
Phylum Platyhelminthes	
Subphylum Catenulidea	Order Catenulida
Subphylum Rhabditophora	
Class Macrostomorpha	Order Haplopharyngida Order Macrostomida
Class Neophora	
Subclass Eulecithophora	
Infraclass Adiaphanida	Order Fecampiida Order Prolecithophora Order Tricladida
Infraclass Rhabdocoela	Order Dalytyphloplanida Order Endoaxonemata Order Kalyptorhynchia
Subclass Neodermata	
Infraclass Cestoda	Order Amphilinidea Order Bothriocephalidea Order Caryophyllidea Order Cyclophyllidea Order Diphyllidea Order Diphylobothriidea Order Gyrocotylidea Order Lecanicephalidea Order Litobothriidea Order Proteocephalidea Order Pseudophyllidea Order Rhinebothriidea Order Spathebothriidea Order Tetrabothriidea Order Tetraphyllidea Order Trypanorhyncha
Infraclass Monogenea	Order Capsalidea Order Chimaericolidea Order Dactylogyridea Order Dicybothriidea Order Gyrodactylidea Order Mazocraeidea Order Monocotylidea Order Montchadskyellidea Order Polystomatidea
Infraclass Trematoda	Order Aspidogastriida Order Diplostomida Order Plagiorchiida

(Continued)

Table 2. (Continued)

		Order Stichocotylida
	Class Polycladidea	Order Lecithoepitheliata
		Order Polycladida
	Subclass Proseriata	Order Proseriata
Phylum Rotifera		
	Class Eurotatoria	
	Subclass Bdelloidea (e.g., Adinetidae)	
	Subclass Monogonta	Order Collothecaceae
		Order Flosculariaceae
		Order Ploima
	Class Pararotatoria	Order Seisonacea
Phylum Sipuncula		
	Class Phascolosomatidea	Order Aspidosiphoniformes
		Order Phascolosomatiformes
	Class Sipunculidea	Order Golfingiiformes
		Order Sipunculiformes
INFRAKINGDOM DEUTEROSTOMIA		
Phylum Chordata		
Subphylum Cephalochordata		Order Amphioxiformes
Subphylum Urochordata		
	Class Appendicularia	Order Copelata
	Class Ascidiacea	Order Enterogona
		Order Pleurogona
	Class Thaliacea	Order Doliolida
		Order Pyrosomida
		Order Salpida
Subphylum Vertebrata [= Craniata]		
Infraphylum Agnatha		
	Class Cephalaspidomorphi	Order Petromyzontiformes
	Class Myxini	Order Myxiniformes
Infraphylum Gnathostomata		
Superclass Actinopterygii		
	Class Chondrostei	Order Acipenseriformes
	Class Cladistei	Order Polypteriformes
	Class Holostei	Order Amiiformes

(Continued)

Table 2. (Continued)

	Order Lepisosteiformes
Class Teleostei	Order Acanthuriformes
	Order Albuliformes
	Order Alepocephaliformes
	Order Anabantiformes
	Order Anguilliformes
	Order Argentiniformes
	Order Ateleopodiformes
	Order Atheriniformes
	Order Aulopiformes
	Order Batrachoidiformes
	Order Beloniformes
	Order Beryciformes
	Order Blenniiformes
	Order Carangiformes
	Order Centrarchiformes
	Order Characiformes
	Order Cichliformes
	Order Cirrhitiformes
	Order Clupeiformes
	Order Cypriniformes
	Order Cyprinodontiformes
	Order Elopiformes
	Order Ephippiformes
	Order Esociformes
	Order Gadiformes
	Order Galaxiiformes
	Order Gobiiformes
	Order Gonorynchiformes
	Order Gymnotiformes
	Order Hidontiformes
	Order Holocentriformes
	Order Istiophoriformes
	Order Kurtiformes
	Order Labriformes
	Order Lampridiformes
	Order Lepidogalaxiiformes
	Order Lobotiformes
	Order Lophiiformes
	Order Mugiliformes
	Order Myctophiformes
	Order Notacanthiformes
	Order Ophidiiformes
	Order Osmeriformes
	Order Osteoglossiformes
	Order Pempheriformes
	Order Perciformes
	Order Percopsiformes
	Order Pholidichthyiformes

(Continued)

Table 2. (Continued)

	Order Pleuronectiformes
	Order Polymixiiformes
	Order Salmoniformes
	Order Scombriformes
	Order Siluriformes
	Order Spariformes
	Order Stomiatiformes
	Order Stylephoriformes
	Order Synbranchiformes
	Order Syngnathiformes
	Order Terapontiformes
	Order Tetraodontiformes
	Order Uranoscopiformes
	Order Zeiformes
	Superclass Chondrichthyes
	Class Elasmobranchii
	Order Carcharhiniformes
	Order Heterodontiformes
	Order Hexanchiformes
	Order Lamniformes
	Order Myliobatiformes
	Order Orectolobiformes
	Order Pristiformes
	Order Pristiophoriformes
	Order Rajiformes
	Order Squaliformes
	Order Squatiniformes
	Order Torpediniformes
	Class Holocephali
	Order Chimaeriformes
	Superclass Sarcopterygii
	Class Coelacanthi
	Order Coelacanthiformes
	Class Dipnoi
	Order Ceratodontiformes
	Order Lepidosirenoformes
	Superclass Tetrapoda
	Class Amphibia
	Order Anura
	Order Caudata
	Order Gymnophiona
	Class Mammalia
	Subclass Prototheria
	Order Monotremata
	Subclass Theria
	Infraclass Eutheria [= Placentalia]
	Order Afrosoricida
	Order Artiodactyla
	Order Carnivora
	Order Cetacea

(Continued)

Table 2. (Continued)

	Order Chiroptera
	Order Cingulata
	Order Dermoptera
	Order Erinaceomorpha
	Order Hyracoidea
	Order Lagomorpha
	Order Macroscelidea
	Order Perissodactyla
	Order Pholidota
	Order Pilosa
	Order Primates
	Order Proboscidea
	Order Rodentia
	Order Scandentia
	Order Sirenia
	Order Soricomorpha
	Order Tubulidentata
	Infraclass Metatheria [= Marsupialia]
	Order Dasyuromorphia
	Order Didelphimorphia
	Order Diprotodontia
	Order Microbiotheria
	Order Notoryctemorphia
	Order Paucituberculata
	Order Peramelemorphia
	Class Reptilia
	Subclass Aves
	Infraclass Neognathae
	Superorder Galloanseri
	Order Anseriformes
	Order Galliformes
	Superorder Neoaves
	Order Accipitriformes
	Order Apodiformes
	Order Bucerotiformes
	Order Caprimulgiformes
	Order Cariamiformes
	Order Charadriiformes
	Order Ciconiiformes
	Order Coliiformes
	Order Columbiformes
	Order Coraciiformes
	Order Cuculiformes
	Order Eurypygiformes
	Order Falconiformes
	Order Gaviiformes
	Order Gruiformes
	Order Leptosomiformes
	Order Mesitornithiformes
	Order Musophagiformes

(Continued)

Table 2. (Continued)

	Order Opisthocomiformes
	Order Otidiformes
	Order Passeriformes
	Order Pelecaniformes
	Order Phaethontiformes
	Order Phoenicopteriformes
	Order Piciformes
	Order Podicipediformes
	Order Procellariiformes
	Order Psittaciformes
	Order Pteroclidiformes
	Order Sphenisciformes
	Order Strigiformes
	Order Suliformes
	Order Trogoniformes
	Infraclass Paleognathae
	Order Apterygiformes
	Order Casuariiformes
	Order Rheiformes
	Order Struthioniformes
	Order Tinamiformes
	Subclass Crocodylomorpha
	Order Crocodylia
	Subclass Rhynchocephalia
	Order Sphenodontida
	Subclass Squamata
	Order Anguimorpha
	Order Gekkota
	Order Inguania
	Order Lacertoidea
	Order Scincoidea
	Order Serpentes
	Subclass Testudinata
	Order Testudines
Phylum Echinodermata	
Subphylum Asterozoa	
	Class Asteroidea
	Order Brisingida
	Order Forcipulatida
	Order Notomyotida
	Order Paxillosida
	Order Peripoda
	Order Spinulosida
	Order Valvatida
	Order Velatida
	Class Ophiuroidea
	Order Euryalida
	Order Ophiurida
Subphylum Crinozoa	
	Class Crinoidea

(Continued)

Table 2. (Continued)

	Order Comatulida
	Order Cyrtocrinida
	Order Hyocrinida
	Order Isocrinida
Subphylum Echinozoa	
Class Echinoidea	
Subclass Cidaroidea	
	Order Cidaroida
Subclass Euechinoidea	
Infraclass N.N.	
	Order Echinothurioida
Infraclass Acroechinoidea	
	Order Aspidodiadematoida
	Order Diadematoida
	Order Micropygoida
	Order Pedinoidea
Infraclass Carinacea	
	Order Arbacioidea
	Order Camarodonta
	Order Salenioidea
	Order Stomopneustoida
Infraclass Irregularia	
	Order Cassiduloida
	Order Clypeasteroida
	Order Echinolampadoida
	Order Holasteroida
	Order Spatangoida
Class Holothuroidea	
	Order N.N. (<i>Thyone</i>)
	Order Apodida
	Order Aspidochirotida
	Order Dendrochirotida
	Order Elasipodida
	Order Molpadida
Phylum Hemichordata	
Class Enteropneusta (e.g., Harrimaniidae)	
Class Pterobranchia	
Subclass Cephalodiscida (<i>Cephalodiscus</i>)	
Subclass Graptolithina	
	Order Rhabdopleurida
Phylum Xenacoelomorpha	
Subphylum Acoelomorpha	
Class Acoela (e.g., Diopisthoporidae)	
Class Nemertodermatida (e.g., Nemertodermatidae)	
Subphylum Xenoturbellida	
Class N.N. (Xenoturbellidae)	

Names below rank of infrakingdom are arranged alphabetically within each parent rank, except for taxa that are not named (N.N.). Brackets indicate synonyms. Quoted names are not validly published but in common use.

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the many taxa therein and provides for easier import and manipulation of data by information systems.

Supporting Information

S1 Appendix. List of sources consulted for proposed higher level classification of all living organisms.

(PDF)

S1 Table. Proposed hierarchical classification from superkingdom to order.

(XLSX)

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Author Contributions

Conceived and designed the experiments: MR DG NB TB RB TC-S MG PK TO. Analyzed the data: MR DG NB TB RB TC-S MG PK TO. Wrote the paper: MR DG NB TB RB TC-S MG PK TO.

References

1. Hennig W. Phylogenetic systematics, translated by Davis D & Zangerl R. Champaign-Urbana: University of Illinois; 1966.
2. Mayr E, Bock WJ. Classifications and other ordering systems. *J Zool Syst Evol Res.* 2002; 40: 169–194.
3. Stuessy TF, Hoerandl E. The importance of comprehensive phylogenetic (evolutionary) classification—a response to Schmidt-Lebuhn’s commentary on paraphyletic taxa. *Cladistics.* 2014; 30: 291–293.
4. Schmidt-Lebuhn AN. “Evolutionary” classifications do not have any information content—a reply to Stuessy and Hoerandl. *Cladistics.* 2014; 30: 229–231.
5. Chapman AD. Numbers of living species in Australia and the world, second edition. Australian Biodiversity Information Services, Toowoomba, Australia. A Report for the Australian Biological Resources Study; 2009.
6. Roskov Y, Kunze T, Orrell T, Abucay L, Paglinawan L, Culham A, et al., editors. *Species 2000 & ITIS Catalogue of Life, 2014 Annual Checklist [DVD]*. 2014; Naturalis, Leiden, the Netherlands: Species 2000.
7. Parker SP, editor. *Synopsis and classification of living organisms, volumes 1 & 2*. New York: McGraw Hill; 1982.
8. Vences M, Guayasamin JM, Miralles A, De la Riva I. To name or not to name: criteria to promote economy of change in Linnaean classification schemes. *Zootaxa.* 2013; 3636: 201–244.
9. Linnaeus C. *Species plantarum, exhibentes plantas rite cognitatas, ad genera relatas, cum differentiis specificis, nominis trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas*. Stockholm: Laurentius Salvius; 1753.
10. Linnaeus C. *Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis* (10th edition). Stockholm: Laurentius Salvius; 1758.
11. David J, Garrity GM, Greuter W, Hawksworth D, Jahn R, Kirk P et al. Biological nomenclature terms for facilitating communication in the naming of organisms. *ZooKeys.* 2012; 192: 67–72. doi: [10.3897/zookeys.192.3347](https://doi.org/10.3897/zookeys.192.3347) PMID: [22639540](https://pubmed.ncbi.nlm.nih.gov/22639540/)

12. Adl SM, Simpson AGB, Farmer MA, Andersen RA, Anderson OR, Barta JR, et al. The new higher level classification of eukaryotes with emphasis on the taxonomy of protists. *J Eukaryot Microbiol.* 2005; 52: 399–451. PMID: [16248873](#)
13. Baldauf SL. The deep roots of eukaryotes. *Science.* 2003; 300: 1703–1706. PMID: [12805537](#)
14. Simpson AGB, Roger AJ. The real 'kingdoms' of eukaryotes. *Curr Biol.* 2004; 14: R693–R696. PMID: [15341755](#)
15. Keeling PJ, Burger G, Durnford DG, Lang BF, Lee RW, Pearlman RE, et al. The tree of eukaryotes. *Trends Ecol Evol.* 2005; 20: 670–676. PMID: [16701456](#)
16. Wegener Parfrey L, Barbero E, Lasser E, Dunthorn M, Bhattacharya D, Patterson D, et al. Evaluating support for the current classification of eukaryotic diversity. *PLoS Genet.* 2. 2006; (e220:): 2062–2073.
17. Lane CE, Archibald JM. The eukaryotic tree of life: endosymbiosis takes its TOL. *Trends Ecol Evol.* 2008; 23: 268–275. doi: [10.1016/j.tree.2008.02.004](#) PMID: [18378040](#)
18. Adl SM, Simpson AGB, Lane CE, Lukeš J, Bass D, Bowser SS, et al. The revised classification of eukaryotes. *J. Eukaryot Microbiol.* 2012; 59: 429–493. doi: [10.1111/j.1550-7408.2012.00644.x](#) PMID: [23020233](#)
19. Cavalier-Smith T. A revised six-kingdom system of life. *Biol Rev.* 1998; 73: 203–266. PMID: [9809012](#)
20. Mayr E, Ashlock PD. *Principles of systematic zoology*, 2nd edition. New York: McGraw Hill; 1991.
21. Cavalier-Smith T. Deep phylogeny, ancestral groups, and the four ages of life. *Philos Trans R Soc Lond B Biol Sci.* 2010; 365: 111–132. doi: [10.1098/rstb.2009.0161](#) PMID: [20008390](#)
22. Keeling PJ, Palmer JD. Horizontal gene transfer in eukaryotic evolution. *Nat Rev Genet.* 2008; 9: 605–618. doi: [10.1038/nrg2386](#) PMID: [18591983](#)
23. Liu R, editor. *Checklist of marine biota of Chinese seas*. Beijing: Science Press, Academia Sinica; 2008.
24. Gordon DP, editor. *New Zealand inventory of biodiversity, volume one, Kingdom Animalia: Radiata, Lophotrochozoa, Deuterostomia*. Christchurch: Canterbury University Press. 2009.
25. Gordon DP, editor. *New Zealand inventory of biodiversity, volume two, Kingdom Animalia: Chaetognatha, Ecdysozoa, Ichnofossils*. Christchurch: Canterbury University Press. 2010.
26. Gordon DP, editor. *New Zealand inventory of biodiversity, volume three, Kingdoms Bacteria, Protozoa, Chromista, Plantae, Fungi*. Christchurch: Canterbury University Press. 2012.
27. Woese CR, Fox GE. Phylogenetic structure of the prokaryote domain: the primary kingdoms. *Proc Natl Acad Sci USA.* 1977; 74(11): 5088–5090. PMID: [270744](#)
28. Margulis L, Schwartz KV. *Five kingdoms: an illustrated guide to the phyla of life on earth*, third edition. New York: WH Freeman and Company; 2001.
29. Cavalier-Smith T. The neomuran revolution and phagotrophic origin of eukaryotes in the light of intracellular coevolution and a revised tree of life. In: *The origin and evolution of eukaryotes*. Keeling PJ, Koonin EV, editors. Cold Spring Harb Perspect Biol; 2014. doi: [10.1101/cshperspect.a016006](#)
30. LPSN—list of prokaryotic names with standing in nomenclature; 2013. Available: <http://www.bacterio.net>. Accessed 21 October 2014.
31. Garrity GM, Lilburn TG, Cole JR, Harrison SH, Euzéby J, Tindall BJ. Taxonomic Outline of Bacteria and Archaea (TOBA) Release 7.7; 2007. Available: <http://www.taxonomicoutline.org/index.php/toba/issue/view/3>. Accessed 2012 October 23.
32. Parte AC. LPSN—list of prokaryotic names with standing in nomenclature. *Nucleic Acids Research.* 2014; 42, Database issue D613–D616, doi: [10.1093/nar/gkt1111](#) PMID: [24243842](#)
33. Cavalier-Smith T. What are Fungi? In: McLaughlin DJ, McLaughlin EJ, Lemke P, editors. *The Mycota, volume VII Part A*. Berlin: Springer-Verlag; 2000.
34. James TY, Pelin A, Bonen L, Ahrendt S, Sain D, Corradi N, et al. Shared signatures of parasitism and phylogenomics unite Cryptomycota and Microsporidia. *Curr Biol.* 2013; 23: 1548–1553. doi: [10.1016/j.cub.2013.06.057](#) PMID: [23932404](#)
35. Cavalier-Smith T. Eukaryote kingdoms: seven or nine? *Biosystems.* 1981; 14: 461–481. PMID: [7337818](#)
36. Burki F, Inagaki Y, Bråte J, Archibald JM, Keeling PJ, Cavalier-Smith T, et al. Large-scale phylogenomic analyses reveal that two enigmatic protist lineages, Telonemia and Centroheliozoa, are related to photosynthetic chromalveolates. *Genome Biol Evol.* 2009; 1: 231–238. doi: [10.1093/gbe/evp022](#) PMID: [20333193](#)

37. Burki F, Okamoto N, Pombert JF, Keeling PJ. The evolutionary history of haptophytes and cryptophytes: phylogenomic evidence for separate origins. *Proc R Soc Lond B Biol Sci.* 2012; 279: 2246–2254.
38. Cavalier-Smith T. Early evolution of eukaryote feeding modes, cell structural diversity, and classification of the protozoan phyla Loukozoa, Sulcozoa, and Choanozoa. *Eur J Protistol.* 2013; 49: 115–178. doi: [10.1016/j.ejop.2012.06.001](https://doi.org/10.1016/j.ejop.2012.06.001) PMID: [23085100](https://pubmed.ncbi.nlm.nih.gov/23085100/)
39. Cavalier-Smith T, Chao EE, Snell EA, Berney C, Fiore-Donno AM, Lewis R. Multigene eukaryote phylogeny reveals the likely protozoan ancestors of opisthokonts (animals, fungi, choanozoans) and Amoebozoa. *Mol Phylogen Evol.* 2014; 81: 71–85. doi: [10.1016/j.ympev.2014.08.012](https://doi.org/10.1016/j.ympev.2014.08.012) PMID: [25152275](https://pubmed.ncbi.nlm.nih.gov/25152275/)
40. Kirk PM, Cannon PF, Minter DM, Stalpers JA. *Dictionary of Fungi*, 10th Edition. Oxon, UK: CAB International; 2008.
41. Jeffrey C. Thallophytes and kingdoms—a critique. *Kew Bull.* 1971; 25: 291–299.
42. Cavalier-Smith T. The origin, losses and gains of chloroplasts. In: Lewin RA, editor. *Origin of plastids: Symbiogenesis, prochlorophytes and the origins of chloroplasts.* Chapman & Hall, New York; 1993.
43. Bremer K. Summary of green plant phylogeny and classification. *Cladistics.* 1985; 1(4): 369–385.
44. Chase MW, Reveal JL. A phylogenetic classification of the land plants to accompany APG III. *Bot J Linn Soc.* 2009; 161: 122–127.
45. Stech M, Frey W. A morpho-molecular classification of the mosses (Bryophyta). *Nova Hedwigia.* 2008; 86: 1–21.
46. Villarreal JC, Cargill C, Hagborg A, Söderström L, Renzaglia KS. A synthesis of hornwort diversity: patterns, causes and future work. *Phytotaxa.* 2010; 9: 150–166.
47. Mabberley DJ. *Mabberley's plant-book: A portable dictionary of plants, their classifications, and uses.* Cambridge, UK: Cambridge University Press; 2008.
48. Stevens PF. Angiosperm phylogeny website, Version 12; 2014. Available: <http://www.mobot.org/MOBOT/research/APweb>. Accessed 18 November 2014.
49. Zrzavý J, Mihulka S, Kepka P, Bezdák A. Phylogeny of the Metazoa based on morphological and 18S ribosomal DNA evidence. *Cladistics.* 1998; 14: 249–285.
50. Giribet G. Relationships among metazoan phyla as inferred from 18S rRNA sequence data: a methodological approach. In: Desalle R, Giribet G, Wheeler WC, editors. *Molecular systematics and evolution: theory and practice.* Basel: Birkhauser Verlag; 2002.
51. Mallatt J, Winchell CJ. Testing the new animal phylogeny: first use of combined large-subunit and small-subunit rRNA gene sequences to classify the protostomes. *Mol Biol Evol.* 2002; 19: 289–301. PMID: [11861888](https://pubmed.ncbi.nlm.nih.gov/11861888/)
52. Halanych KM. The new view of animal phylogeny. *Annu Rev Ecol Evol Syst.* 2004; 35: 229–256.
53. Jenner RA. Towards a phylogeny of the Metazoa: evaluating alternative phylogenetic positions of Platyhelminthes, Nemertea, and Gnathostomulida, with a critical appraisal of cladistics characters. *Contrib Zool.* 2004; 73: 3–163.
54. Giribet G, Dunn CW, Edgecombe GD, Rouse GW. A modern look at the animal tree of life. *Zootaxa.* 2007; 1668: 61–79.
55. Dunn CW, Hejnol A, Matus DQ, Pang K, Browne WE, Smith SA, et al. Broad phylogenomic sampling improves resolution of the animal tree of life. *Nature.* 2008; 452: 745–749. doi: [10.1038/nature06614](https://doi.org/10.1038/nature06614) PMID: [18322464](https://pubmed.ncbi.nlm.nih.gov/18322464/)
56. Paps J, Baguña J, Riutort M. Lophotrochozoa internal phylogeny: new insights from an up-to-date analysis of nuclear ribosomal genes. *Proc R Soc Lond B Biol Sci.* 2009; 276: 1245–1254.
57. Hejnol A, Obst M, Stamatakis A, Ott M, Rouse GW, Edgecombe GD, et al. Assessing the root of bilaterian animals with scalable phylogenomic methods. *Proc R Soc Lond B Biol Sci.* 2009; 276: 4261–4270.
58. Pick KS, Philippe H, Schreiber F, Erpenbeck D, Jackson DJ, Wrede P, et al. Improved phylogenomic taxon sampling noticeably affects nonbilaterian relationships. *Mol Biol Evol.* 2010; 27: 1983–1987. doi: [10.1093/molbev/msq089](https://doi.org/10.1093/molbev/msq089) PMID: [20378579](https://pubmed.ncbi.nlm.nih.gov/20378579/)
59. Edgecombe GD, Giribet G, Dunn CW, Hejnol A, Kristensen RM, Neves RC, et al. Higher-level metazoan relationships: recent progress and remaining questions. *Org Divers Evol.* 2011; 11: 151–172.
60. Zhang Z-Q. Animal diversity: an introduction to higher-level classification and taxonomic richness. *Zootaxa.* 2011; 3148: 7–12.
61. Zhang Z-Q. Animal biodiversity: an update of classification and diversity in 2013. *Zootaxa.* 2013; 3703: 5–11.

62. Nielsen C. Six major steps in animal evolution: are we derived sponge larvae? *Evol Dev.* 2008; 10: 241–257. doi: [10.1111/j.1525-142X.2008.00231.x](https://doi.org/10.1111/j.1525-142X.2008.00231.x) PMID: [18315817](https://pubmed.ncbi.nlm.nih.gov/18315817/)
63. Sperling EA, Peterson KJ, Pisani D. Phylogenetic-signal dissection of nuclear-housekeeping genes supports the paraphyly of sponges and the monophyly of Eumetazoa. *Mol Biol Evol.* 2009; 26: 2261–2274. doi: [10.1093/molbev/msp148](https://doi.org/10.1093/molbev/msp148) PMID: [19597161](https://pubmed.ncbi.nlm.nih.gov/19597161/)
64. Philippe H, Derelle R, Lopez P, Pick K, Borchiellini C, Boury-Esnault N, et al. Phylogenomics revives traditional views on deep animal relationships. *Curr Biol.* 2009; doi: [10.1016/j.cub.2009.02.052](https://doi.org/10.1016/j.cub.2009.02.052)
65. Hooper JNA, van Soest RWM, editors. *Systema Porifera: a guide to the classification of sponges.* New York: Kluwer Academic/Plenum Publishers; 2002.
66. Hooper JNA, van Soest RWM, Pisera A. Phylum Porifera Grant, 1826. In: Zhang Z-Q, editor. *Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness* *Zootaxa.* 2011; 3148: 13–18.
67. Gazave E, Lapébie P, Ereskovsky AV, Vacelet J, Renard E, Cárdenas P, et al. No longer Demospongiae: Homoscleromorpha formal nomination as a fourth class of Porifera. *Hydrobiologia.* 2012; 687: 3–10.
68. Jiménez-Guri E, Philippe H, Okamura B, Holland PWH. *Buddenbrockia* is a cnidarian worm. *Science.* 2007; 317: 116–118. PMID: [17615357](https://pubmed.ncbi.nlm.nih.gov/17615357/)
69. Gruhl A, Okamura B. Development and myogenesis of the vermiform *Buddenbrockia* (Myxozoa) and implications for cnidarian body plan evolution. *Evodevo.* 2012; 310: 1–15.
70. Nielsen C. *Animal evolution: interrelationships of the living phyla.* Oxford, UK: Oxford University Press; 1995.
71. Egger B, Steinke D, Tarui H, De Mulder K, Arendt D, Borgonie G, et al. To be or not to be a flatworm: the acoel controversy. *PLoS One.* 2009; 45e5502: 1–10.
72. Philippe H, Brinkmann H, Copley RR, Moroz LL, Nakano H, Poustka AJ, et al. Acoelomorph flatworms are deuterostomes related to *Xenoturbella*. *Nature.* 2011; 470: 255–258. doi: [10.1038/nature09676](https://doi.org/10.1038/nature09676) PMID: [21307940](https://pubmed.ncbi.nlm.nih.gov/21307940/)
73. Tyler S, Schilling S. Phylum Xenacoelomorpha Philippe et al, 2011. In: Zhang Z-Q, editor. *Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness.* *Zootaxa.* 2011; 3148: 24–25.
74. Riutort M, Álvarez-Presas M, Lázaro E, Solà E, Paps J. Evolutionary history of the Tricladida and the Platyhelminthes: an up-to-date phylogenetic and systematic account. *Int J Dev Biol.* 2012; 56: 5–17. doi: [10.1387/ijdb.113441mr](https://doi.org/10.1387/ijdb.113441mr) PMID: [22450992](https://pubmed.ncbi.nlm.nih.gov/22450992/)
75. Tyler S. Turbellarian taxonomic database; 2014. Available: <http://turbellaria.umaine.edu/>. Accessed 3 February 2014.
76. Ruppert EE, Barnes RD. *Invertebrate zoology, sixth edition.* Orlando: Saunders College Publishing, Harcourt Brace and Company; 1994.
77. Brusca RC, Brusca GJ. *Invertebrates, second edition.* Sunderland, MA: Sinauer Associates Inc.; 2003.
78. Monks S. Phylogeny of the Acanthocephala based on morphological characters. *Syst Parasitol.* 2001; 48: 81–116. PMID: [11252279](https://pubmed.ncbi.nlm.nih.gov/11252279/)
79. Monks S, Richardson DJ. Phylum Acanthocephala Kohlreuter, 1771. In: Zhang Z-Q, editor. *Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness.* *Zootaxa.* 2011; 3148: 234–237.
80. Segers H. Phylum Rotifera Cuvier, 1817. In: Zhang Z-Q, editor. *Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness.* *Zootaxa.* 2011; 3148: 231–233.
81. Garey JR, Near TJ, Nonnemacher MR, Nadler SA. Molecular evidence for Acanthocephala as a sub-taxon of Rotifera. *J Mol Evol.* 1996; 43: 287–292. PMID: [8703095](https://pubmed.ncbi.nlm.nih.gov/8703095/)
82. Philippe H, Telford MJ. Large-scale sequencing and the new animal phylogeny. *Trends Ecol Evol.* 2006; 21(11): 614–620. PMID: [16919363](https://pubmed.ncbi.nlm.nih.gov/16919363/)
83. Garcia-Varela M, Nadler SA. Phylogenetic relationships among Syndermata inferred from nuclear and mitochondrial gene sequences. *Mol Phylogenet Evol.* 2006; 40: 61–72. PMID: [16574435](https://pubmed.ncbi.nlm.nih.gov/16574435/)
84. Hausdorf B, Helmkampf M, Meyer A, Witek A, Herlyn H, Bruchhaus I, et al. Spiralian phylogenomics supports the resurrection of Bryozoa comprising Ectoprocta and Entoprocta. *Mol Biol Evol.* 2007; 24(12): 2723–2729. PMID: [17921486](https://pubmed.ncbi.nlm.nih.gov/17921486/)
85. Witek A, Herlyn H, Meyer A, Boell L, Bucher G, Hankeln T. EST based phylogenomics of Syndermata questions monophyly of Eurotatoria. *BMC Evol Biol.* 2008; 8: 345. doi: [10.1186/1471-2148-8-345](https://doi.org/10.1186/1471-2148-8-345) PMID: [19113997](https://pubmed.ncbi.nlm.nih.gov/19113997/)

86. Gazi M, Sultana T, Min G, Park YC, García-Varela M, Nadler SA, et al. The complete mitochondrial genome sequence of *Oncicola luehei* (Acanthocephala: Archiacanthocephala) and its phylogenetic position within Syndermata. *Parasitol Int.* 2012; 61: 307–316. doi: [10.1016/j.parint.2011.12.001](https://doi.org/10.1016/j.parint.2011.12.001) PMID: [22198415](https://pubmed.ncbi.nlm.nih.gov/22198415/)
87. Alrichs WH. Ultrastruktur und Phylogenie von *Seison nebaliae* (Gube 1859) und *Seison annulatus* (Claus 1876)—Hypothesen zu phylogenetischen Verwandtschaftsverhältnissen innerhalb der Bilateria. Dissertation, Georg-August University, Göttingen Cuvillier-Verlag, Göttingen; 1995.
88. Alrichs WH. Epidermal ultrastructure of *Seison nebaliae* and *Seison annulatus* and a comparison of epidermal structures within the Gnathifera. *Zoomorphology.* 1977; 117: 41–48.
89. Rieger RM, Tyler S. Sister-group relationship of Gnathostomulida and Rotifera-Acanthocephala. *Invertebr Biol.* 1995; 114: 186–188.
90. Sørensen MV. Further structures in the jaw apparatus of *Limnognathia maerski* (Micrognathozoa), with notes on the phylogeny of the Gnathifera. *J Morphol.* 2002; 255: 131–145.
91. Segers H, Melone G. A comparative study of trophi morphology in Seisonidea (Rotifera). *J Zool.* 2002; 244: 201–207.
92. Kristensen RM, Funch P. Micrognathozoa: a new class with complicated jaws like those of Rotifera and Gnathostomulida. *J Morphol.* 2000; 246: 1–49. PMID: [11015715](https://pubmed.ncbi.nlm.nih.gov/11015715/)
93. De Smet H. A new record of *Limnognathia maerski* Kristensen & Funch, 2000 (Micrognathozoa) from the subantarctic Crozet Islands, with redescription of the trophi. *J Zool.* 2002; 258: 381–393.
94. Giribet G, Sørensen MV, Funch P, Kristensen RM, Sterrer W. Investigations into the phylogenetic position of Micrognathozoa using four molecular loci. *Cladistics.* 2004; 20: 1–13.
95. Nielsen C. *Animal evolution: interrelationships of the living phyla*, third edition. Oxford: Oxford University Press; 2012.
96. Adrianov AV, Malakhov VV. The phylogeny and classification of the phylum Cephalorhyncha. *Zoosyst Ross.* 1995; 3: 181–201.
97. Lemburg C. Ultrastructure of sense organs and receptor cells of the neck and lorica of the *Halicryptus spinulosus* larva (Priapulida). *Microfauna Marina.* 1995; 10: 7–30.
98. Neuhaus B, Higgins RP. Ultrastructure, biology, and phylogenetic relationships of Kinorhyncha. *Integr Comp Biol.* 2002; 42: 619–632. doi: [10.1093/icb/42.3.619](https://doi.org/10.1093/icb/42.3.619) PMID: [21708758](https://pubmed.ncbi.nlm.nih.gov/21708758/)
99. Mallatt J, Winchell CJ. Ribosomal RNA genes and deuterostome phylogeny revisited: more cyclostomes, elasmobranchs, reptiles, and a brittle star. *Mol Phylogenet Evol.* 2007; 43: 1005–1022. PMID: [17276090](https://pubmed.ncbi.nlm.nih.gov/17276090/)
100. Mallatt J, Craig CW, Yoder MJ. Nearly complete rRNA genes assembled from across the metazoan animals: effects of more taxa, a structure-based alignment, and paired-sites evolutionary models on phylogenetic reconstruction. *Mol Phylogenet Evol.* 2010; 55: 1–17. doi: [10.1016/j.ympev.2009.09.028](https://doi.org/10.1016/j.ympev.2009.09.028) PMID: [19786108](https://pubmed.ncbi.nlm.nih.gov/19786108/)